



**LaACES
Student
Ballooning
Course**

Schematics and Prototyping Lecture



Schematic Diagrams

Schematic diagrams represent an electronic circuit in symbolic form.

A schematic need not depict the actual physical arrangement of the components



Schematic Symbols

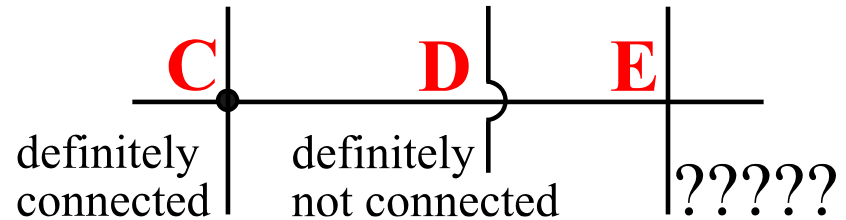
Wires and wire connections

single wire

connected wires



intersecting wires



Current practice:

Either **A** or **B** is acceptable

D is seldom used

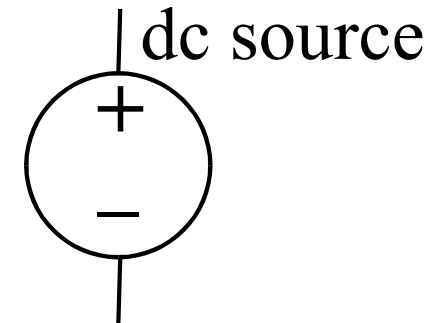
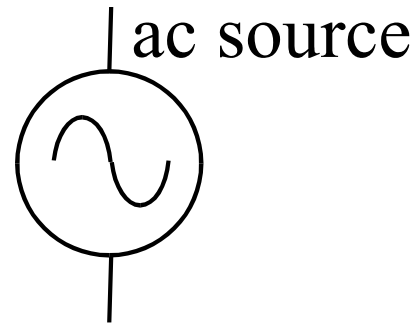
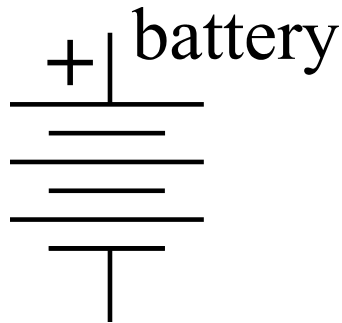
C is the preferred style

E is interpreted as a non-connection



Schematic Symbols Cont.

Power sources (V) common connections (GND)

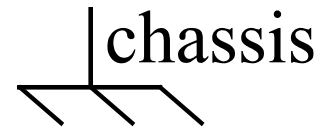
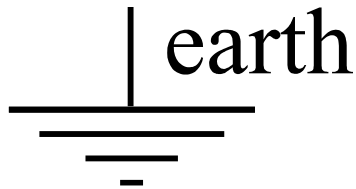


- The “+” sign may not always appear on a battery symbol. By convention, the longer horizontal line represents the positive terminal
- Note that no polarity is shown for the ac source



Schematic Symbols Cont.

Common connections (GND)



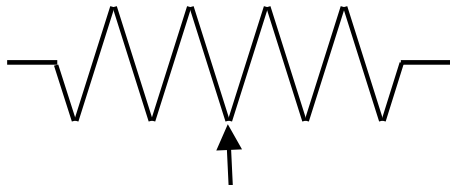
- “Earth” means an actual connection to a conductor driven into the soil.
- “Chassis” means a bonded electrical connection to the metallic case of chassis of a device.



Schematic Symbols Cont.

