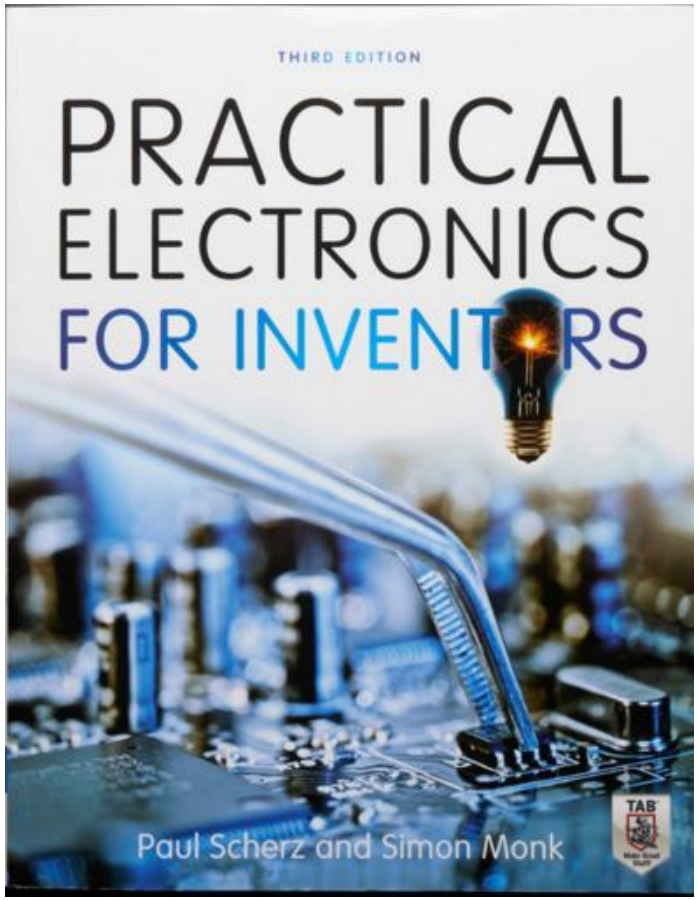
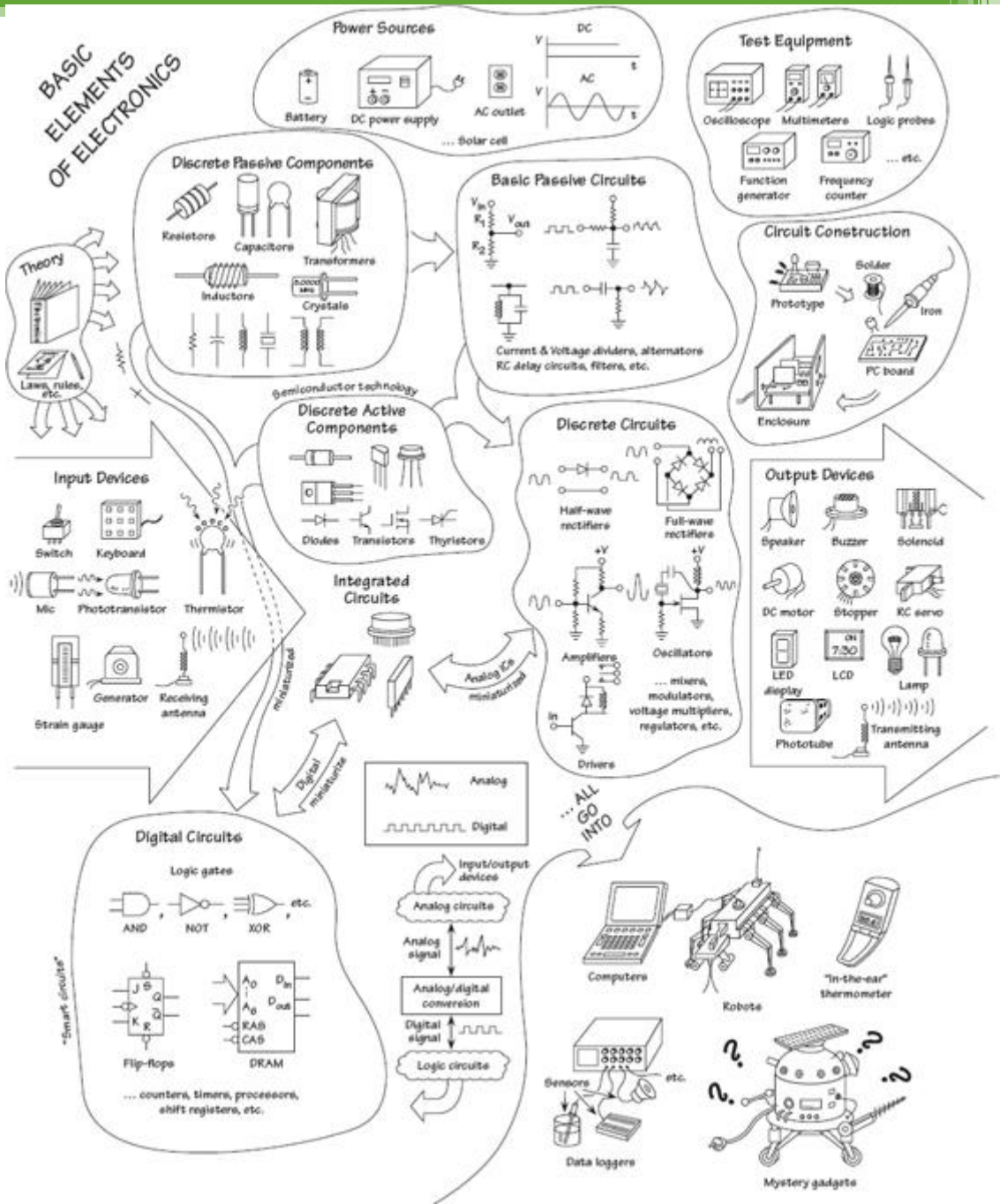
CO2015

Basic Electronic Circuit Components

DCE
DEPT. OF COMPUTER ENGINEERING


THIRD EDITION
PRACTICAL
ELECTRONICS
FOR INVENTORS
Paul Scherz and Simon Monk
TAB


BASIC ELEMENTS OF ELECTRONICS
Power Sources
Battery
DC power supply
AC outlet
Solar cell
DC
AC
Test Equipment
Oscilloscope
Multimeters
Logic probes
Function generator
Frequency counter
... etc.
Discrete Passive Components
Resistors
Capacitors
Transformers
Inductors
Crystals
Basic Passive Circuits
Current & voltage dividers, alternators
RC delay circuits, filters, etc.
Circuit Construction
Prototype
Solder
Iron
PC board
Enclosure
Theory
Laws, rules, etc.
Semiconductor technology
Discrete Active Components
Diodes
Transistors
Thyristors
Discrete Circuits
Half-wave rectifiers
Full-wave rectifiers
Amplifiers
Oscillators
Drivers
... mixers, modulators, voltage multipliers, regulators, etc.
Input Devices
Switch
Keyboard
Mic
Phototransistor
Thermistor
Strain gauge
Generator
Receiving antenna
Integrated Circuits
Analog ICs miniaturized
miniaturized
Output Devices
Speaker
Buzzer
Solenoid
DC motor
Stepper
RC servo
LED display
LCD
Lamp
Phototube
Transmitting antenna
Analog
Digital
Digital miniaturized
Digital Circuits
Logic gates
AND
NOT
XOR
etc.
Flip-flops
DRAM
... counters, timers, processors, shift registers, etc.
"Smart circuits"
Input/output devices
Analog circuits
Analog signal
Analog/digital conversion
Digital signal
Logic circuits
... ALL GO INTO
Computers
Robots
"In-the-ear" thermometer
Sensors
etc.
Data loggers
Mystery gadgets

Actually....

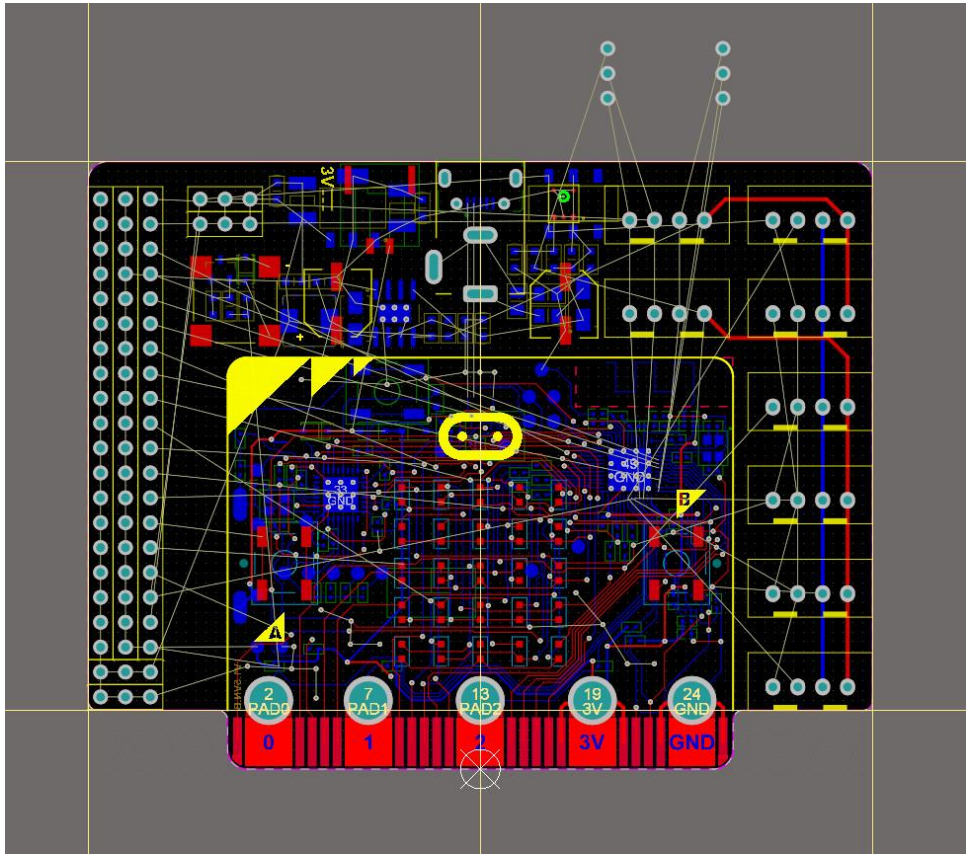
- Circuit Analysis
- Electronics Components
  - Resistor, Capacitor, Transistor
- Hardware computer Exercise
  - Design and Layout the Circuit

