



FABLAB
Kamp-Lintfort



**HOCHSCHULE
RHEIN-WAAL**
Rhine-Waal University
of Applied Sciences

Electronics Design

Remote lecture for Fab Lab Brighton

By Daniele Ingrassia

Electronics Design - Voltage

Voltage or electric potential difference (formally denoted ΔV , but more often simply as V) is the difference in electric potential energy between **two points** per unit electric charge. The voltage between two points is equal to the work done per unit of charge against a static electric field to move the test charge between two points and is measured in units of volts. If in one point there is more electrical potential than the other, then it is called plus +, and the other is called minus -.

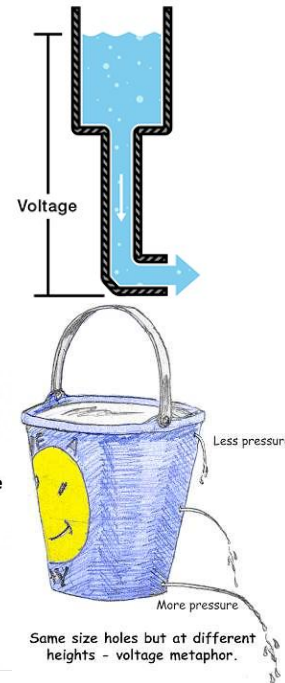
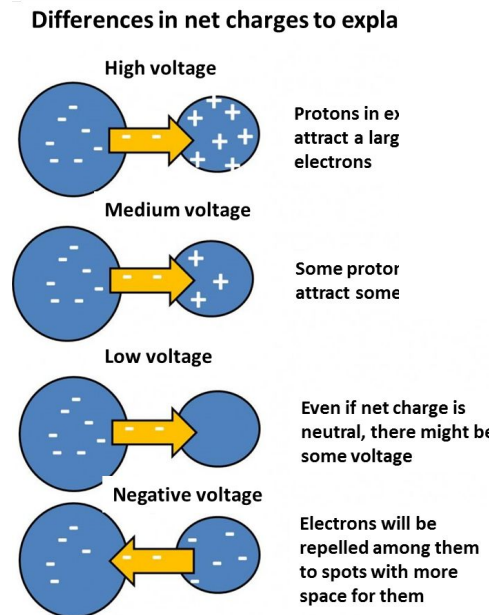
SI unit: Volt, V

Plus, +:

- V_{DC} = Volts direct Current
- V_{CC} = Ic power supply pin
- 5V = 5 Volts

Minus, -:

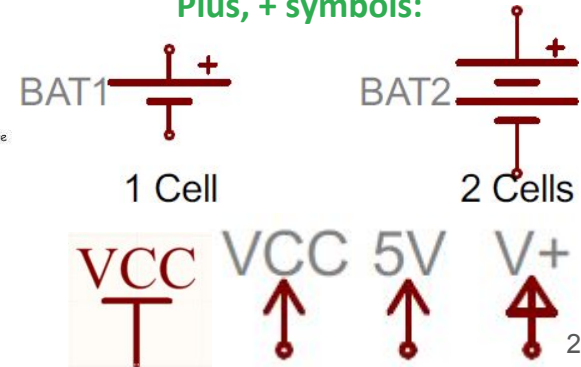
- GND = Ground
- Common
- Negative



Minus, - symbols:



Plus, + symbols:

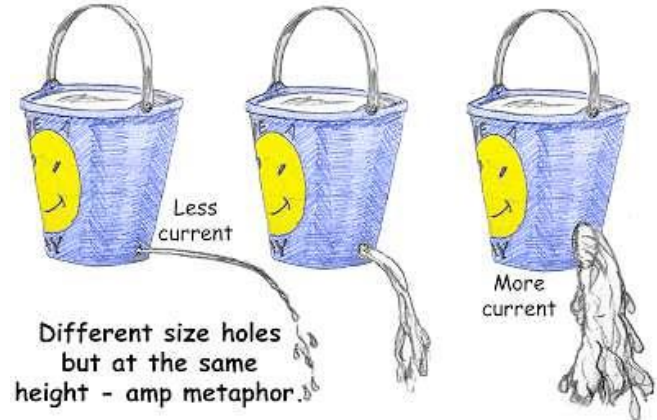
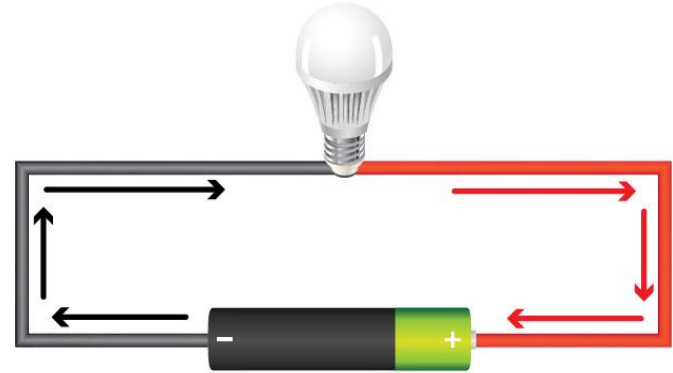
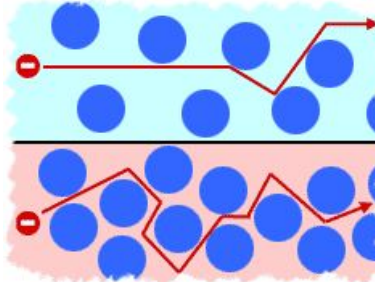
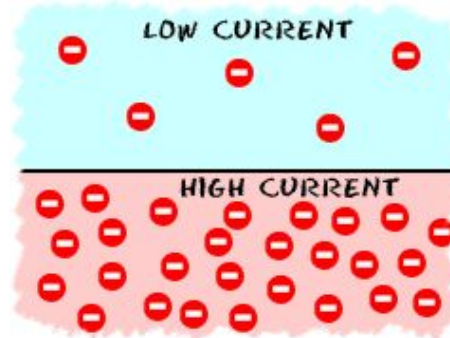
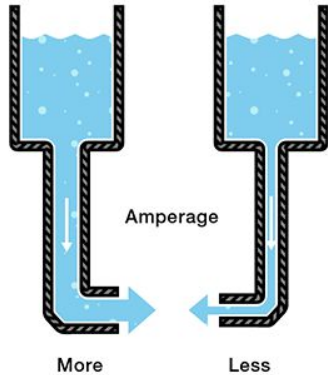


Electronics Design - Current

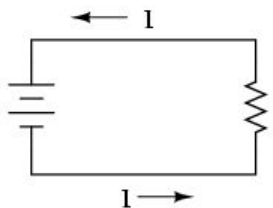
An electric current is a flow of electric charge. In electric circuits this charge is often carried by moving electrons in a wire. It can also be carried by ions in an electrolyte, or by both ions and electrons such as in a plasma.