Resistors (R) and Capacitors (C)

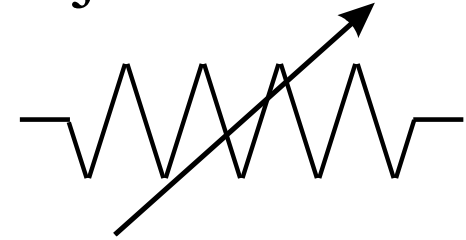
tapped resistor
or
potentiometer



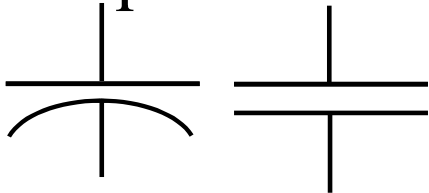
resistor



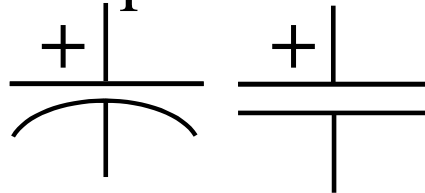
adjustable resistor



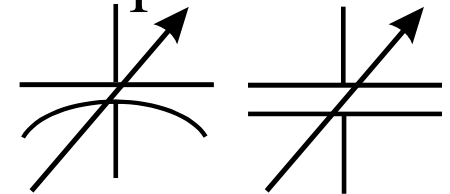
unpolarized
capacitors



polarized
capacitors



adjustable
capacitors





Schematic Symbols

Inductors (L) and Transformers (T)

simple
inductors



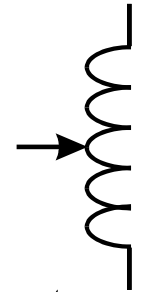
adjustable



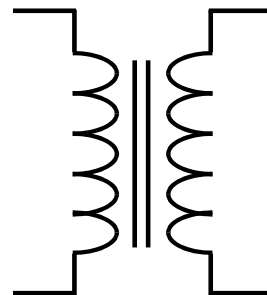
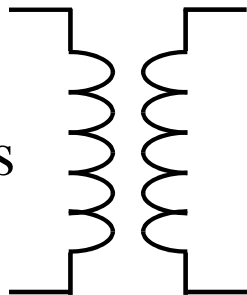
adjustable



tapped



transformers

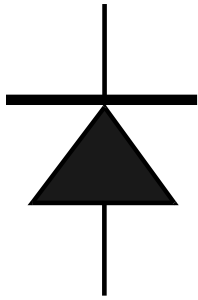


The two parallel lines indicate that the inductor is wound on a core of iron, iron powder, or ferrite material.

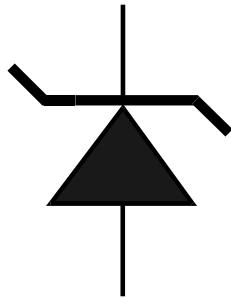


Schematic Symbols

diode



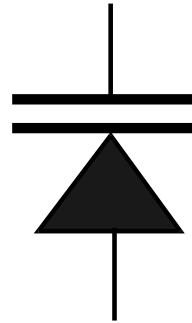
zener diode



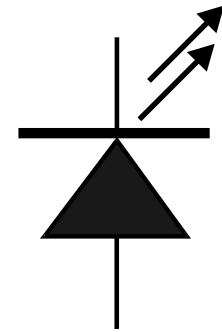
Diodes (D)

variable capacitance

diode



light emitting diode
(LED)



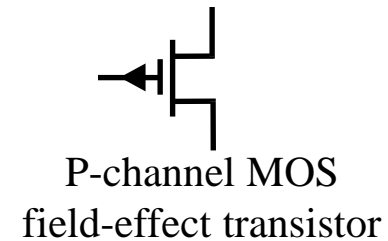
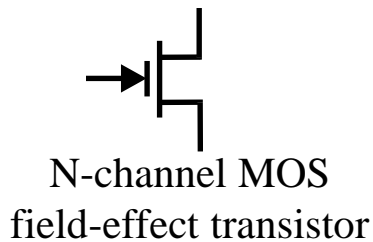
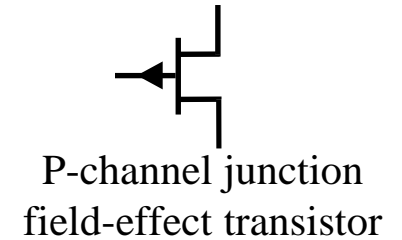
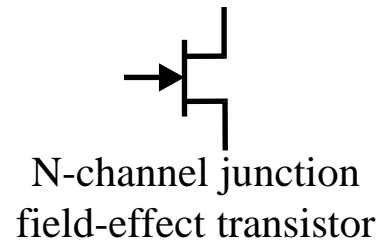
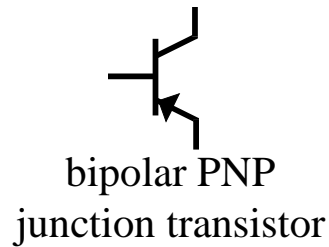
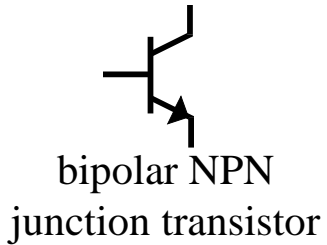
The arrow points in the allowed direction of conventional (positive charges) current flow.

