Electronics 101

iRoboticist.com

Electronics

Ohm's Law

$$\text{Current (I)} = \frac{\text{Voltage (V)}}{\text{Resistance (R)}}$$

"The current (I) passing through a conductor between two points is directly proportional to the potential difference (V) across the two points, and inversely proportional to the resistance (R) between them"

Power

Power(P) = Current(I) x Voltage(V)

$P = IV = I(IR) = I^2R$

$$= \frac{V}{R}V = \frac{V^2}{R}$$

Resistors

FIXED

VARIABLE

TYPES OF RESISTORS: FIXED VALUE

Carbon Film Resistors (CFR)

- Low Precision, high tolerance (>=5%)
- Cheap
- 4 band color coding

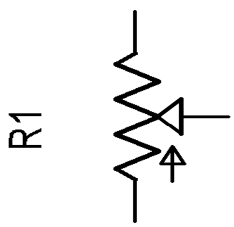
Metal Film Resistors (MFR)

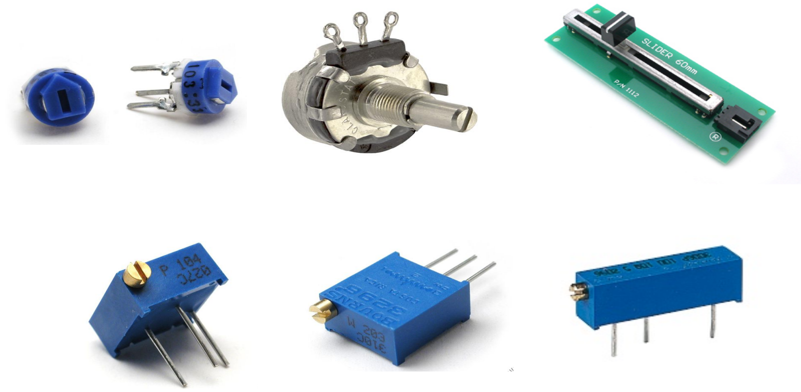
- High precision, low tolerance (<=1%)
- Slightly expensive
- 5 band color coding

Wire Wound Resistors

- Poor tolerance
- Expensive
- High Watt applications

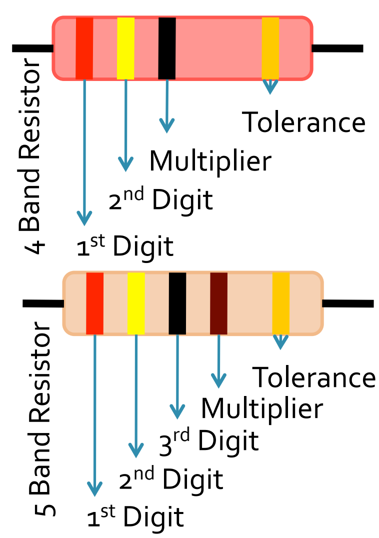
TYPES OF RESISTORS: VARIABLE





Color Coding

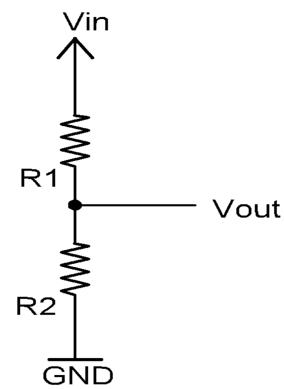
Band Color	Digit	Multiplier	Tolerance
Black	0	1	--
Brown	1	10	+-1%
Red	2	100	+-2%
Orange	3	1000	--
Yellow	4	10000	--
Green	5	100000	+-0.5%
Blue	6	1000000	+-0.25%
Violet	7	10000000	+-0.1%
Grey	8	100000000	+-0.05%
White	--	--	--
Gold	--	0.1	+-5%
Silver	--	0.01	+-10%
None	--	--	+-20%