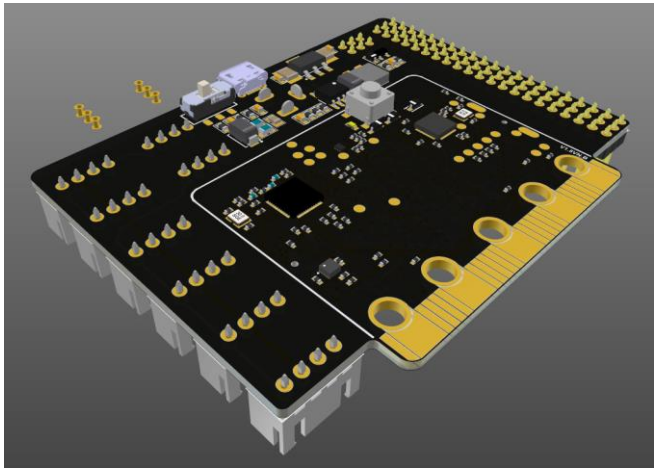
- 20% for Midterm, 30% for Labs and 50% for final term

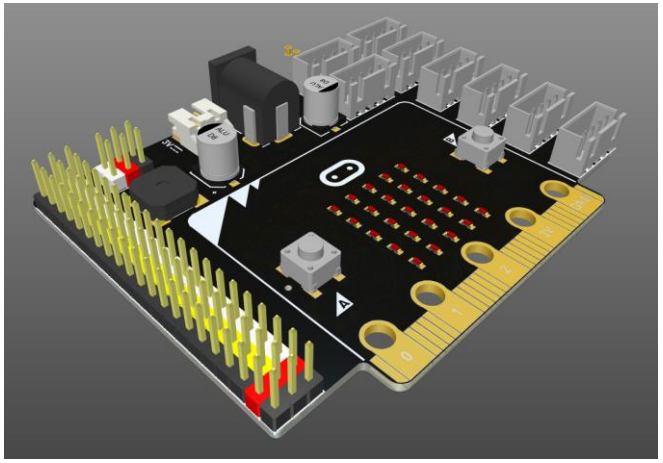
- Labs are very important (5 hour/ week)
  - ***Don't share your report!!!!***

Some projects

Complicated Project







https://ubc.sgp1.cdn.digitaloceanspaces.com/Altium/Altium%20Designer%2020.1.11%20Build%20218.zip

Basic Electronic Circuit Components

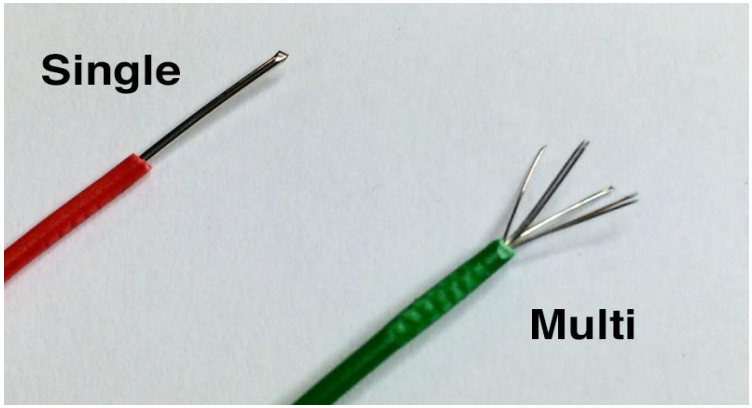
- Wires, Cables, and Connectors
- Batteries
- Switches
- Resistors
- LED (Light Emitted Diode)
- Exercises
- ***Pull up and Pull down resistors***

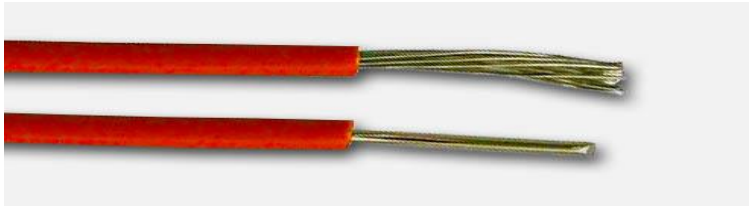
Solid Core Wires

- Strong
- High current

Solid Core Applications

Stranded Wires (Multicore Wires)



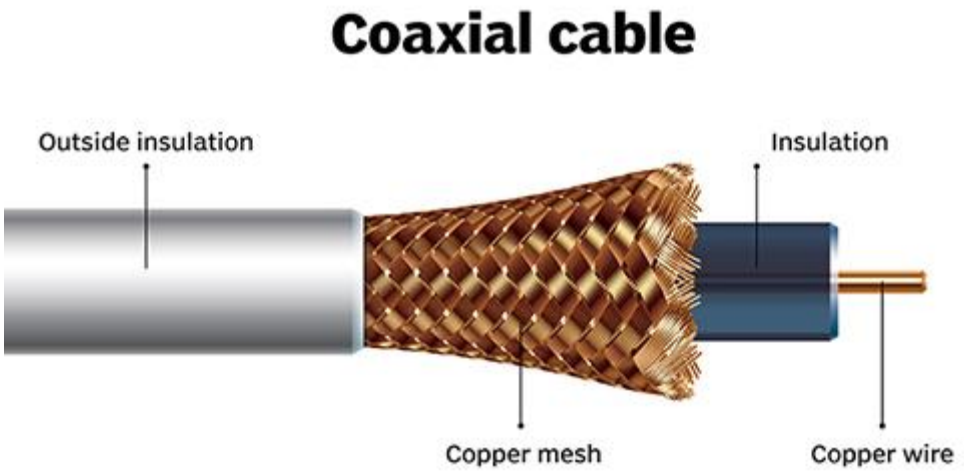


- Soft
- Smaller current
- Easy to Draw

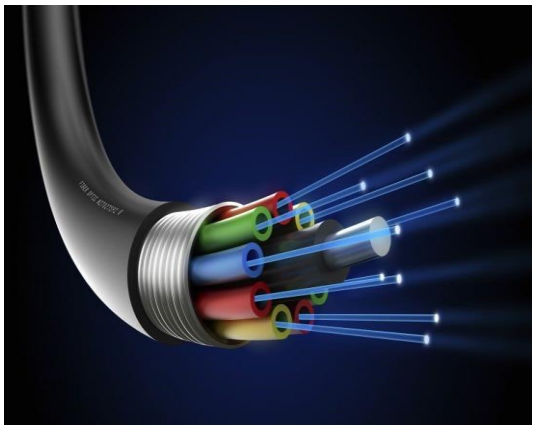
Braided Wires

- Soft and High current

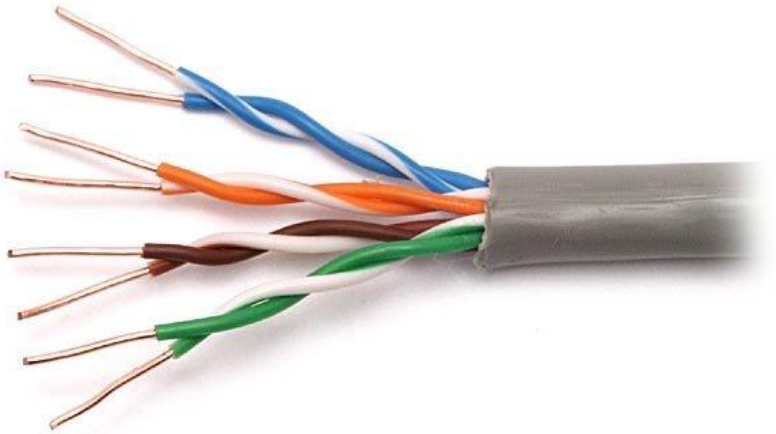
Coaxial Cables



- High speed communication systems



Twisted Pair Cables



- Pulse noise avoidance
- ADSL Modem (RJ45)

Battery

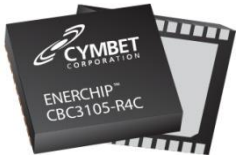
- The most popular storage device

Rechargeable Batteries

- Battery capacity: 3500mAh

Super Capacitors

Rechargeable Batteries vs Super Capacitor



[Cymbet]

500 recharge cycles

Difficult to estimate the state of charge

Low leakage current

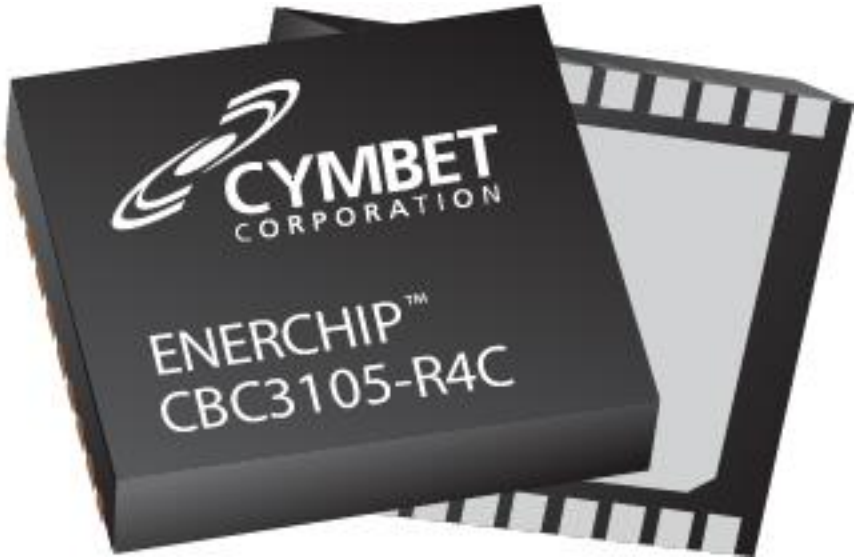
[CapXX]

500 000 recharge cycles

Easy to estimate the state of charge

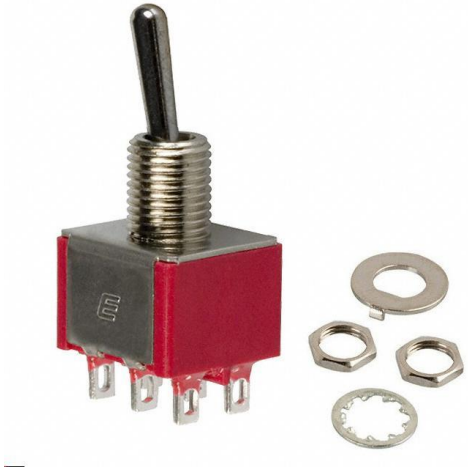
High leakage current

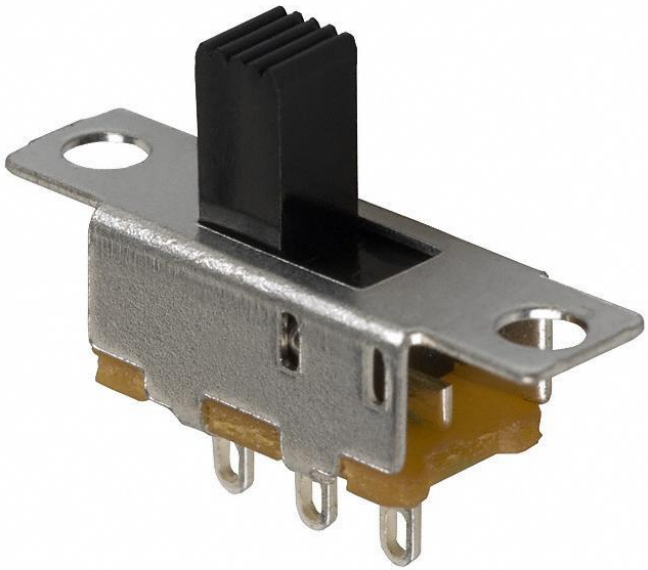
New Generation of Batteries



- IC Rechargeable Batteries
- Hybrid Batteries (Batteries + Capacitors)