The bar represents the cathode, marked with a band on most parts.



Schematic Symbols

Transistors (Q)

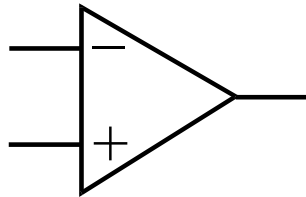




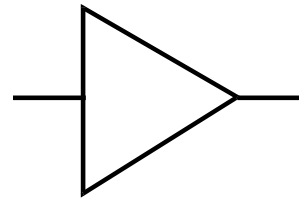
Schematic Symbols

Logic Gates

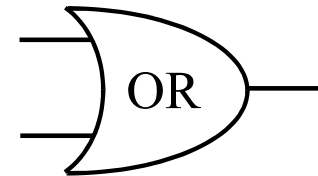
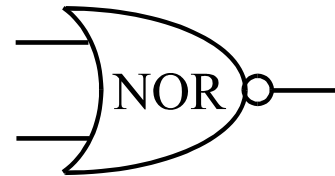
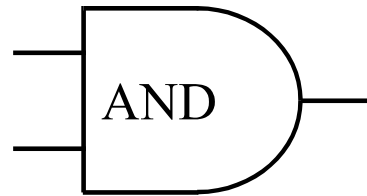
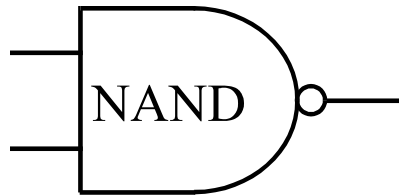
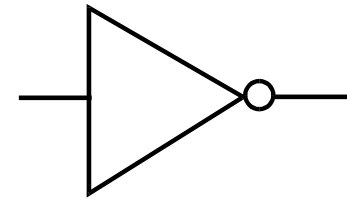
operational amplifier



buffer



inverting buffer



Most complex integrated circuits are represented on schematic diagrams as a rectangular block symbol, with pin numbers and, usually, pin functions indicated; but many logic integrated circuits have special symbols that identify their function.



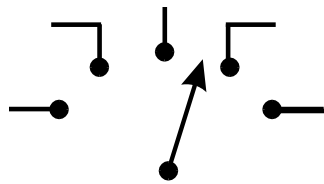
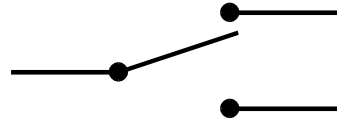
Schematic Symbols

Switches (S) and Relays (K)

single pole single throw
SPST

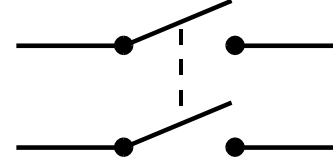


single pole double throw
SPDT

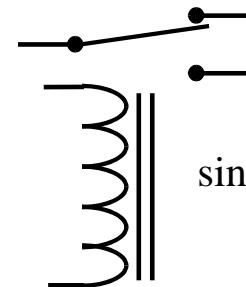
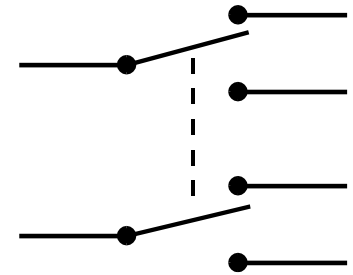


rotary switch
1 pole, 5 position

double pole single throw
DPST



double pole double throw
DPDT



single pole double throw
relay



Drawing Schematic Diagrams

You can use one of the many *schematic capture* programs available on the internet for free. The *SkeeterSat* schematic shown earlier was prepared with ExpressPCB.