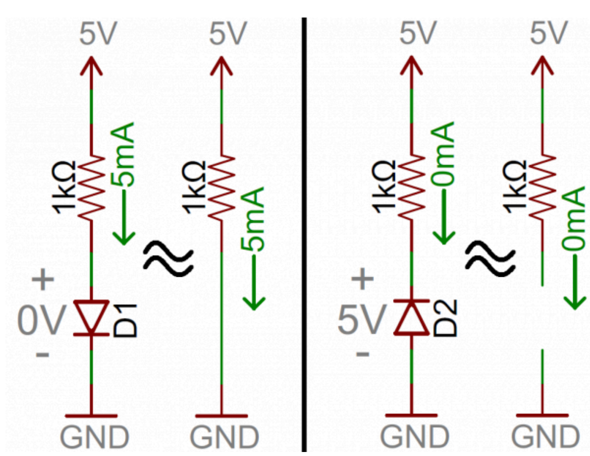
Voltage Divider

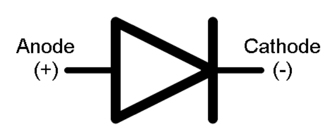
$$V_{out} = \frac{R2}{R1+R2} V_{in}$$

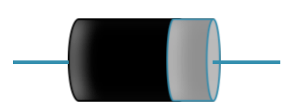
Example:
Vin = 5 Volts
R1 = 90K
R2 = 10K



Diode

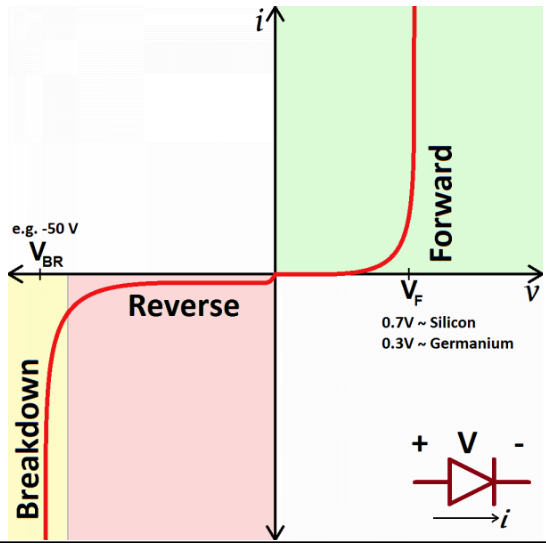
- 





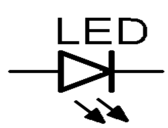
Diode Characteristics

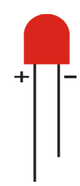
-

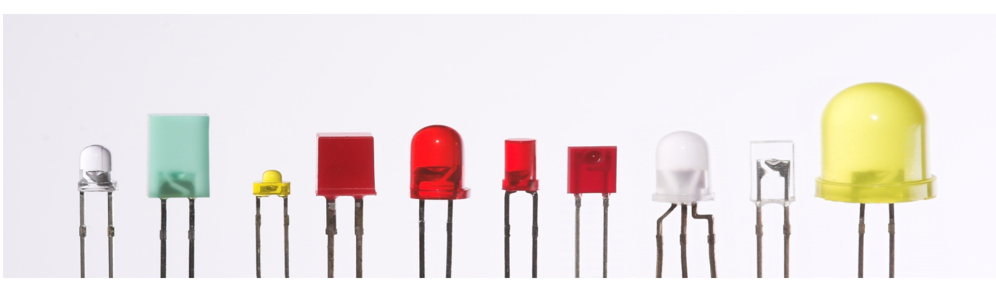


LEDs

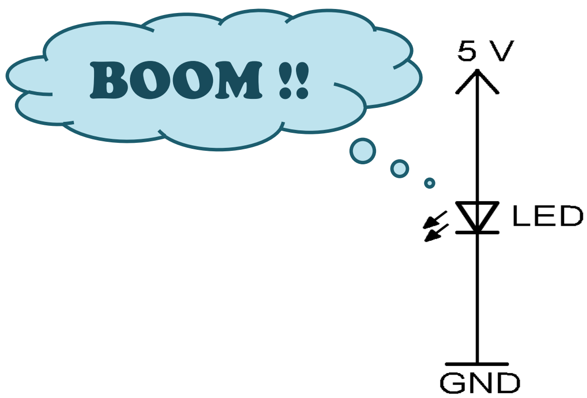
- Light Emitting Diodes
- Cheap, Efficient, Easy to use
- Many colors available





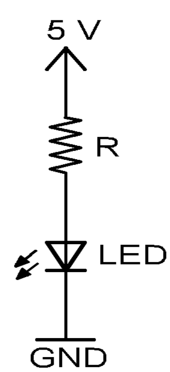


LED: Lighting it up



LEDS : NEED FOR CURRENT LIMITING

$$\text{Current Limiting Resistance (R)} = \frac{\text{Supply Voltage} - \text{Voltage drop across LED}}{\text{Desired Current}}$$