SI unit: Ampere, Amp, A

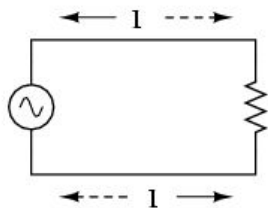
Symbols: I



DIRECT CURRENT
(DC)



ALTERNATING CURRENT
(AC)

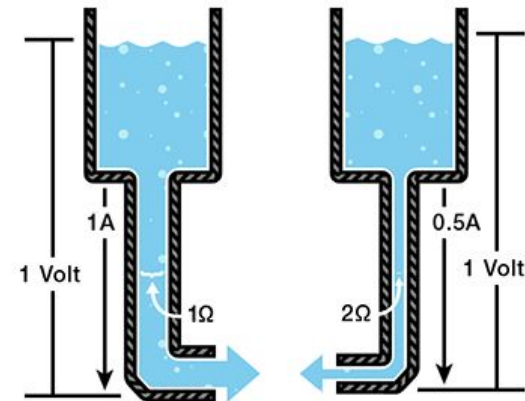
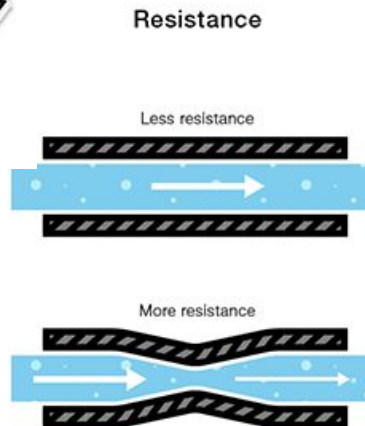
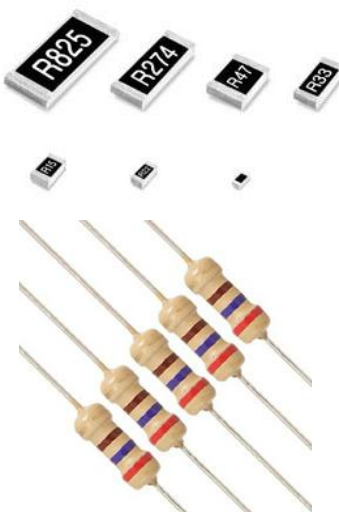


Electronics Design - Resistor

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. High-power resistors that can dissipate many watts of electrical power as heat may be used as part of motor controls, in power distribution systems, or as test loads for generators. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.

SI unit: Ohm, Ω
 $1K = 1000\Omega$
 $1M = 1000000\Omega$

Symbols:

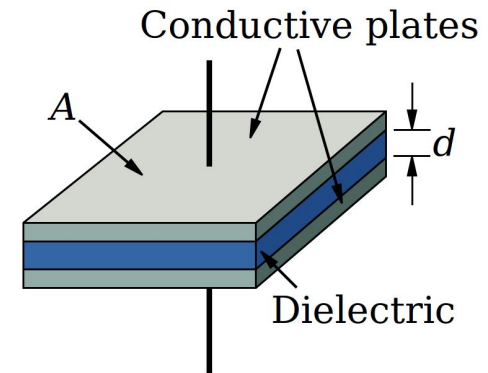
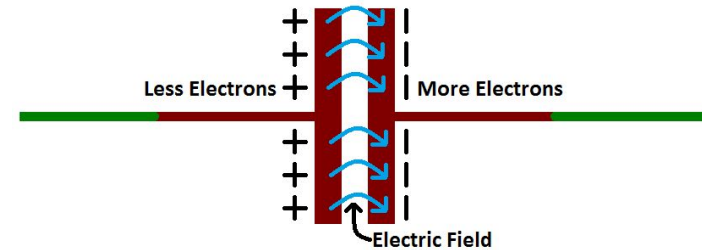
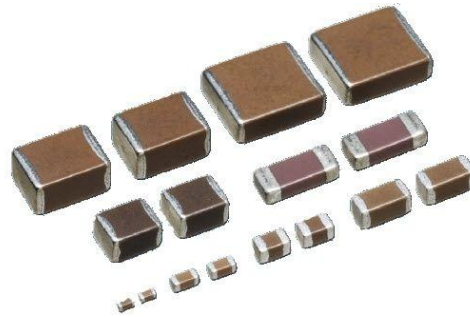
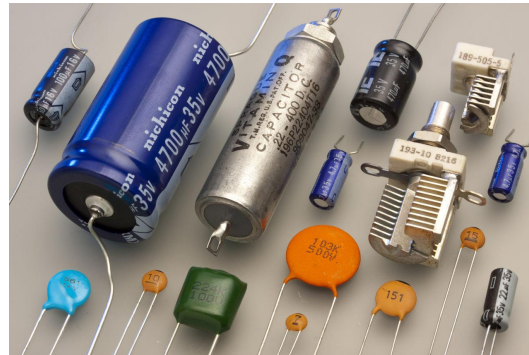


Electronics Design - Capacitor

A capacitor is a passive two-terminal electrical component that stores electrical energy in an electric field. The effect of a capacitor is known as capacitance. While capacitance exists between any two electrical conductors of a circuit in sufficiently close proximity, a capacitor is specifically designed to provide and enhance this effect for a variety of practical applications by consideration of size, shape, and positioning of closely spaced conductors, and the intervening dielectric material.