Schematic Capture Programs

- **ExpressPCB** <http://www.expresspcb.com/>
- **Eagle** <http://www.cadsoftusa.com/freeware.htm>

Schematic capture is a step in the design cycle where the electronic diagram of the electronic circuit is created by a designer.



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Building a prototype

- Solderless breadboards
- Perfboards or Protoboards
- *Manhattan* Construction
- *Dead Bug* Construction
- Etched Circuit Boards

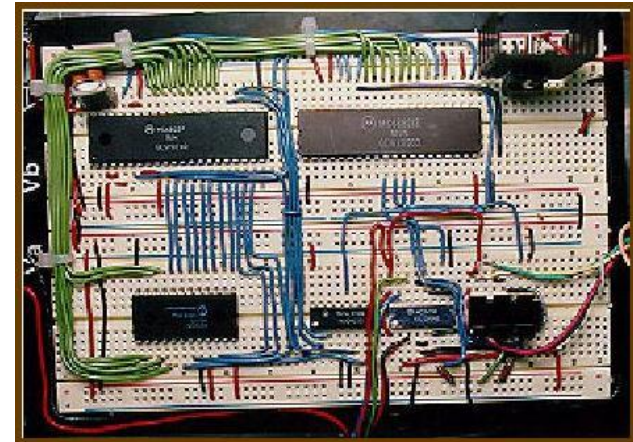


Solderless Breadboards

The term *breadboard* originated in the early days of radio, when many experimenters actually built circuits on the wooden boards used in the kitchen for rolling out bread dough.