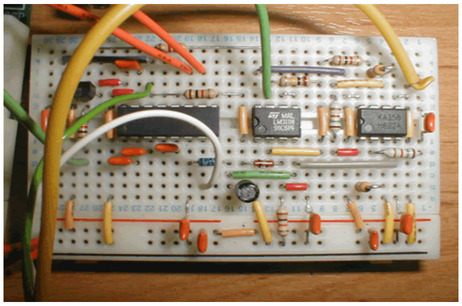
Example:

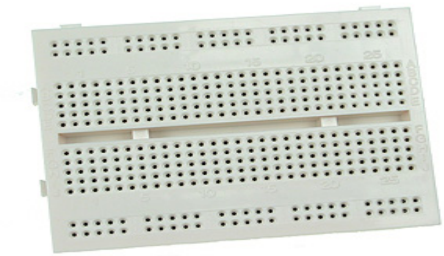
- LED = RED (Voltage drop = 2Volts)
- Supply Voltage = 5 Volts
- Current = 3mA
- Resistance (R) = ??

Approximate Voltage Drop			
RED	GREEN	YELLOW	BLUE
2 Volts	2 Volts	1.9 Volts	3.5 Volts

BREADBOARD (SKETCHBOOK)

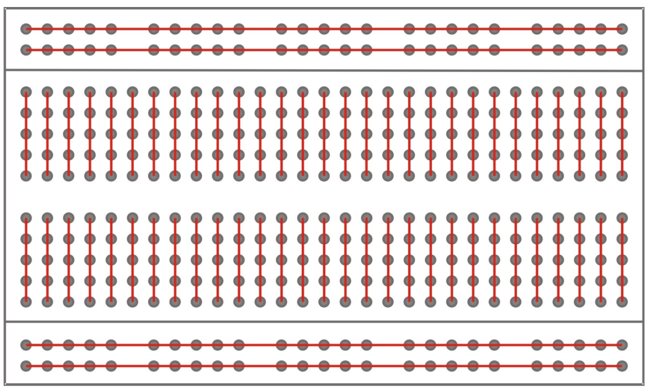
- Prototyping
- Testing





Breadbording

- Internal Electrical Connections of a Breadboard

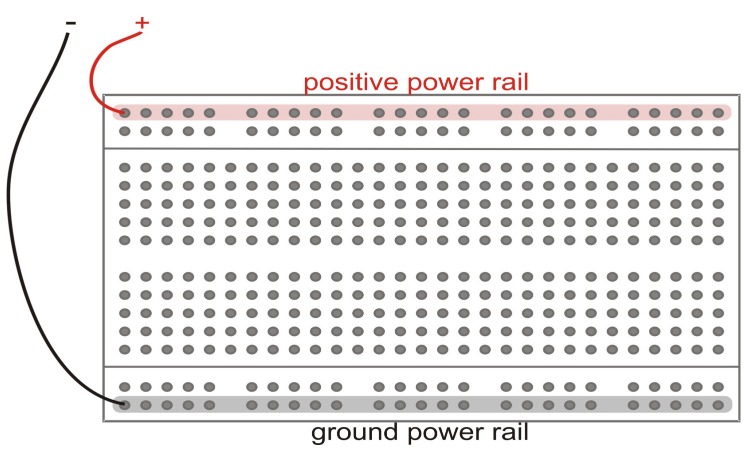


Getting the Wires ready

- 22-24 AWG (American Wire Gauge) wires (single strand)
- Use multicolor wires
- Cut-Strip into different lengths
- Use a Stripper and not your teeth!!