Switch

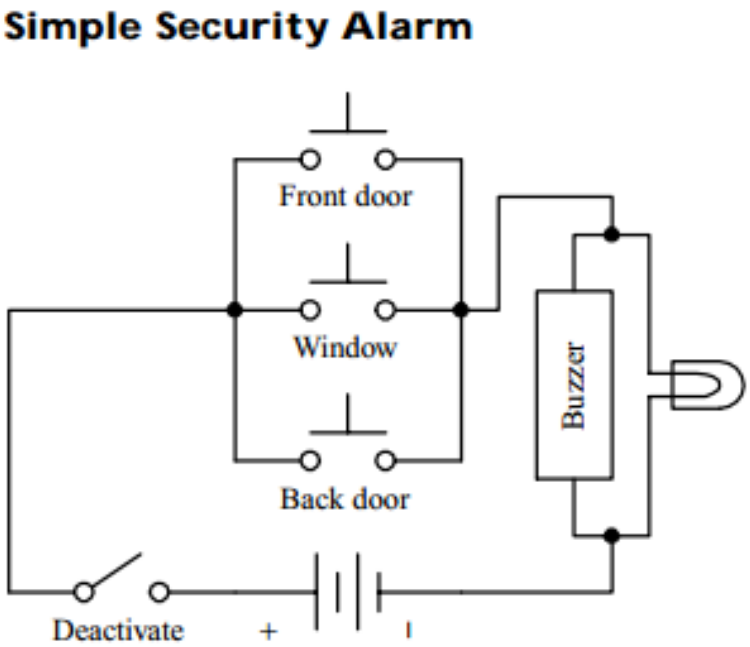




- A switch is a mechanical device that interrupts or diverts electric current flow within a circuit

Switch Applications (1)

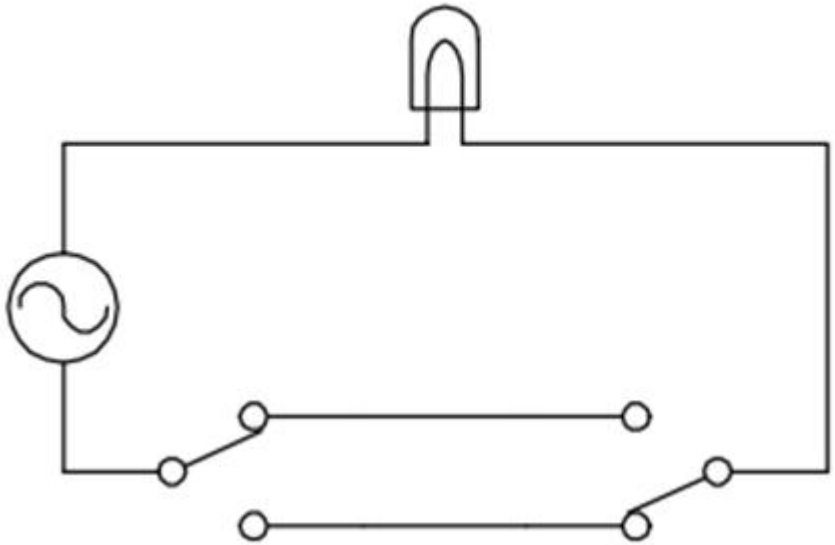
- Here's a simple home security alarm that's triggered into action (buzzer and light go on) when one of the normally open switches is closed. Magnetic reed switches work particularly well in such applications.



Switch Applications (2)

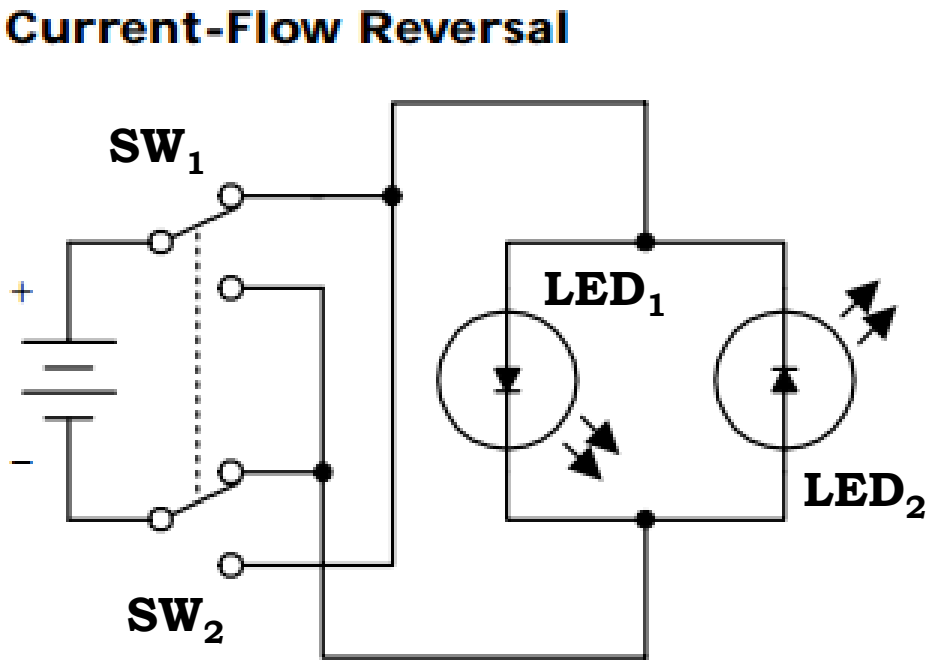
- Here's a switch network that allows an individual to turn a light on or off from either of two locations. This setup is frequently used in household wiring applications.

Dual-Location On/Off Switching Network



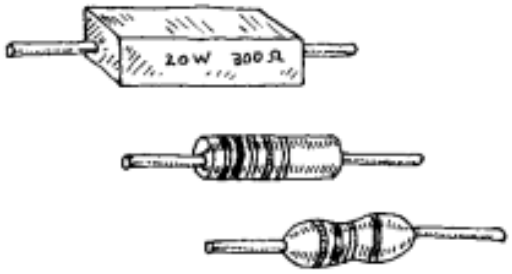
Switch Application (3)

- A DPDT switch, shown here, can be used to reverse the direction of current flow. When the switch is thrown up, current will flow throw the left light-emitting diode (LED). When the switch is thrown down, current will flow throw the right LED. (LEDs only allow current to flow in one direction.)

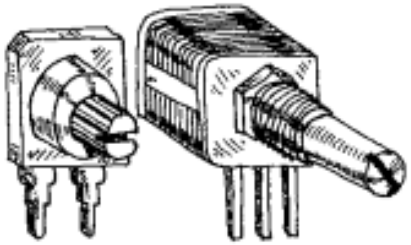


Resistors

- Resistors are electrical devices that act to reduce current flow and at the same time act to lower voltage levels within circuits.
  - The relationship between the voltage applied across a resistor and the current through it is given by $V = IR$.
- Resistors may have fixed resistances, or they may be designed to have variable resistances. They also may have resistances that change with light or heat exposure (e.g., photo-resistors, thermistors).