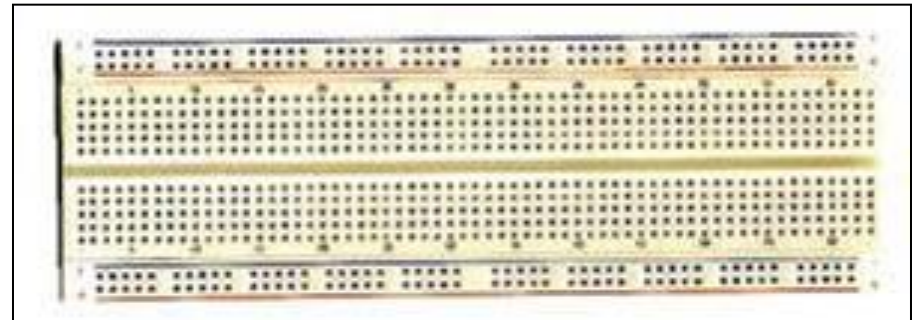


A ham radio transmitter circa 1930



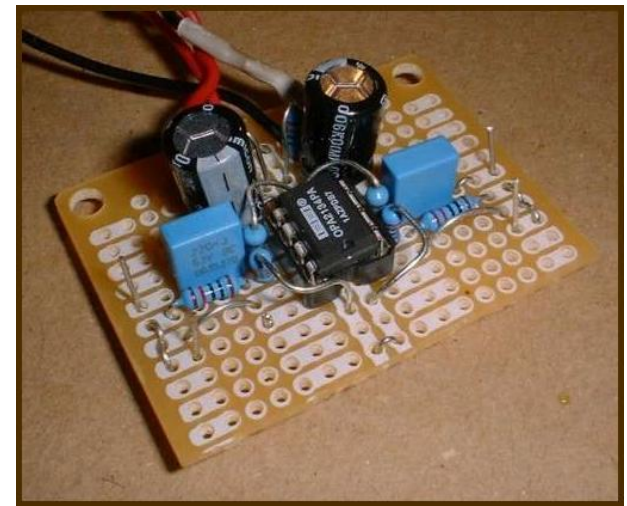
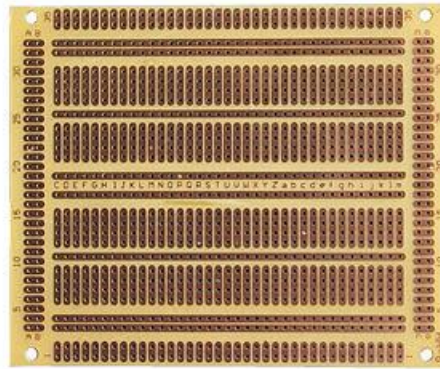
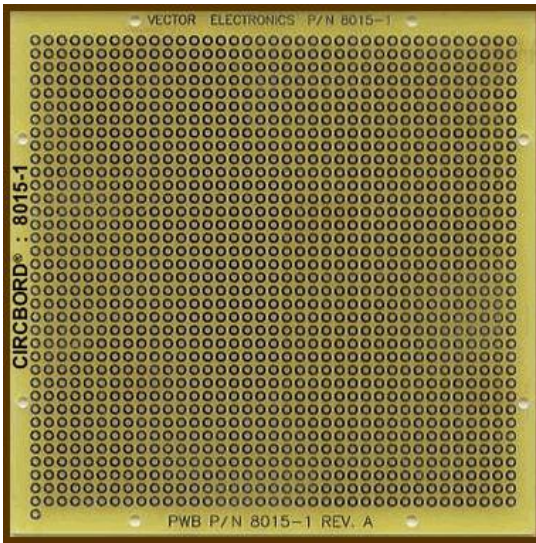
Modern solderless breadboards

Best thing to come along since sliced bread!





Perfbord or Protoboard

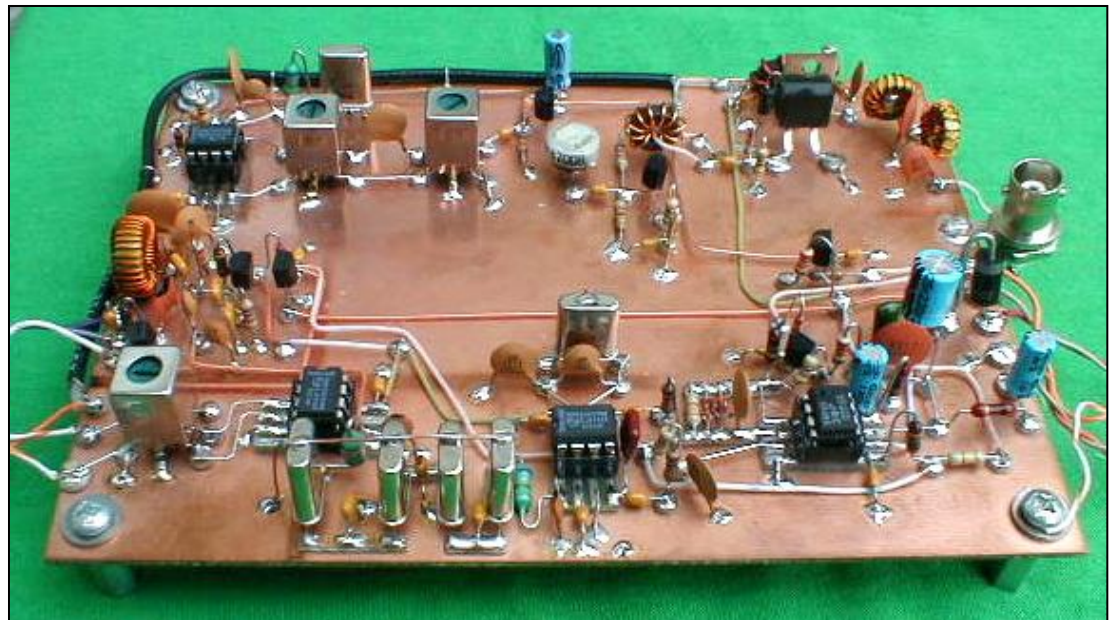


Components are soldered to the board, with connections made using a combination of short pieces of wire and the copper traces already present on some versions of these boards.