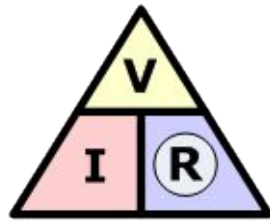
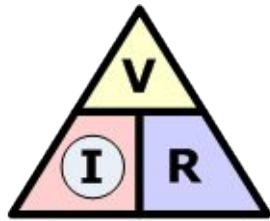
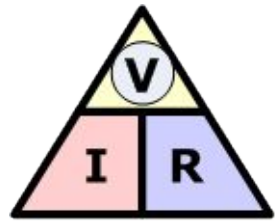
SI unit: Farad, F
 $1\mu\text{F} = 0.000001\text{F}$
 $1\text{nF} = 0.001\mu\text{F}$

Symbols:



Electronics Design - Ohm's Law and Power

Ohm's law states that the current through a conductor between two points is directly proportional to the voltage across the two points. Introducing the constant of proportionality, the resistance, [1] one arrives at the usual mathematical equation that describes this relationship $R = V/I$ (DC).



$$R = \frac{\rho L}{A}$$

ρ = resistivity

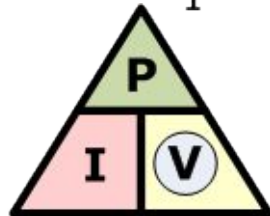
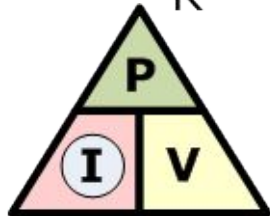
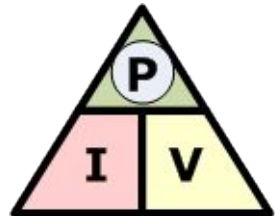
L = length

A = cross sectional area

$$V = I \times R$$

$$I = \frac{V}{R}$$

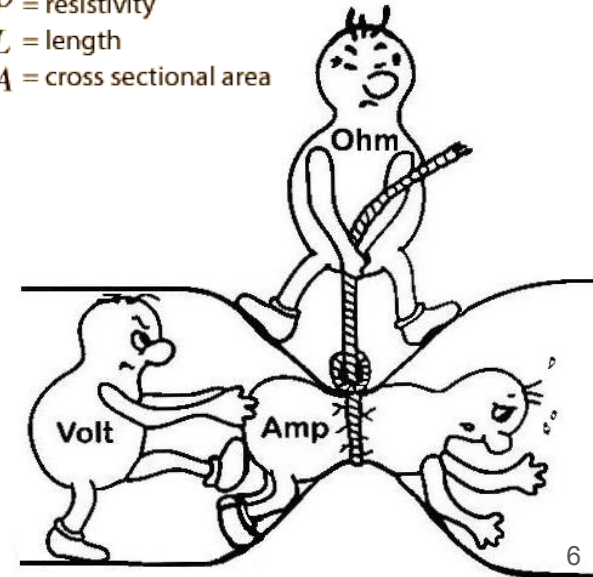
$$R = \frac{V}{I}$$



$$P = I \times V$$

$$I = \frac{P}{V}$$

$$V = \frac{P}{I}$$

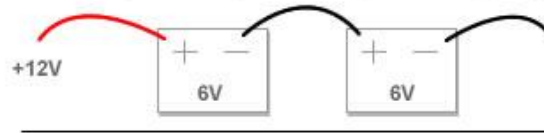


Electronics Design - Series & Parallel Circuits

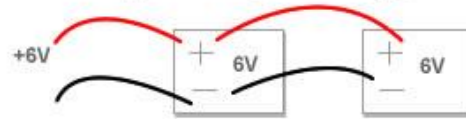
Components of a circuit can be connected in many different ways. The two simplest of these are called series and parallel and occur frequently. Components connected in series are connected along a single path, so the same current flows through all of the components. Components connected in parallel are connected, so the same voltage is applied to each component.

Batteries

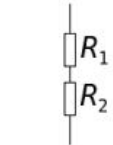
Connecting in Series (double voltage, same capacity [ah])



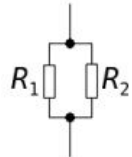
Connecting in Parallel (same voltage, double capacity [ah])



Resistors

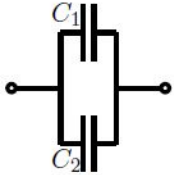
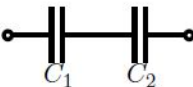


$$R_{TOTAL} = R_1 + R_2 \dots R_n$$

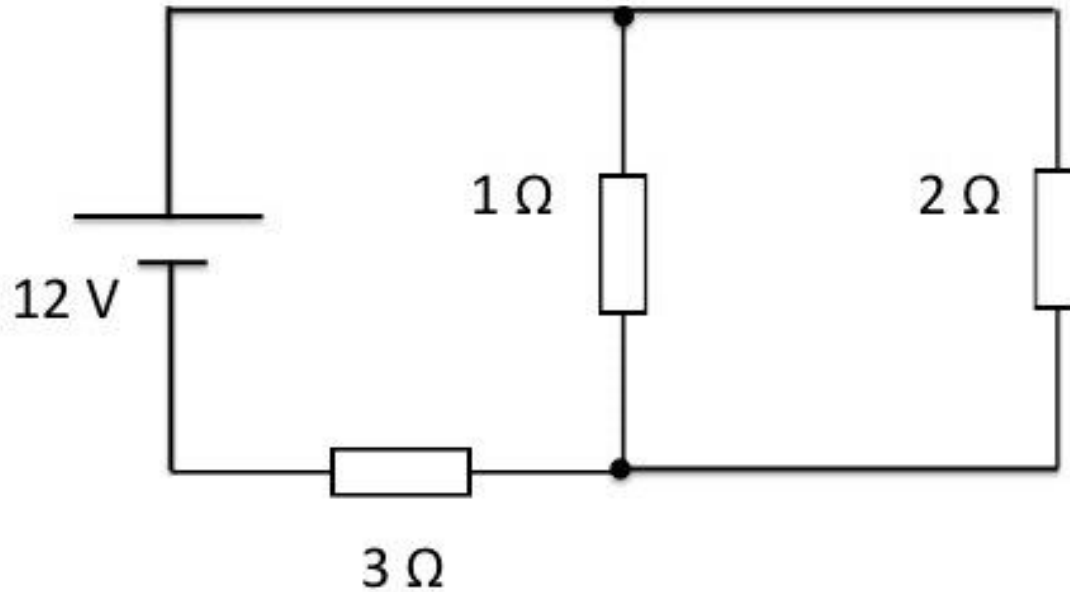


$$\frac{1}{R_{TOTAL}} = \frac{1}{R_1} + \frac{1}{R_2} \dots \frac{1}{R_n}$$

Capacitors

PARALLEL		$C_p = C_1 + C_2$
SERIES		$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}$