Fixed Resistors

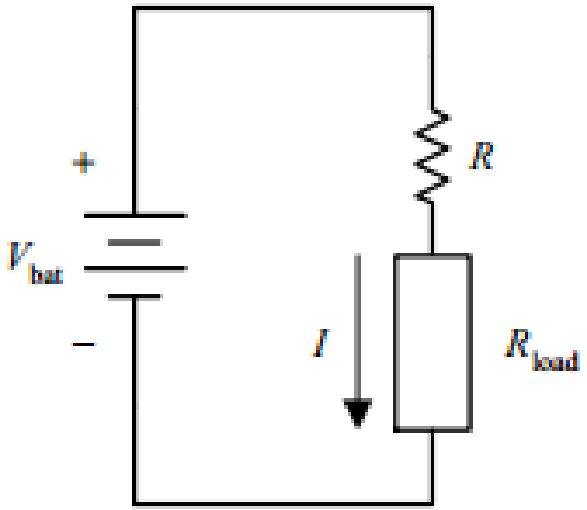


Potentiometers
and
Trimmers

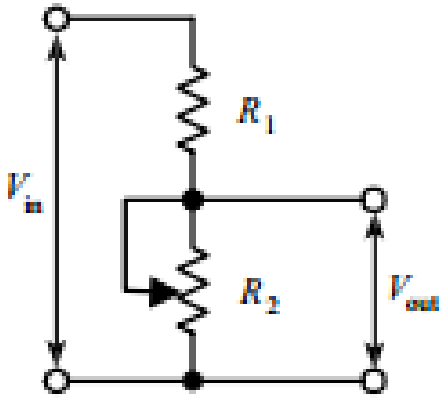
Thermistors
and
Phototransistors

Resistors

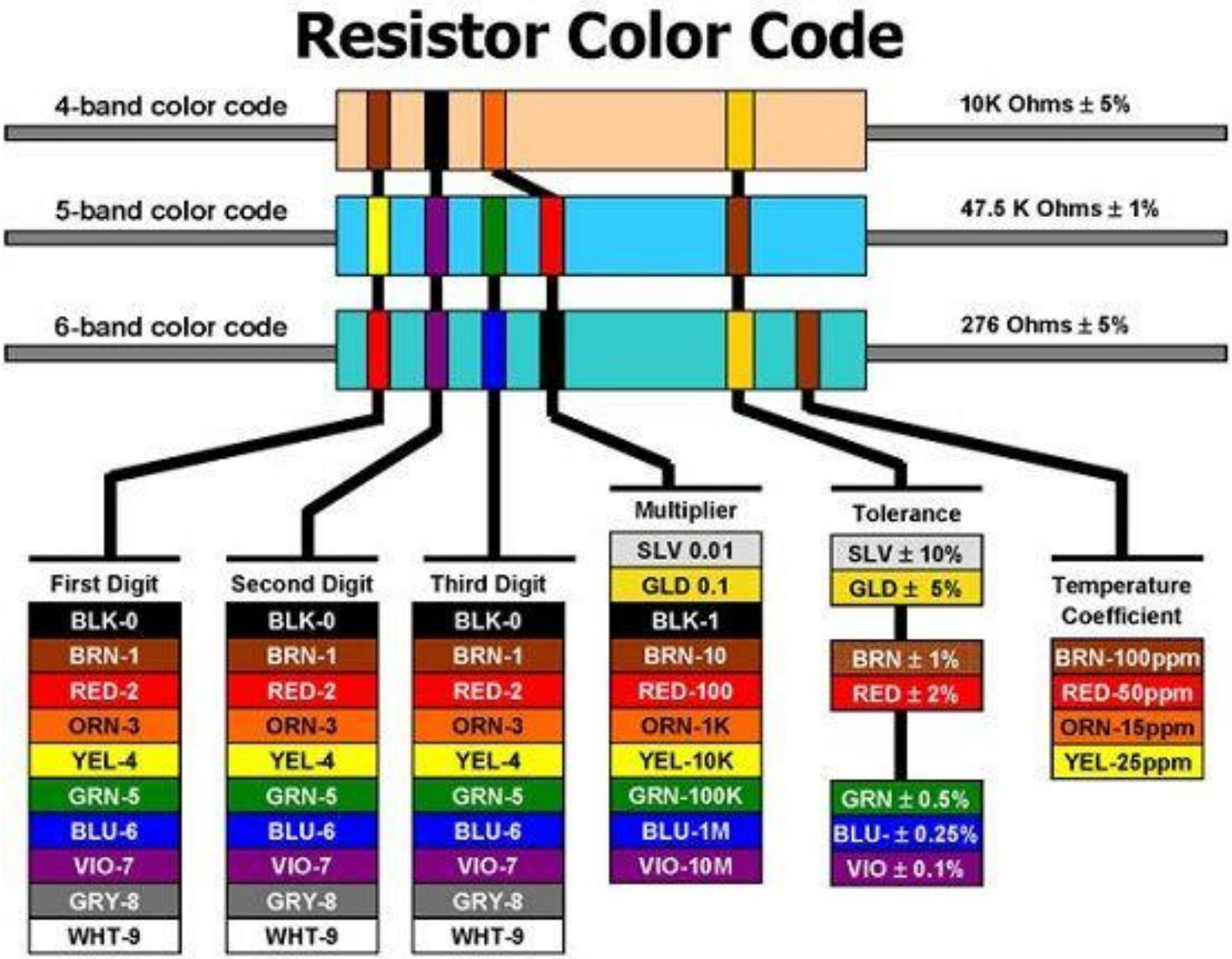
Current Limiter



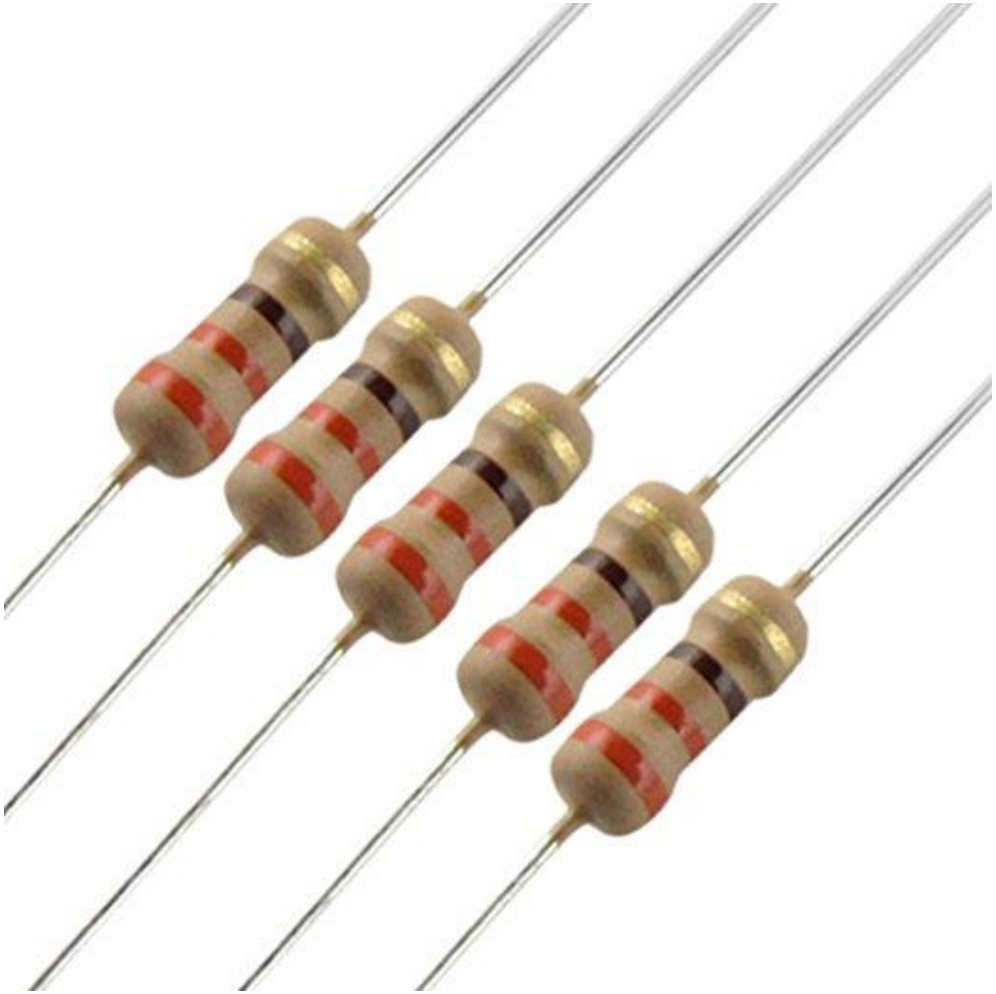
Voltage Divider



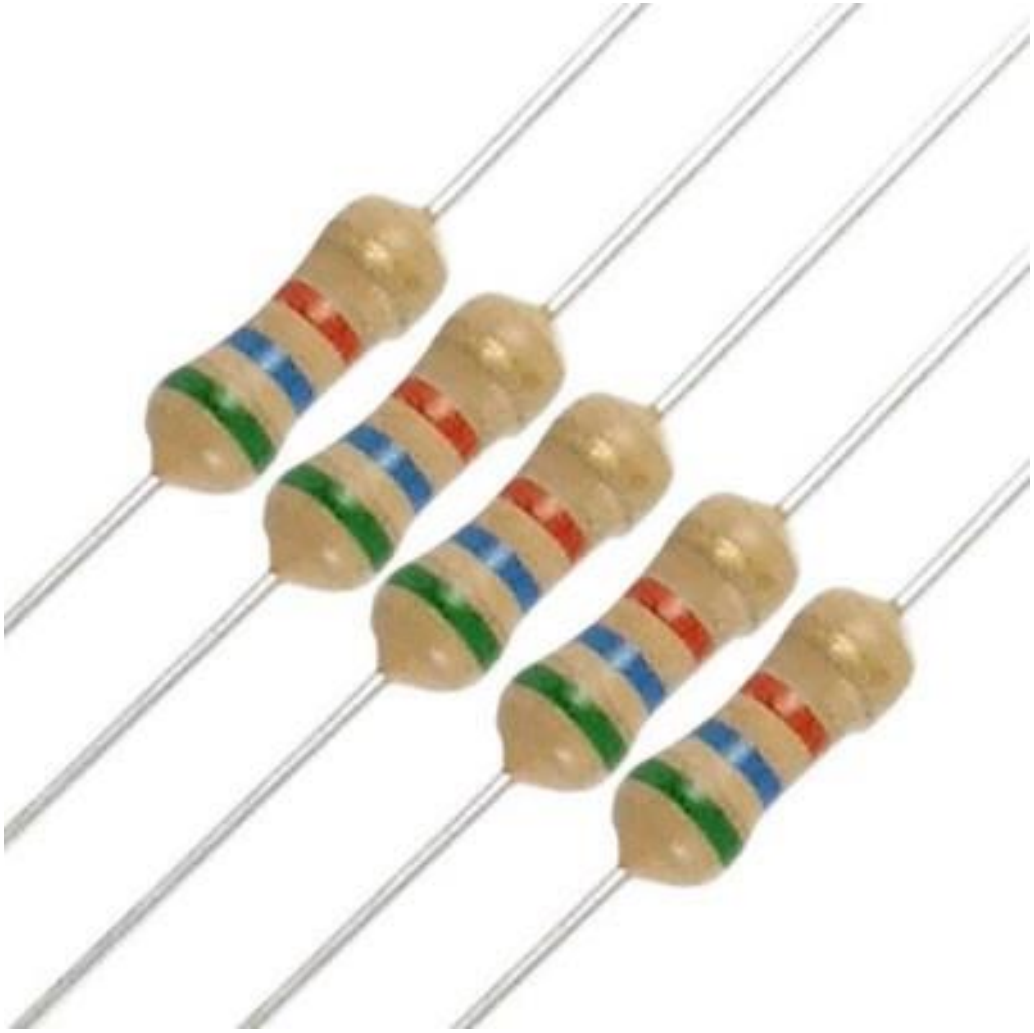
Understanding Resistor Labels



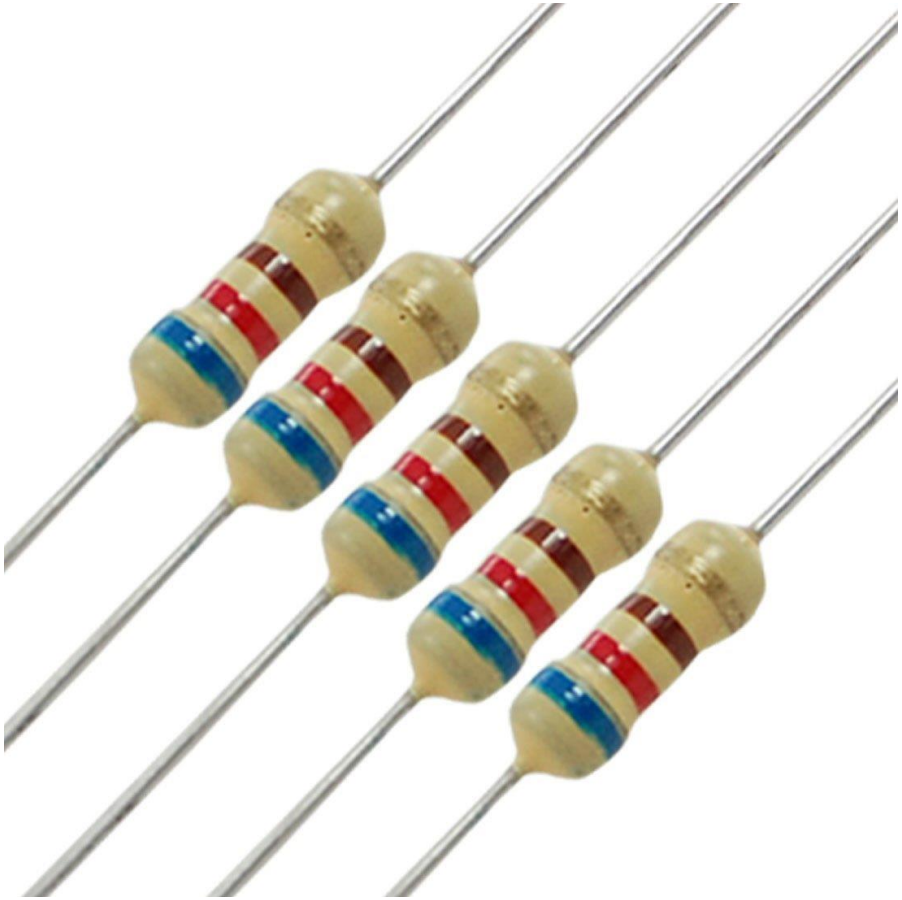
Examples



Examples

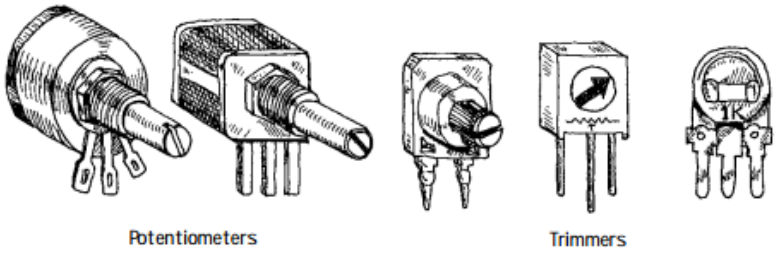


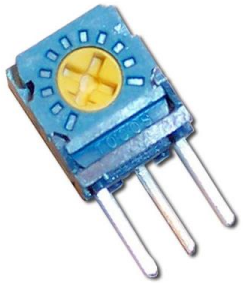
Examples



Variable Resistors

- Special kinds of variable resistors include
  - Potentiometers;
  - Rheostats; and
  - Trimmers.