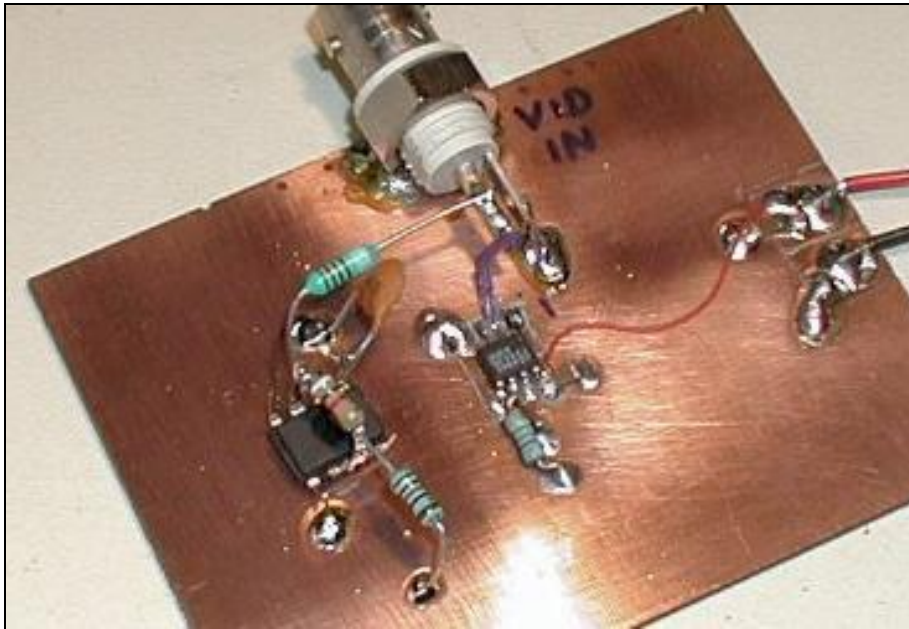
Manhattan Construction

Manhattan Style
uses little “islands”
of PCB material
glues to a substrate
ties points for
components.



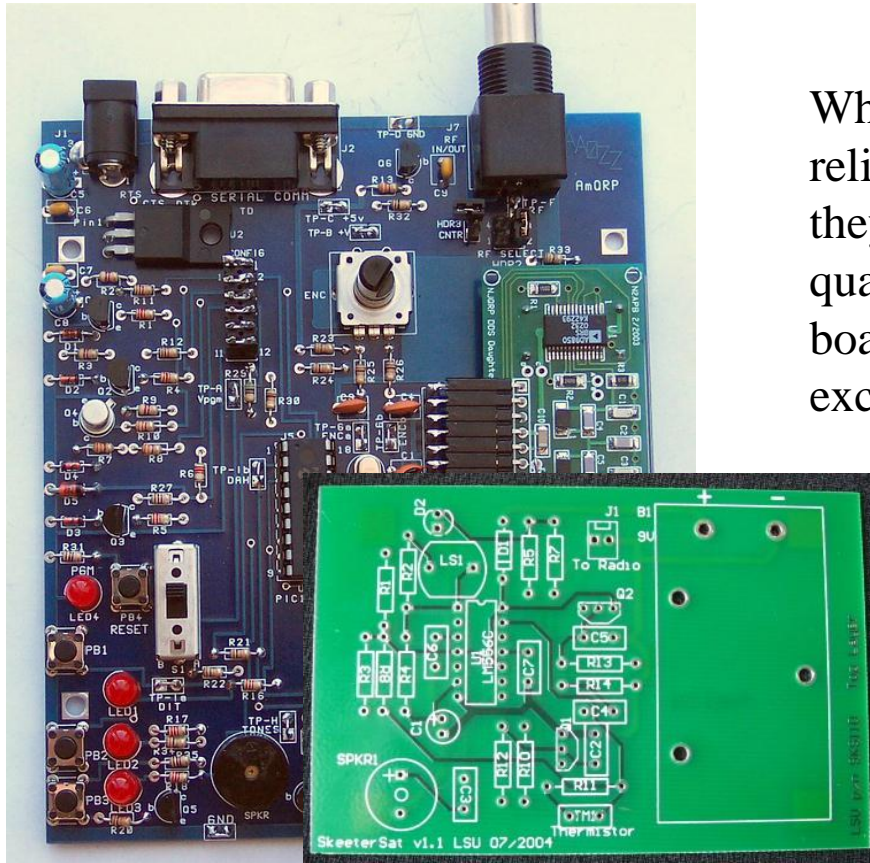


Dead Bug Construction



“*Dead bug*” style is a type of board design with the integrated circuits (IC’s) flipped upside-down with their pins sticking up into the air like a dead insect. While it is messy-looking, it can be used to make more compact circuits than other methods.