Electronics Design - A simple exercise



Please calculate:

- The current passing on the 3 Ohm resistor
- The current passing on the 1 Ohm resistor
- The current passing on the 2 Ohm resistor
- The voltage on the parallel
- The voltage insisting on the 3 Ohm resistor
- The total used power from the circuit

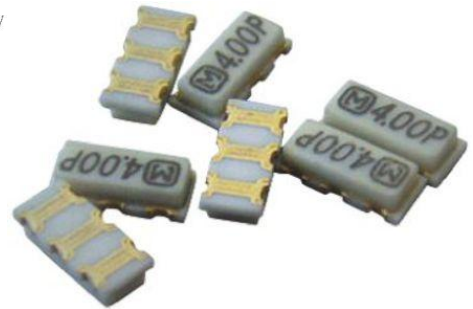
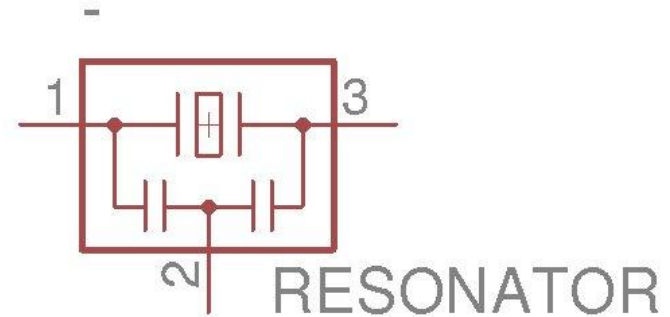
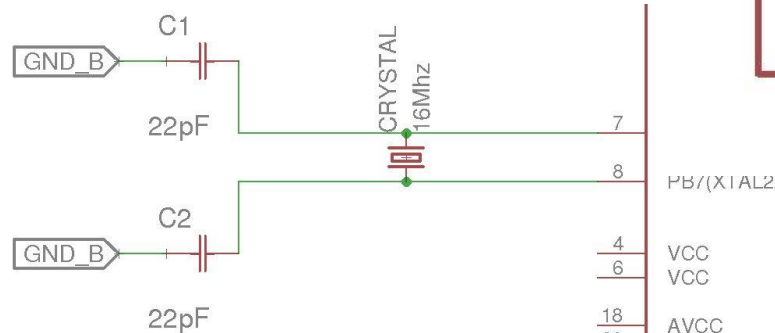
Electronics Design - Oscillators

An electronic oscillator is an electronic circuit that produces a periodic, oscillating electronic signal, often a sine wave or a square wave. Oscillators convert direct current (DC) from a power supply to an alternating current (AC) signal. Common examples of signals generated by oscillators include signals broadcast by radio and television transmitters, clock signals that regulate computers and quartz clocks, and the sounds produced by electronic beepers and video games.

SI unit: Hertz, Hz
1KHz = 1000kHz
1MHz = 1000KHz



CRYSTAL

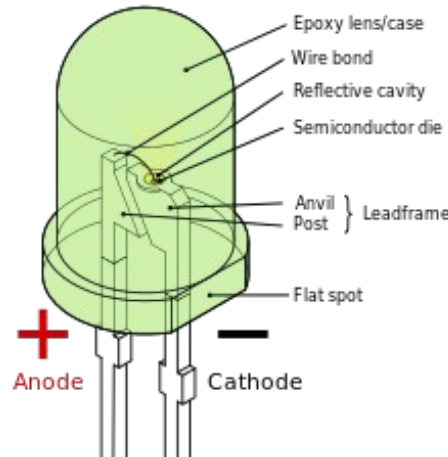
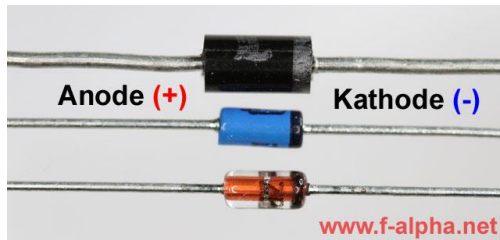
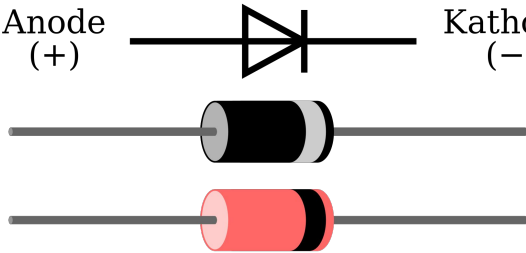


Electronics Design - Diode and LED

In electronics, a **diode** is a two-terminal electronic component that conducts primarily in one direction (asymmetric conductance); it has low (ideally zero) resistance to the flow of current in one direction, and high (ideally infinite) resistance in the other.