Making Connections

- Power lines: Case 1 (simple circuits)

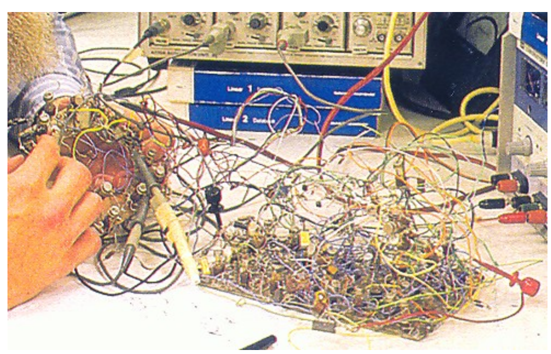


Making Connections

- Points to remember:
  - Segregate the circuit into functional blocks
  - Build one block at a time
  - Test – Debug
  - Build the next block

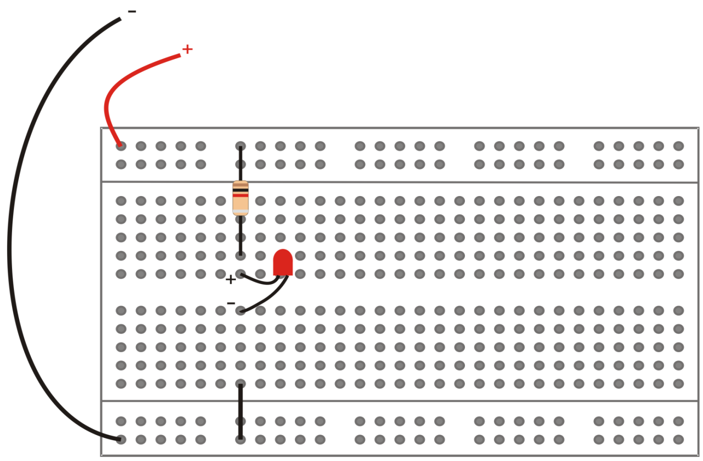
Debugging BB connections

- **8 Golden Steps to debugging**
  1. Check the power supply
  2. Check the connections
  3. Check the connections
  4. Re-check the connections
  5. Check polarities
  6. Check component values
  7. Take a break
  8. Worst case : Rebuild the circuit



Lighting up LEDs

- Experiment 1

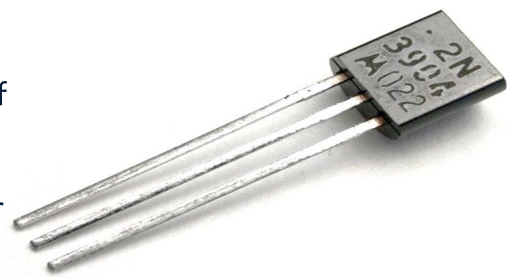


Transistors

iRoboticist.com

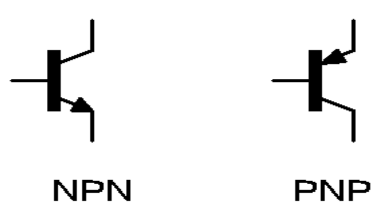
TRANSISTORS

- Transconductance + Varistor
- Fundamental building block of modern day electronics
- Used mostly as an amplifier or switch
- Classified into two categories:
  - BJTs
  - FETs



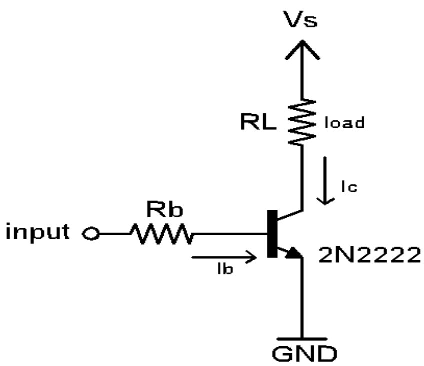
Transistors: BJTs

- Bipolar Junction Transistors (BJTs) available in two flavors

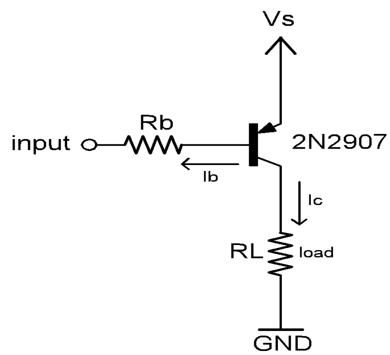


Transistor Biasing

- NPN transistor as a Switch



- PNP transistor as a Switch

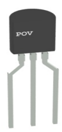
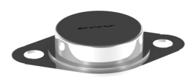


Transistors

- How do we select the right transistor?
  - Define and Calculate requirements
    - Voltage
    - Current
    - Gain
  - Refer datasheets
  - Check availability
  - Test
  - Use