- Potentiometers and rheostats are essentially the same thing, but rheostats are used specifically for high-power ac electricity, whereas potentiometers typically are used with lower-level dc electricity. Both potentiometers and rheostats are designed for frequent adjustment.
- Trimmers, on the other hand, are miniature potentiometers that are adjusted infrequently and usually come with pins that can be inserted into printed-circuit boards.





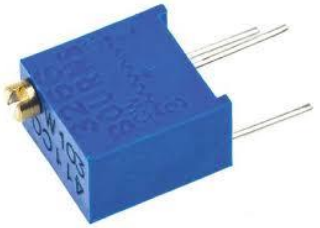
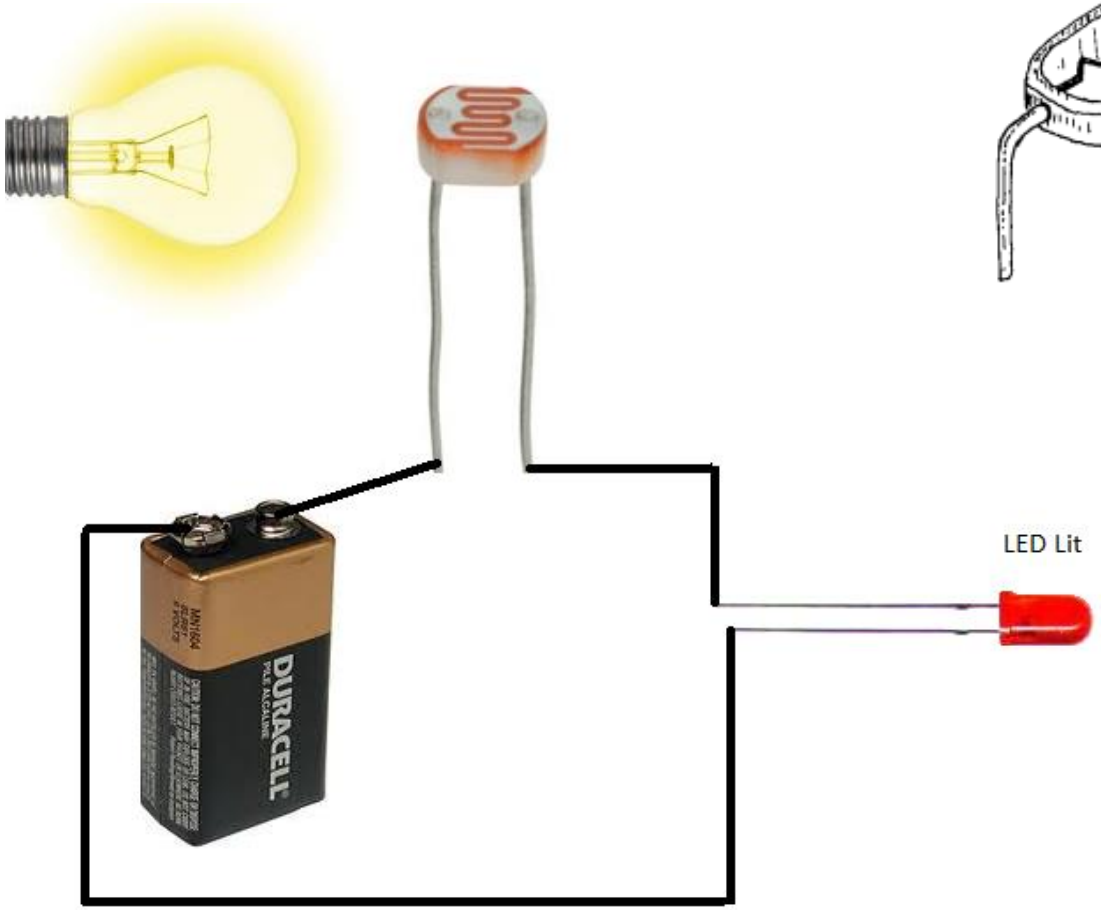
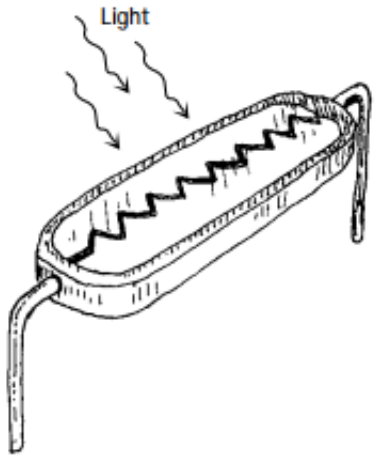


Photo-Resistors and Thermistors

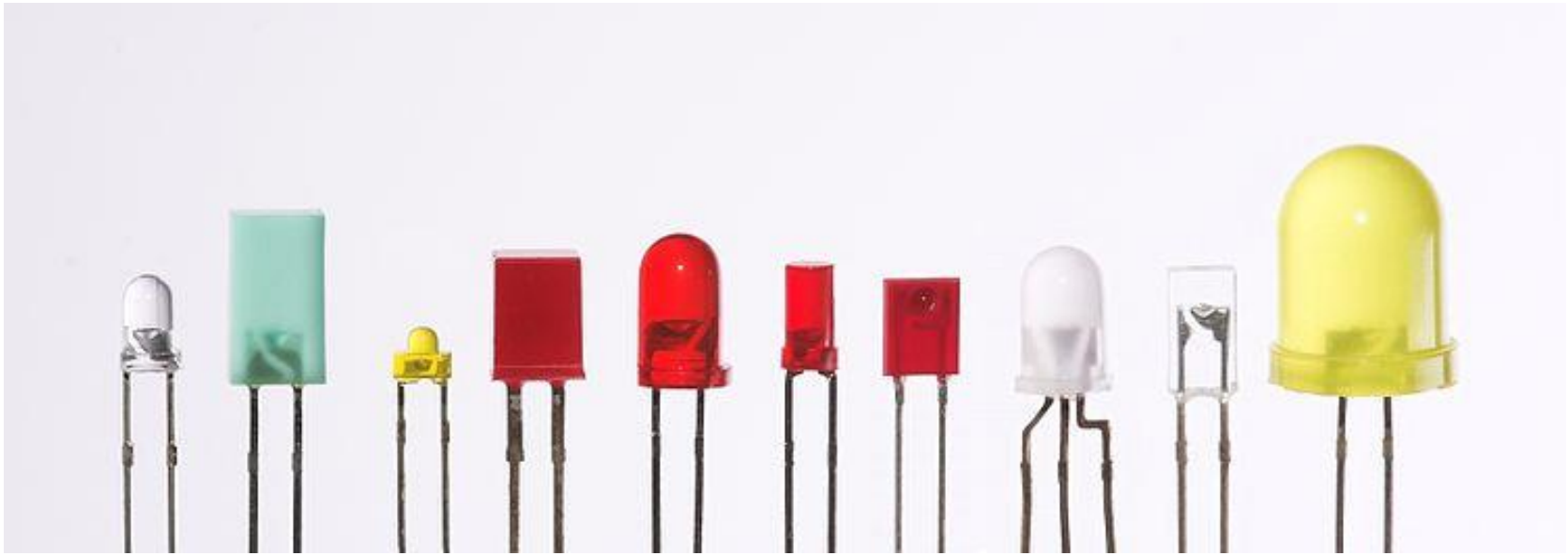


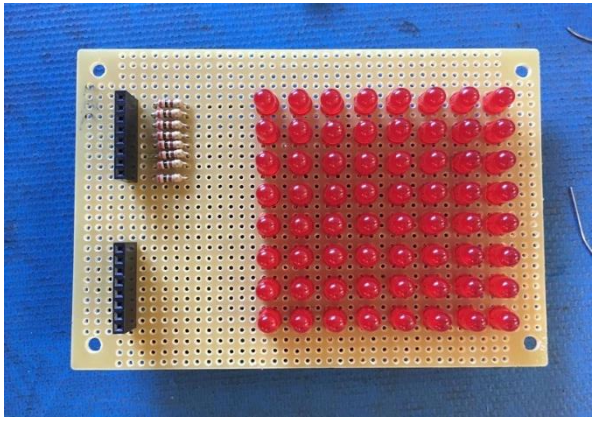


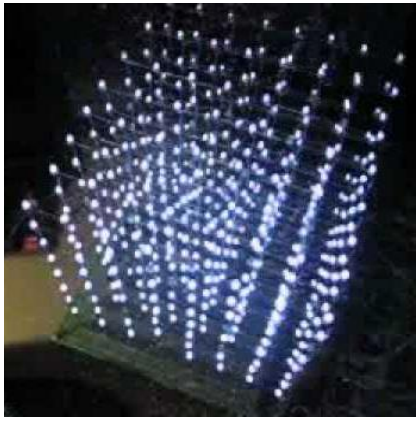
Photoresistor

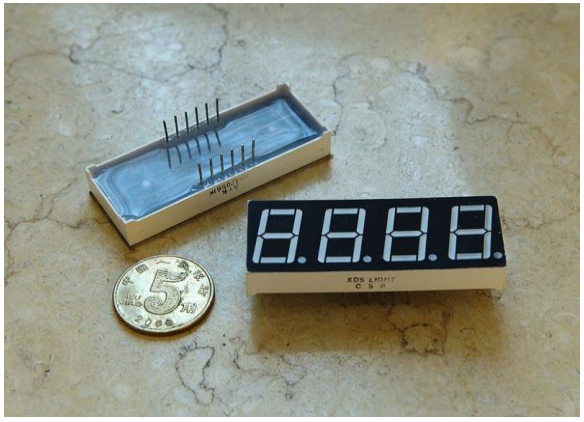
Thermistor

Light Emitted Diode (LED)