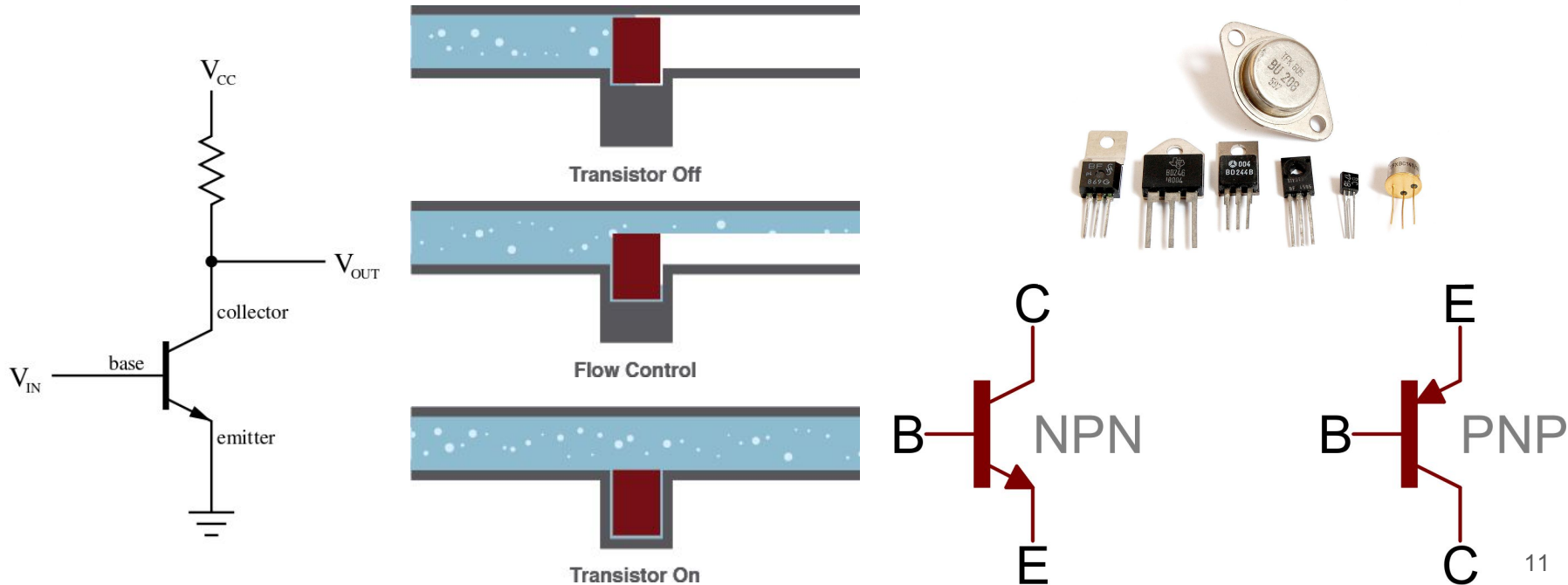
A **light-emitting diode** (LED) is a two-lead semiconductor light source. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor.

Anode (+) Kathode (-)



Electronics Design - Transistor

A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power. It is composed of semiconductor material usually with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals controls the current through another pair of terminals. Because the controlled (output) power can be higher than the controlling (input) power, a transistor can amplify a signal.



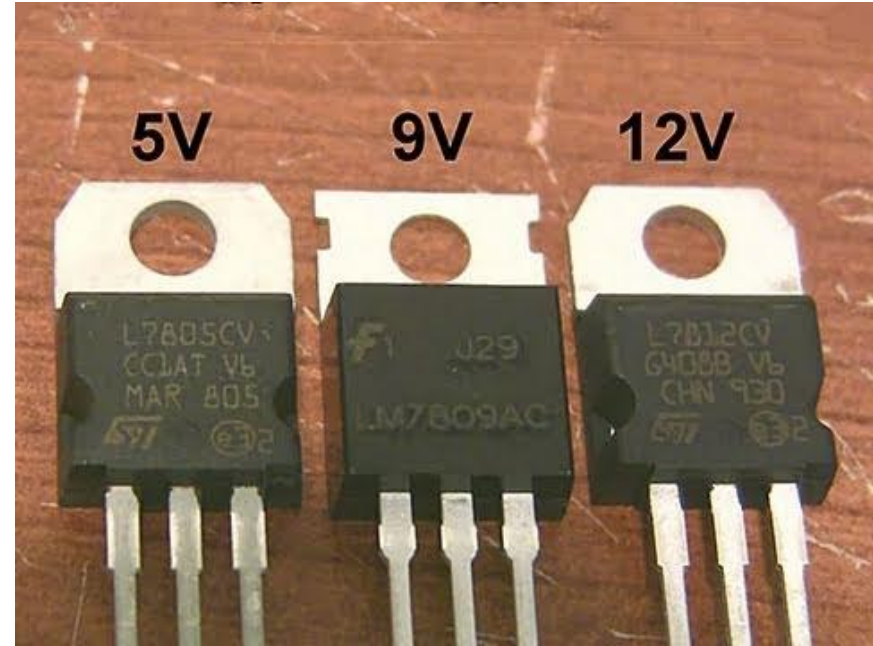
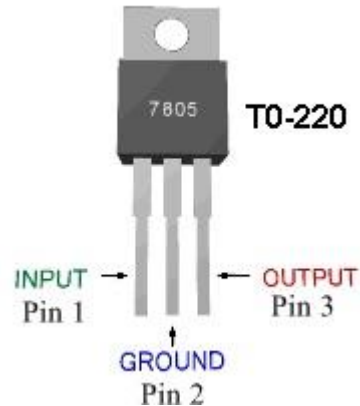
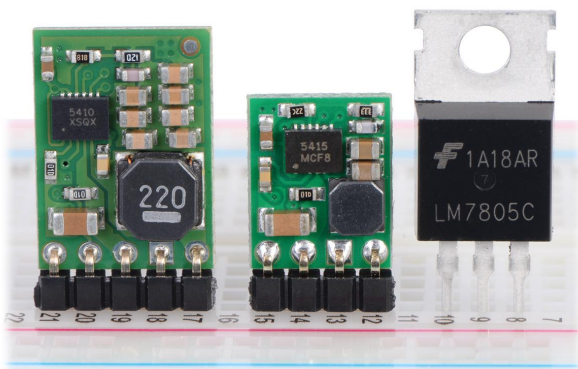
Electronics Design - Voltage Regulator

A voltage regulator is designed to automatically maintain a constant voltage level from different voltage values in input. Electronic voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and other elements.