Etched Circuit Boards



While etched boards are the most reliable method of circuit construction, they can be expensive in small quantities (\$300+ per board). Cost per board drops rapidly when quantities exceed 25 or so.



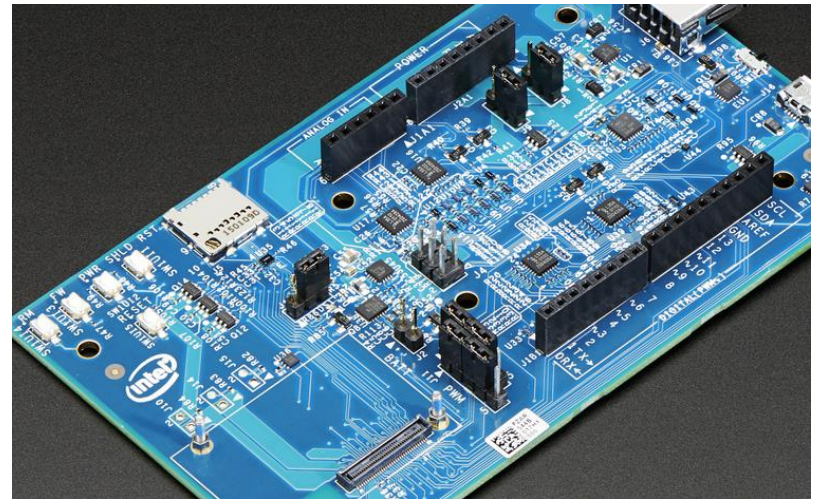
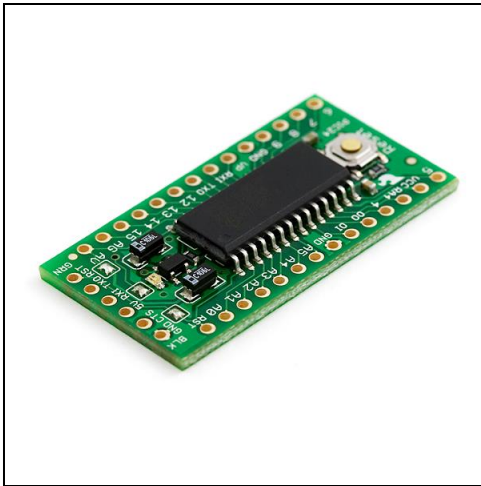
Prototyping with Surface Mounted Device (SMD) components

- Difficult to prototype SMD components without a PCB board
- Can solder wires directly to the leads
 - However, this requires a fair amount of precision and handling to accomplish. May unintentionally damage component if mishandled
 - Some devices are sensitive to electrostatic discharge (ESD) and can be destroyed by touching them.



Breakout Boards

- Common method for testing specific chips is to make or buy a board that draws out all the desired leads to terminals that are easier to interface with.





Two-terminal SMD

- Resistors and Capacitors
 - Case Code usually reported in **XXYY** format where **XX** is the length and **YY** in the width in mm or inches
 - **VERY** important not to mix up imperial and metric values! Ex. 0603 can be 0.6mm x 0.3 mm OR 0.06 x 0.03 in
- Other two terminal devices such as LEDs have their own package sizes and dimensions
- Dimensions are always listed on the **DATASHEET**





Multi-terminal SMD

- Wide variety of packages and footprints available
- Many manufacturers will adhere to standard package sizes common throughout the industry
 - This is not true for all components
- Types of SMD footprints
 - Small outline transistors (SOT), Small outline integrated circuit (SOIC), Dual Flat No-Lead (DFN), Ball Grid Array (BGA)