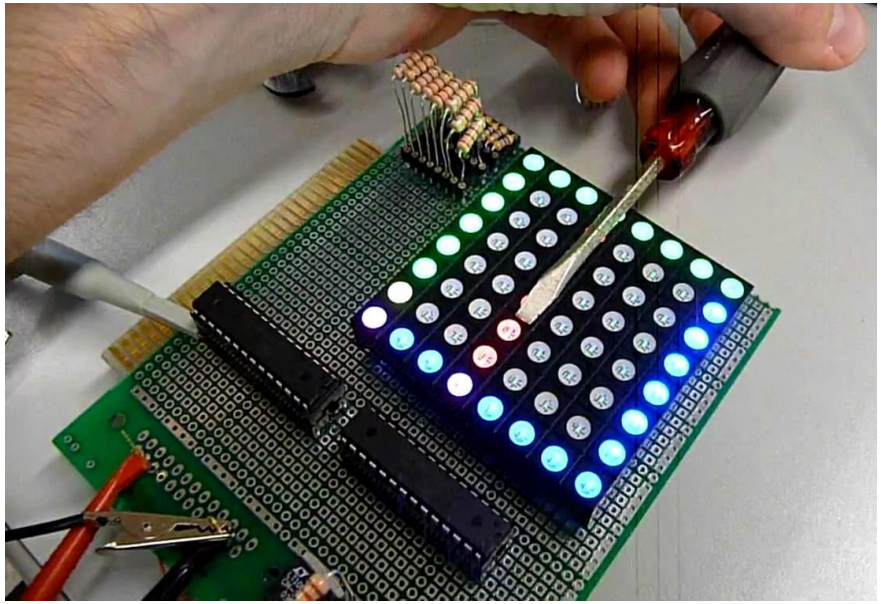


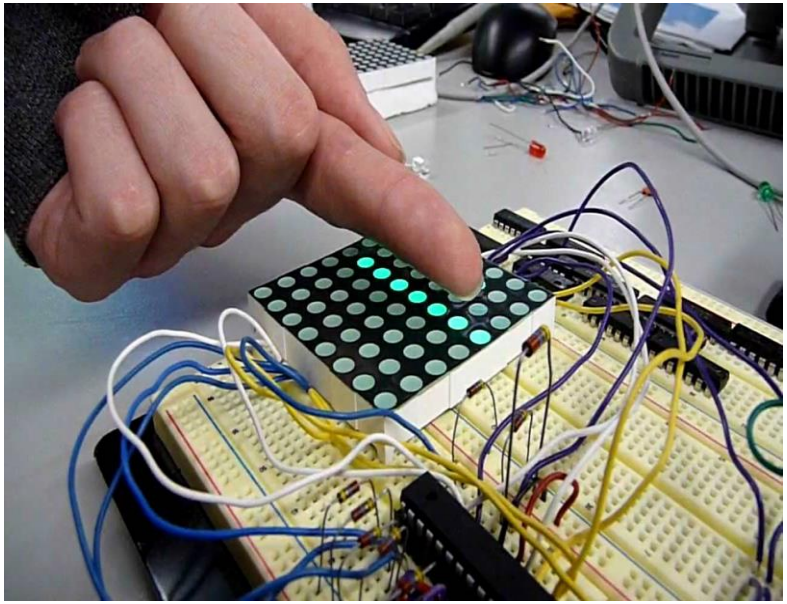




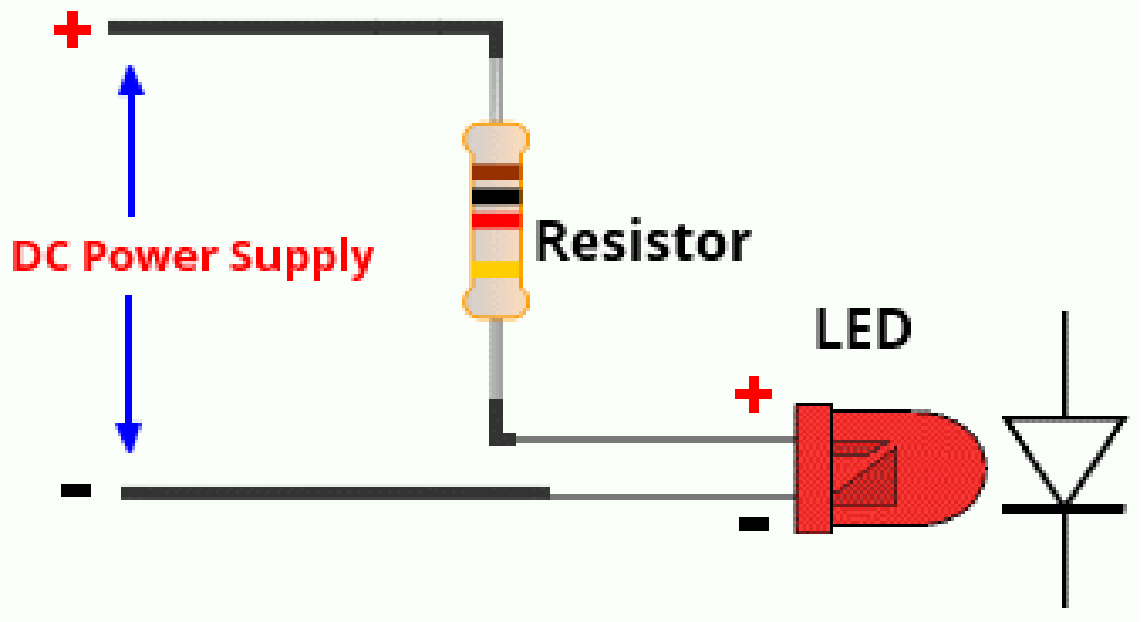


Optical Touch LED Matrix



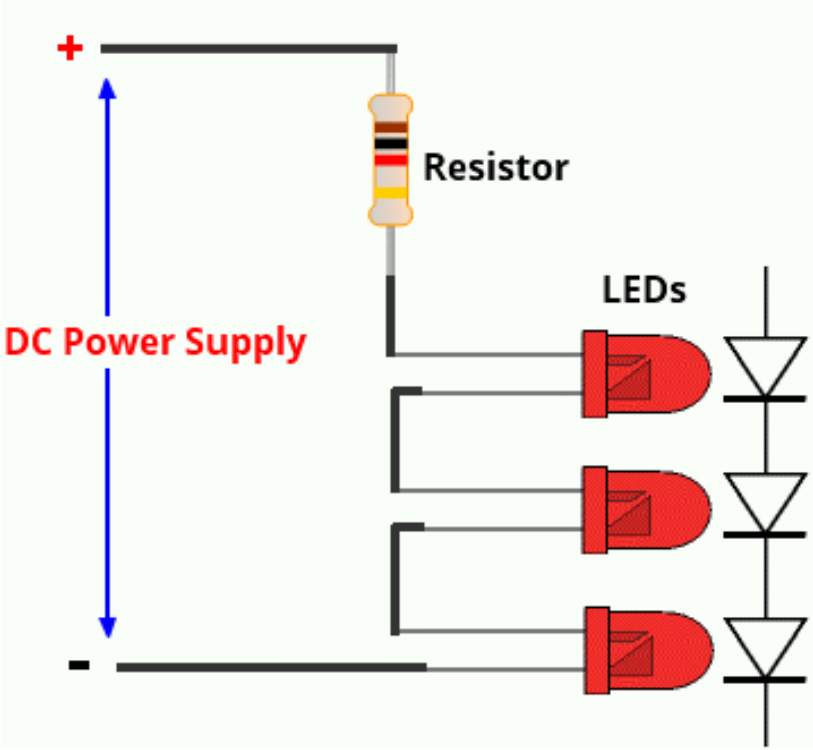


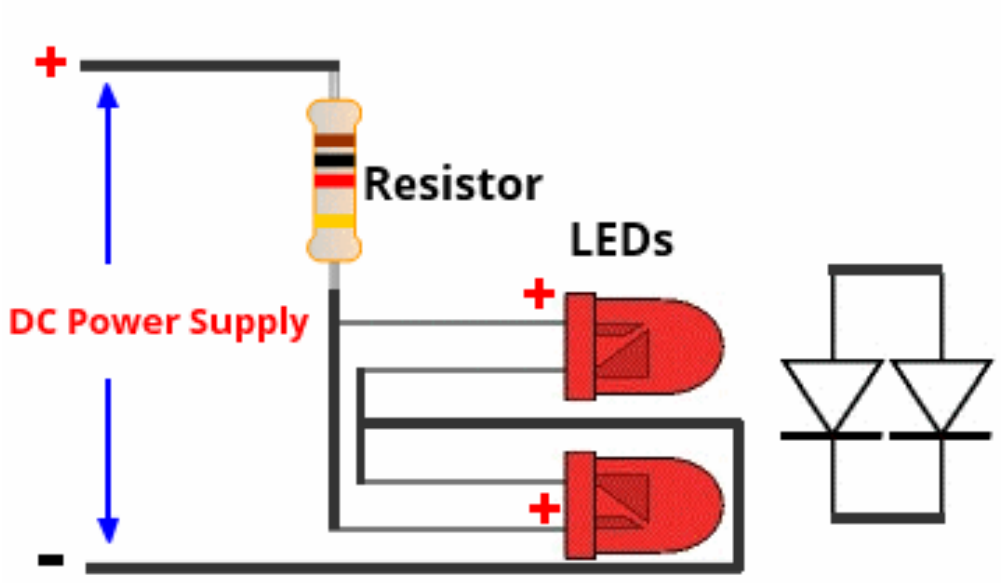
LED and Resistor Calculation



$$R = \frac{(V_s - V_{LED})}{I_{LED}}$$

LED and Resistor Calculation

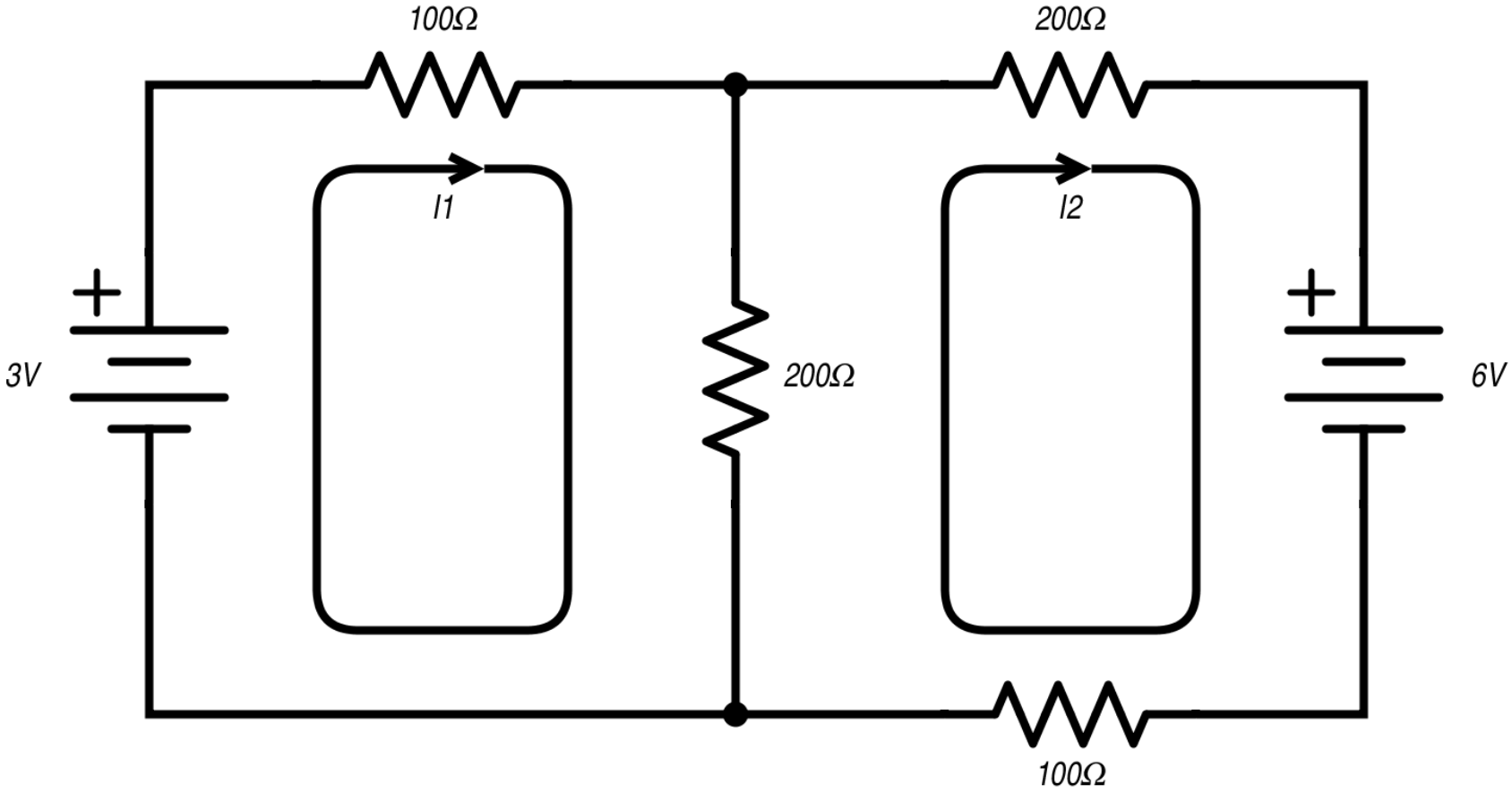




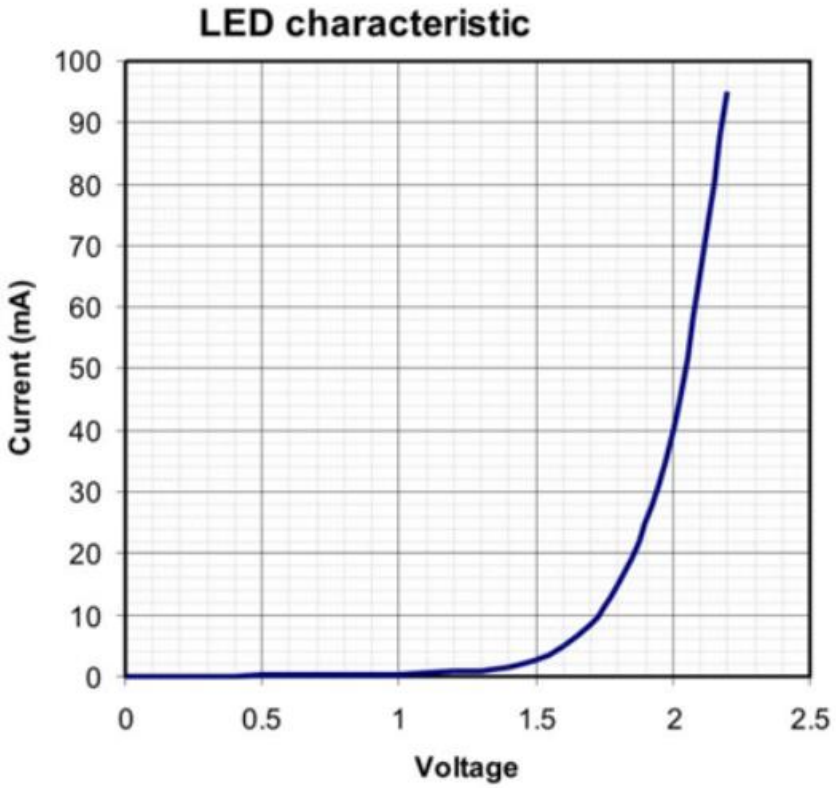
LED Applications

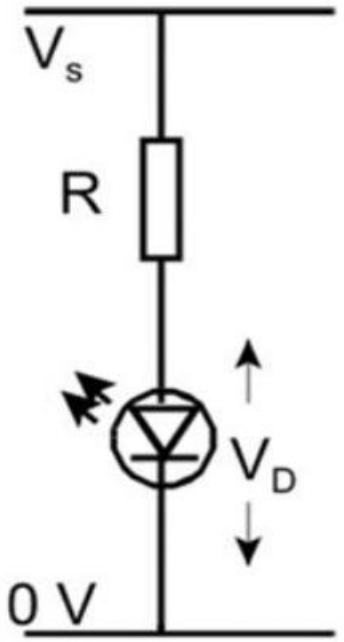
Exercise 1

- Analyze the circuit



Exercise 2

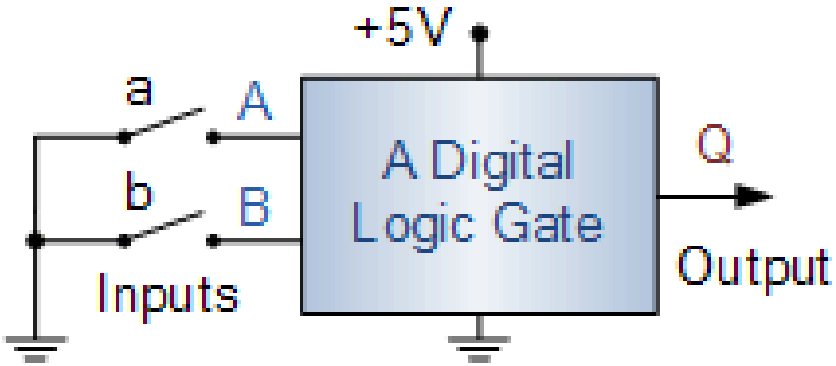

LED characteristic
Current (mA)
100
90
80
70
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
Voltage

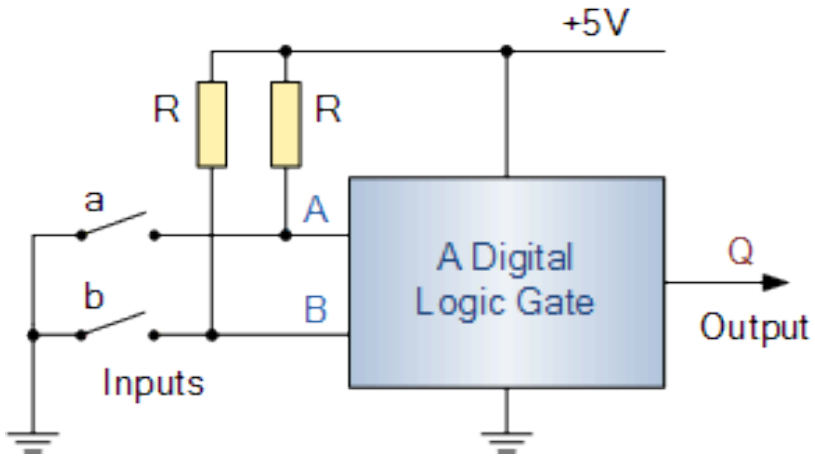

Vs
R
VD
0 V