Step-Down: from higher to lower voltage

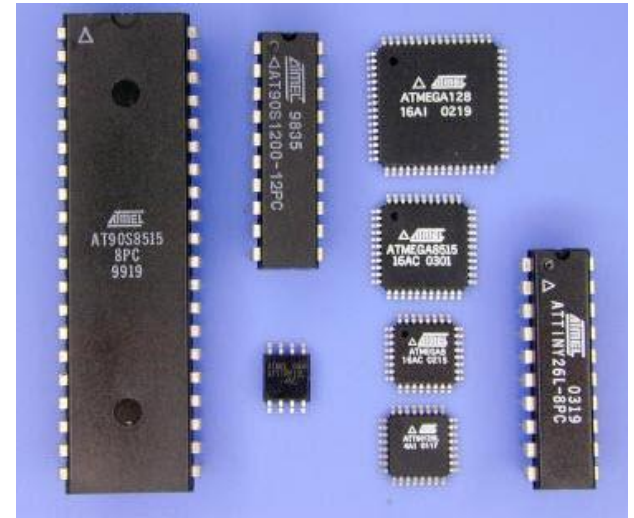
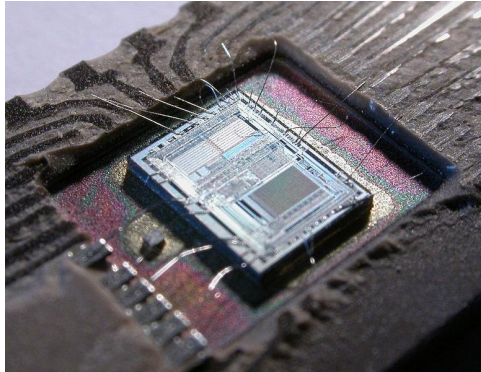
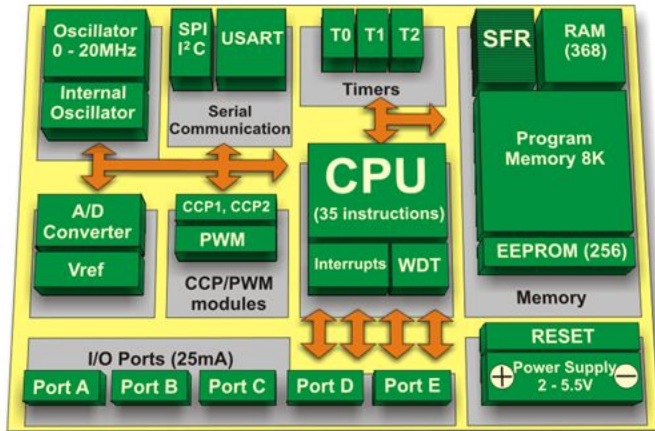
Step-Up: from lower to higher voltage

Step-up/Step-Down: from a range to a fixed voltage inside it



Electronics Design - Microcontroller

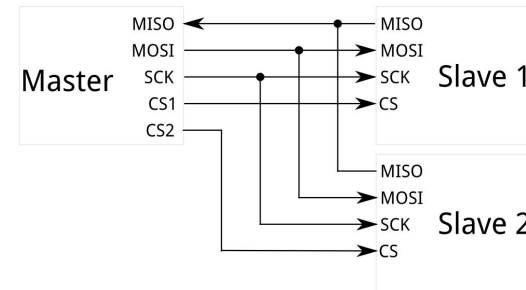
A microcontroller (or MCU) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications consisting of various discrete chips. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems.



Serial communication is the process of sending data one bit at a time, sequentially, over a communication channel. It uses two wires to implement an asynchronous full duplex communication, but only between two devices.

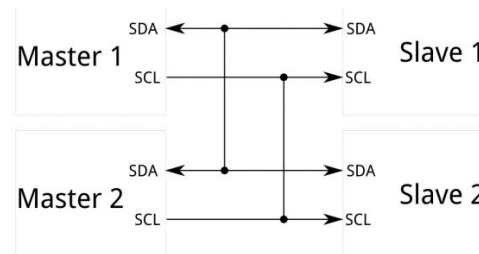


The **SPI** (Serial Peripheral Interface) bus is a synchronous master-slave serial communication interface specification used for short distance communication, primarily in embedded systems. It requires up to four wires allowing full duplex communication for a with a single slave.



Remember that you have always to share the ground between the microcontrollers!

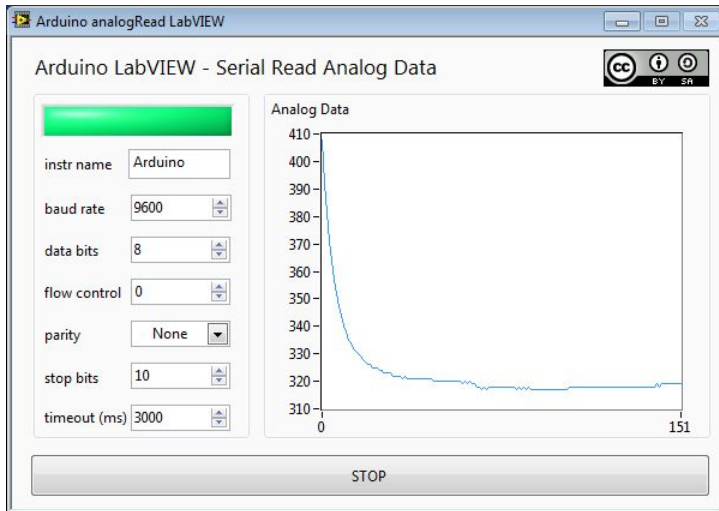
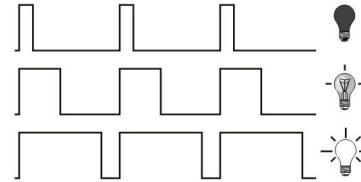
I²C, pronounced I-squared-C, is a multi-master, multi-slave, serial computer bus invented by Philips Semiconductor. It supports several slaves (eg 100+) allowing one transmission per time between the master and one slave. The transmission are not full duplex.



