Schematics, Prototyping and Soldering Lecture
Schematic Diagrams

Schematic diagrams represent an electronic circuit in symbolic form.

A schematic need not depict the actual physical arrangement of the components.
SkeeterSat Schematic
Schematic Symbols Cont.

Wires and wire connections

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.
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
  ![Tapped Resistor](image)
- unpolarized capacitors
  ![Unpolarized Capacitors](image)
- polarized capacitors
  ![Polarized Capacitors](image)
- adjustable resistor
  ![Adjustable Resistor](image)
- adjustable capacitors
  ![Adjustable Capacitors](image)
Schematic Symbols

Inductors (L) and Transformers (T)

- Simple inductors
- Adjustable
- Tapped

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

Diodes (D)

- diode
- zener diode
- 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)

- Bipolar NPN junction transistor
- Bipolar PNP junction transistor
- N-channel junction field-effect transistor
- P-channel junction field-effect transistor
- N-channel MOS field-effect transistor
- P-channel MOS field-effect transistor
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)
- Double pole single throw (DPST)
- Double pole double throw (DPDT)
- Rotary switch, 1 pole, 5 position
- 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/](http://www.expresspcb.com/)
- **Eagle**  [http://www.cadsoftusa.com/freeware.htm](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.
Building a prototype

- Solderless breadboards
- Perfboards or Protoboards
- *Manhattan* Construction
- *Dead Bug* Construction
- Etched Circuit Boards
The term *breadboard* originated in the early days of radio, when many experimenters actually built circuits on the wooden boards used in their mother’s 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 to tie 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.
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)
Soldering Tutorial

Soldering – fastening metal objects together using molten metal (solder) as the glue.

Three requirements

• Low melting point metal (wire solder)
• Heat source (soldering iron)
• Flux (to prevent surfaces from oxidizing)
Types of Solder

Tin-Lead solders

60% Tin, 40% Lead - solid at 361° F, liquid at 374° F
63% Tin, 37% Lead - eutectic point is 361° F

no “pasty” range so joint movement less a problem

Silver-bearing Solder

62% Tin, 36% Lead, 2% Silver - solid at 354° F,
liquid at 372 F

often used for surface mount components whose
contacts contain trace amounts of silver
Soldering Irons

**Constant wattage**
Iron is continuously “ON” and eventually reaches equilibrium temperature
20 to 25 watt iron sufficient for circuit board assembly

**Constant temperature**
Tip incorporates a thermostatic element to maintain desired tip temperature
650 – 750 ° F appropriate for circuit board assembly

**But wait…..even better…**

Weller® 30 watt iron
Soldering Irons

Temperature Controlled Solder Station

Feedback control maintains tip at desired temperature

Adjustable, often with analog or digital temperature display

Many have grounded tip to help prevent ESD damage

Weller® solder station
Types of Flux

• Rosin Flux
  Type R – ordinary rosin – most common
  Leaves a residue that can be removed for cosmetic reasons if desired.
  Type RMA – mildly activated rosin
  Type RA – activated rosin – use with care
    RMA and RA fluxes leave a slightly corrosive residue that generally should be removed (with a solvent) after soldering

• Acid Flux – NEVER, EVER use this for electronics
Flux-core solder

Most solder used for electronics assembly is in wire form, with the flux incorporated inside the solder.

*Multi-core* solder has several (usually five) separate flux channels within the solder.

For circuit board assembly use wire solder with a diameter of about 0.025 inch or less.
Two Types of Soldering

• 1\textsuperscript{st} type: Through Hole
  Component has metal leads that goes through the board.
Two Types of Soldering

- 2\textsuperscript{nd} type: Surface Mount.
  Component has metal pads that rest on top of board.
Activities

A03.01 Use the supplied assortment of components and practice soldering them to the perfboard.