- An LED which has the characteristics shown in this graph is to be used in the circuit below in which both VS and R can be varied. For this LED the switch on voltage (VD) is 1.7 volt which produces a current of 10 mA at which point the LED will just glow dimly. Let us say that the LED operates brightly at 40 mA, but will fail if the current exceeds 90 mA for too long.
- Initially the power supply is set at Vs = 6V. What value is required for the resistor so that the LED operates at 40 mA?
- If a current of 20 mA is flowing and the resistor is 200 Ohm, what is the supply voltage?
- Find the minimum value of the resistor that could be used without damaging the LED

Pull Up and Pull Down Resistor

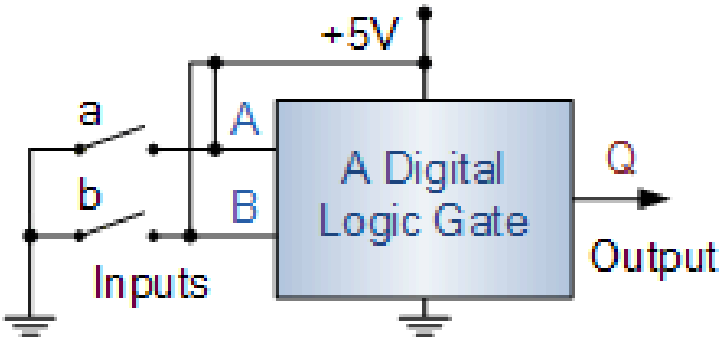
- Pull-up and Pull-down resistors are used to correctly bias the inputs of digital gates to **prevent them from floating** about randomly when there is no input condition