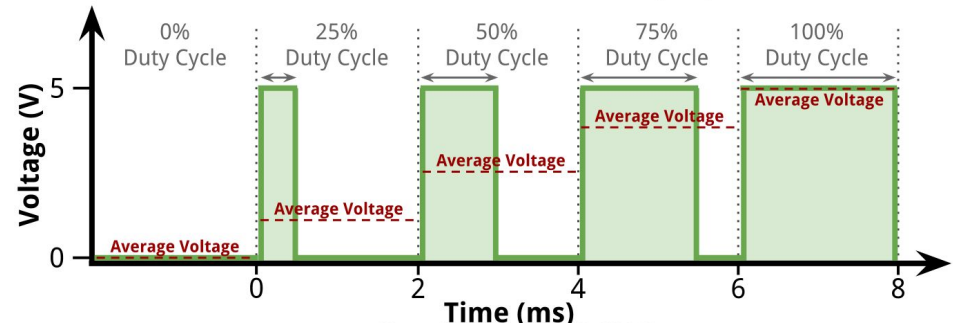
Electronics Design - ADC & PWM

An Analog to Digital Converter (**ADC**) is a very useful feature that converts an analog voltage on a pin to a digital number. By converting from the analog world to the digital world, we can begin to use electronics to interface to the analog world around us.

Pulse-width modulation (**PWM**) is a modulation process or technique used in communication systems for encoding the amplitude of a signal right into a pulse width or duration of another signal, usually a carrier signal, for transmission. Although PWM is also used in communications, its main purpose is actually to control the power that is supplied to various types of electrical devices, most especially to inertial loads such as AC/DC motors.



Pulse Width Modulation Duty Cycles

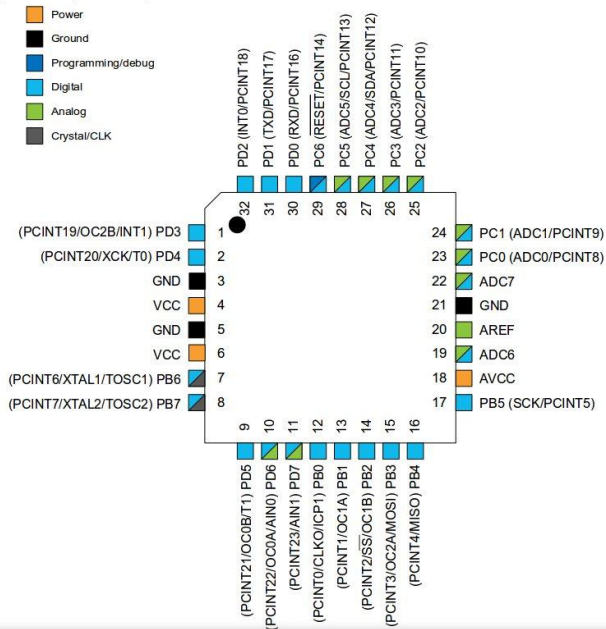


Note: 1 cycle = 2ms @ 500 Hz

Electronics Design - Read the Datasheets!

A datasheet is a document that summarizes the performance and other technical characteristics of a product, machine, component (e.g., an electronic component), material, a subsystem (e.g., a power supply) or software in sufficient detail to be used by a design engineer to integrate the component into a system. Typically, a datasheet is created by the component/subsystem/software manufacturer and begins with an introductory page describing the rest of the document, followed by listings of specific characteristics, with further information on the connectivity of the devices.

Figure 5-3. 32-pin TQFP Top View



µA7800 SERIES POSITIVE-VOLTAGE REGULATORS

SLVS056J – MAY 1976 – REVISED MAY 2003

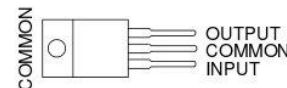
- 3-Terminal Regulators
- Output Current up to 1.5 A
- Internal Thermal-Overload Protection

- High Power-Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation

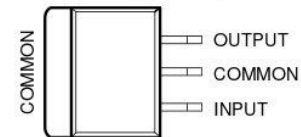
KC (TO-220) PACKAGE
(TOP VIEW)



KCS (TO-220) PACKAGE
(TOP VIEW)