Transistors

- Commonly available packages

TO-18	TO-92	TO-220	TO-3
			
Plastic package used for low power transistors	Metal package used for low power transistors with better thermal dissipation	Plastic package with heat-sink used mostly for high power transistors	Metal package used for high power transistors

Transistors

- Commonly available transistors

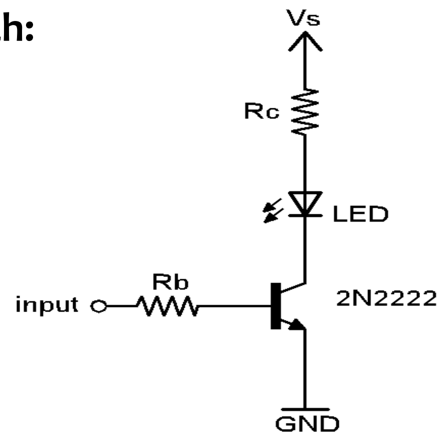
Transistors		Max Voltage (Vce)	Peak Collector Current (Ic)	DC current gain h_{FE}(min)	Transition Frequency (Ft)
NPN	PNP				
2N2222	2N2907	30	800mA	100	300 MHz
2N3904	2N3906	40	200mA	100	300 MHz
BC546 BC547 BC548	BC556 BC557 BC558	65 45 30	100mA	300	100 MHz
TIP140	TIP145	60	10A	1000	

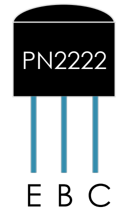
Experiments

Transistor as a switch:

Driving a LED

Rb = 1K
Rc = 500 to 1K

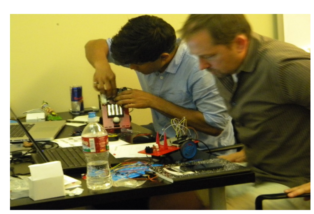




Calculations:
Ib= (Vin – 0.7)/Rb
Ic (max)= Ib x Hfe

How to get started

- Don't be intimidated!
- Jump in
  - "The best way to learn how to swim, is to jump right in"
- Start building! You will learn on-the-go
- Break down learning into several small steps.



Binary Number System

- From left to right, the position of the digit indicates its magnitude (in decreasing order)
  - E.g. in decimal, 123 is less than 321
  - In binary, 011 is less than 100
- A subscript indicates the number’s base
  - E.g. is 100 decimal or binary? We don’t know!
  - But $14_{10} = 1110_2$ is clear

Bytes

- A group of 8 bits is a byte
- A byte can represent $2^8 = 256$ possible states
- Registers are usually a multiple of bytes
- SPARC registers have 32 bits (4 bytes)
- $2^{32} = 4{,}294{,}967{,}296$

Memory Addresses

- Memory addresses are in binary
  - often 32 bits, these days
  - if each memory address maps to 1 byte:
    - 2^{32} bytes = 4 GB
- K = kilo = thousand,
- but 1KB actually means 1024 bytes
- 1MB = 1024 x 1024 bytes
- 1GB = 1024 x 1024 x 1024 bytes

Octal and Hexadecimal

- It is difficult for a human to work with long strings of 0's and 1's
- Octal and Hexadecimal are ways to group bits together
- Octal: base 8
- Hexadecimal: base 16

Hexadecimal

- With 4 bits, there are 16 possibilities
- Use 0, 1, 2, 3, …9 for the first 10 symbols
- Use a, b, c, d, e, and f for the last 6

Bit_3	Bit_2	Bit_1	Bit_0	Symbol
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9
1	0	1	0	a
1	0	1	1	b
1	1	0	0	c
1	1	0	1	d

Binary to Hexadecimal

- 0101011010110011_2 = ? in hex
- Group into 4 bits, from the right:
- 0101, 0110, 1011, 0011_2
- Now translate each (see previous table):

  0101_2 => 5, 0110_2 => 6, 1011_2 => b, 0011_2 => 3

  So this is $56b3_{16}$
- What if there are not enough bits?
  - Pad with 0’s on the **left**

Hexadecimal to Binary

- $f0e5_{16}$ = ? in binary
- Translate each into a group of 4 bits:

f_{16} => 1111_2, 0_{16} => 0000_2, e_{16} => 1110_2, 5_{16} => 0101_2

So this is 1111000011100101_2