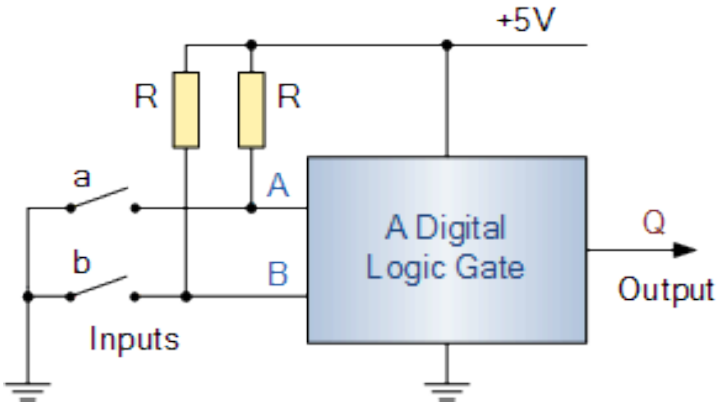


Pull-up Resistors

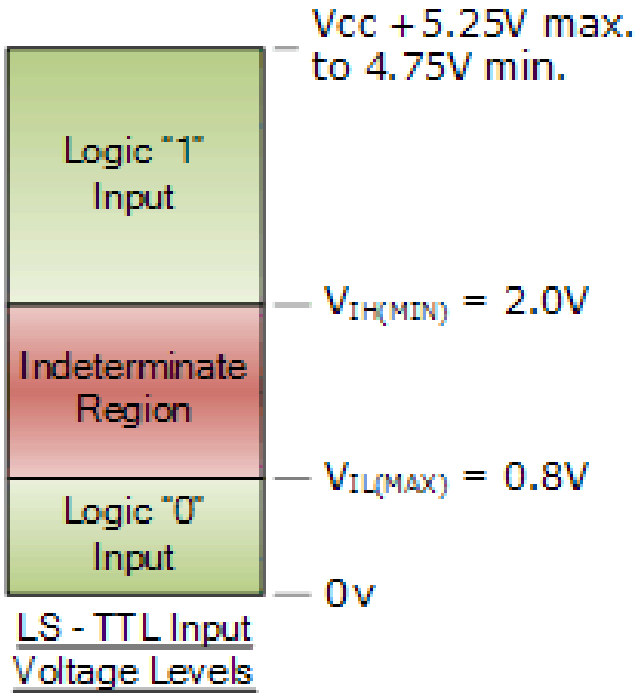
- Short circuit



- Good connection



Calculating Pull-Up Resistor Value



LS - TTL Input Voltage Levels

- TTL 74LSxxx series:
  - Input high: $V_{IH(min)} = 2.0V$, $I_{IH} = 20\mu A$
  - Input low: $V_{IL(max)} = 0.8V$, $I_{IL} = 0.4mA$

Single Gate Pull-up Resistor Value

$$R_{MAX} = \frac{V_{CC} - V_{IH(MIN)}}{I_{IH}} = \frac{5-2}{20\times10^{-6}} = 150K\Omega$$

Multiple Gate Pull-up Resistor Value (10 inputs)

$$R_{MAX} = \frac{V_{CC} - V_{IH(MIN)}}{10\times I_{IH}} = \frac{5-2}{10\times20\times10^{-6}} = 15K\Omega$$

Calculating Pull-Up Resistor Value

- A *Pull-down resistor* works in the same way as the previous pull-up resistor, except this time the logic gates input is tied to ground, logic level "0" (LOW)

$$R_{MAX} = \frac{V_{IL(MAX)} - 0}{I_{IL}} = \frac{0.8 - 0}{400 \times 10^{-6}} = 2K\Omega$$

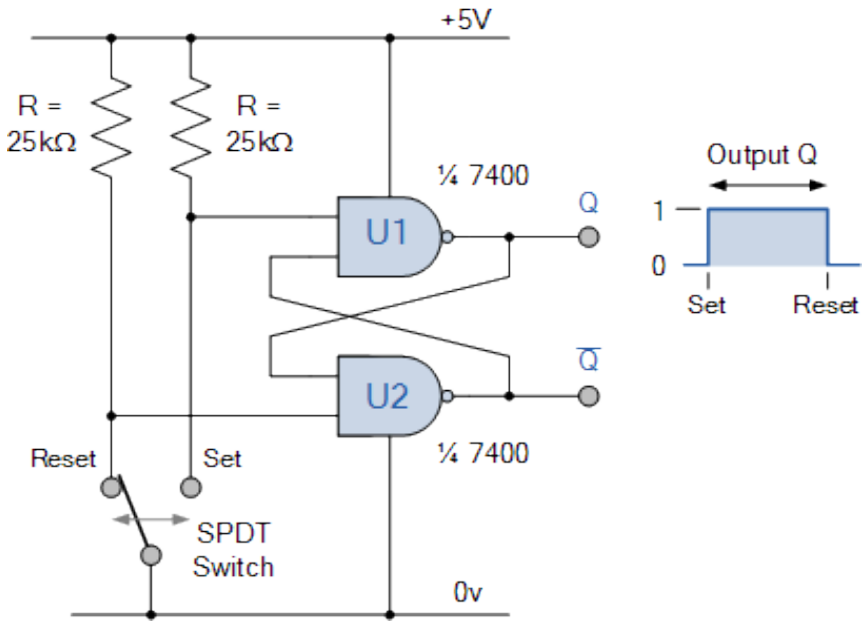
Example

- TTL 74LS00 NAND Gates along with a single-pole double-throw switch are to be used to make a simple set-reset bistable circuit signal. Calculate: 1). The maximum pull-up resistor values if the voltage representing a logic HIGH input is to be held at 4.5 volts when the switch is open, and 2). The current flowing through the resistor when the switch is closed (assume zero contact resistance). Also draw the circuit.

- Data given: Vcc = 5V, V_{IH} = 4.5V, and $I_{IH(max)}$ = 20μA

Answer

Set-Reset Bistable Circuit



$$R_{MAX} = \frac{V_{CC} - V_{IH}}{I_{IH}} = \frac{5 - 4.5}{20 \times 10^{-6}} = 25K\Omega$$

$$I_R = \frac{V_{CC}}{R} = \frac{5V}{25k\Omega} = 200\mu A \text{ or } 0.2mA$$

Programming Arduino

Syntax

```
pinMode(pin, mode)
```

Parameters

`pin`: the Arduino pin number to set the mode of.
`mode`: `INPUT`, `OUTPUT`, or `INPUT_PULLUP`. See the Digital Pins page for a more complete description of the functionality.

Returns

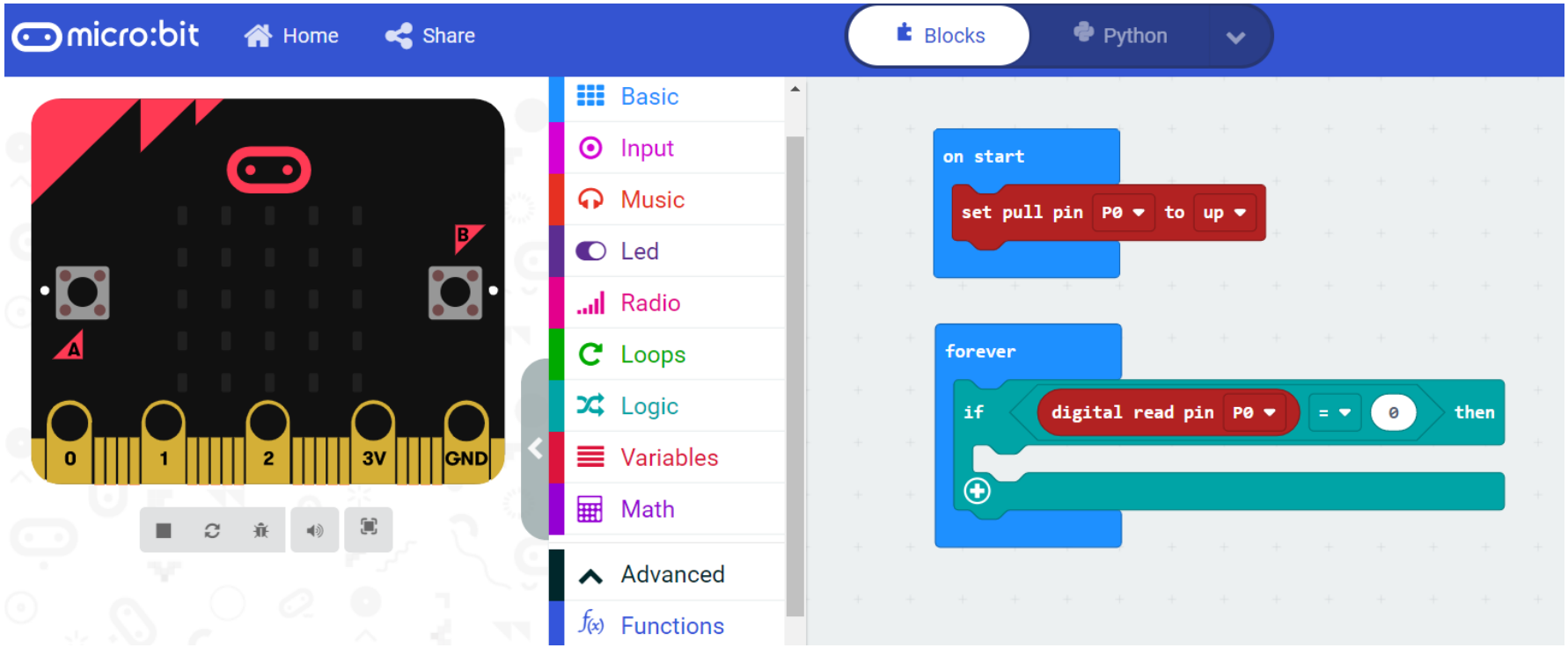
Nothing

Example Code

The code makes the digital pin 13 `OUTPUT` and Toggles it `HIGH` and `LOW`

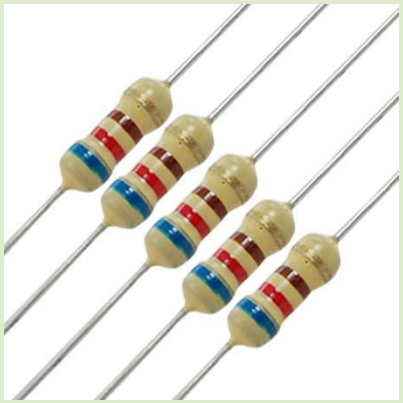
```
void setup() {
  pinMode(13, OUTPUT);    // sets the digital pin 13 as output
}
```

Programming on BBC Microbit



Lab Manual

- Take randomly 10 resistor pictures
- Determine the resistance based on its colors

No	Picture	Value
1		620Ohm

Circuit Simulation on TINA TI

- TINA-TI setup file: http://cse.hcmut.edu.vn/vtphuong/EDAC/Tina90-TIen.exe
- Quick manual
- https://www.youtube.com/watch?v=u7_RP1f82oo

Arduino Programming

- Student can simulate at https://www.tinkercad.com/