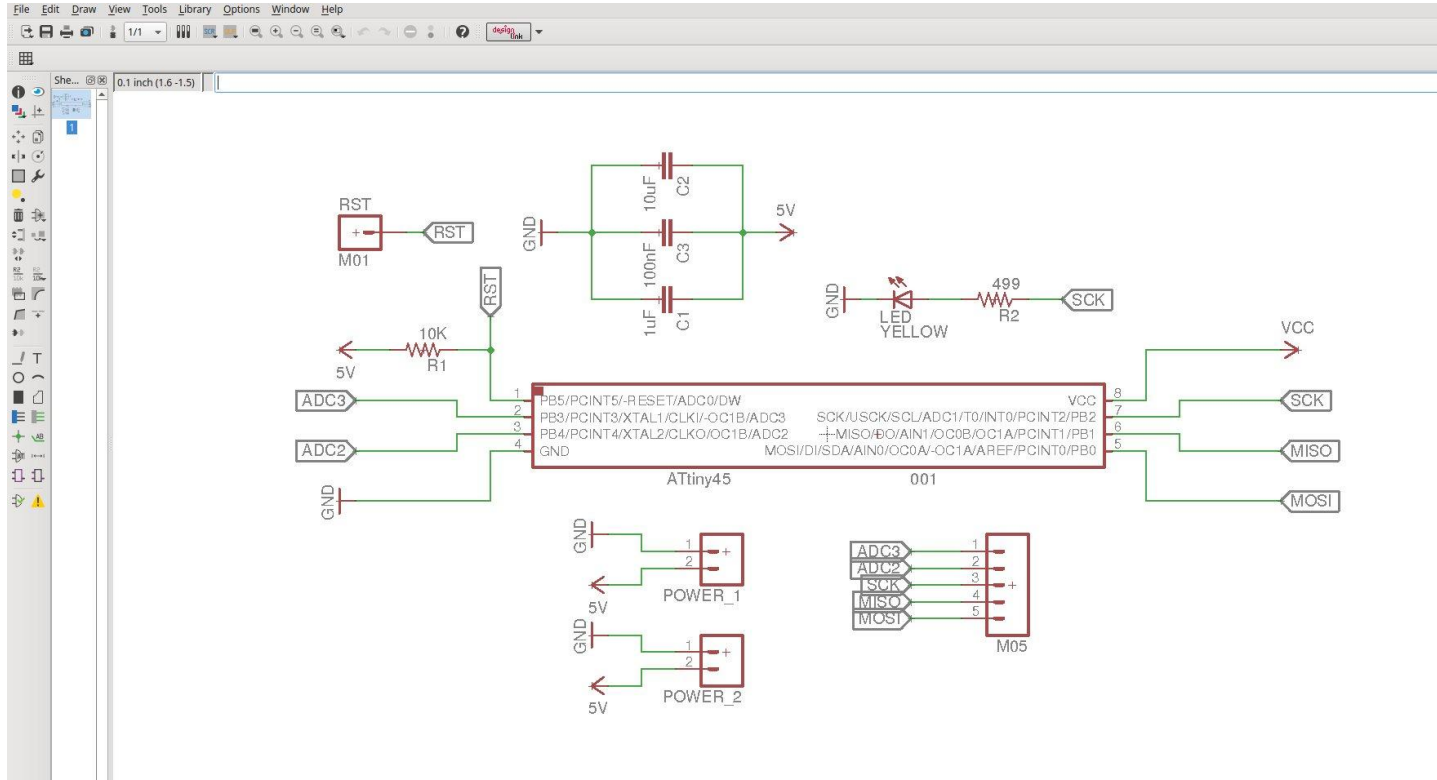


KTE PACKAGE
(TOP VIEW)

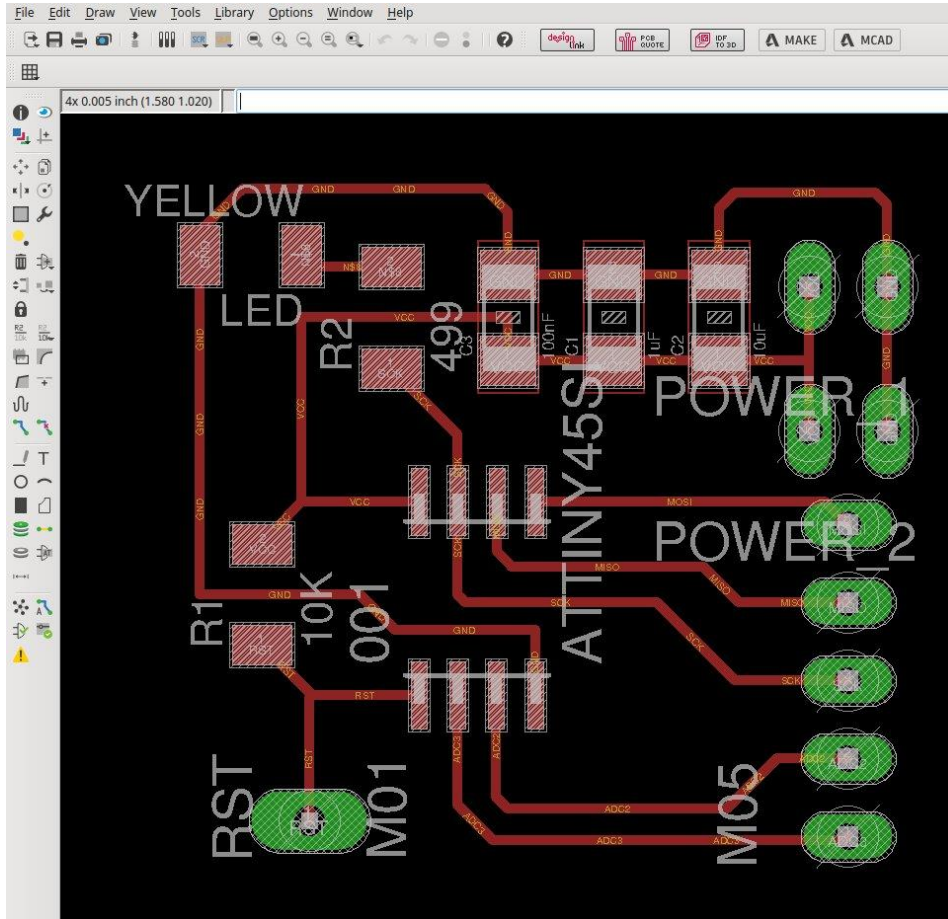


Electronics Design - Eagle Schematic

In schematic editor we are dealing with components specifications and the connections between them. Here we specify the logical part of the PCB, where important thing is how the component are connected or which connections are going where.



Electronics Design - Eagle Board



In the board editor we will work with the physical specifications of the PCB, and every component added in the schematic editor will be added here as well. Here we take care of components' displacement and of the specification of the traces that connects them.

Week Assignments

- modify an existing board design, adding a least:
 - a. a led
 - b. a button
- mill and solder the board
- test and program the board
- create a page to document your progress of week 7, what did you do, in which order, what are your experiences (problems, solutions, etc.), and add a video about the successful programming of the board

References:

- 7 - http://www.12voltbattery.info/index.php?page=batteries_parallel_vs_series
- 8 - <http://www.physics.utah.edu/~bromley/courses/p6720/labs/lab14.html>
- 9 - https://en.wikipedia.org/wiki/Crystal_oscillator
- 9 - https://en.wikipedia.org/wiki/Electronic_oscillator
- 10 - <https://en.wikipedia.org/wiki/Diode>
- 10 - https://en.wikipedia.org/wiki/Light-emitting_diode
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- 12 - https://www.youtube.com/watch?v=GSzVs7_aW-Y
- 12 - <https://www.pololu.com/product/2843>
- 12 - <https://electrosome.com/power-supply-design-5v-7805-voltage-regulator/>
- 13 - <https://en.wikipedia.org/wiki/Microcontroller>
- 13 - <https://www.elprocus.com/avr-microcontroller-serial-data-communication/>
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- 16 - http://www.atmel.com/Images/Atmel-42735-8-bit-AVR-Microcontroller-ATmega328-328P_datasheet.pdf
- 16 - <https://www.sparkfun.com/datasheets/Components/LM7805.pdf>
- 16 - <https://en.wikipedia.org/wiki/Datasheet>
- 17 - 18 <https://cadsoft.io/de/>
- 2 - <https://en.wikipedia.org/wiki/Voltage>
- 2 - <https://learn.sparkfun.com/tutorials/voltage-current-resistance-and-ohms-law>
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