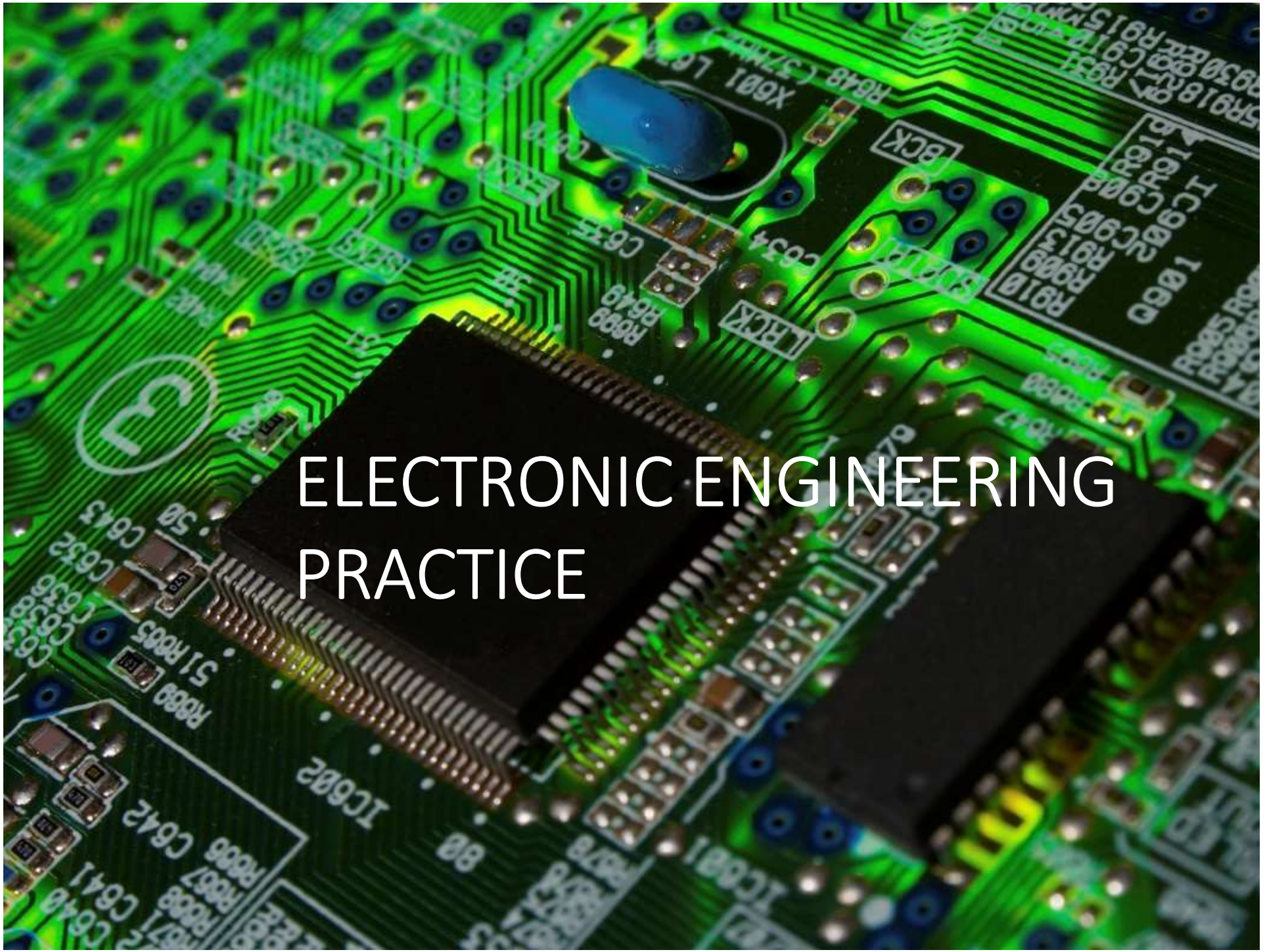
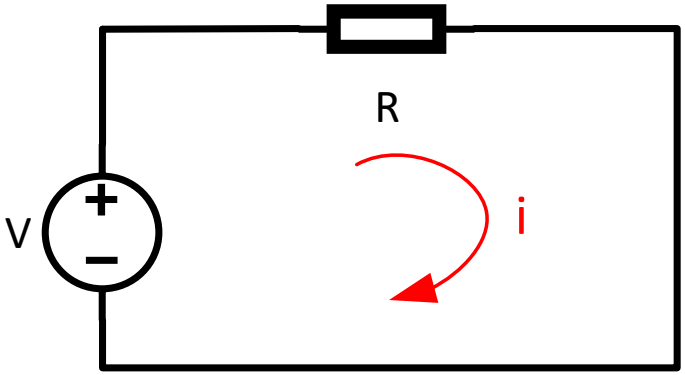

ELECTRONIC ENGINEERING
PRACTICE

- Fundamentals
- Electronic components
- Manufacture of PCB
- Assembly of components on PCB
- Connecting multiple circuit boards
- Documentation

OHMs LAW



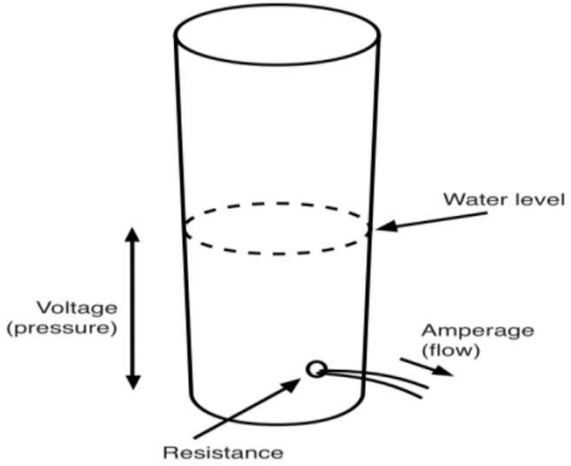


Figure 1-33. *Think of voltage as pressure, and amperes as flow.*

V=iR

Voltage

Potential Difference: When the ends of an electric conductor are at different electric potentials (voltages)

Charge continues to flow until the ends of the conductor has the same voltage

Current

Electric Current: The flow of electric charge

current = charge / time
$I = q/t$

Units: Amps (A)

An amp is the flow of 1 C of charge per second

NOTE: 1 C = the charge of 6,240,000,000,000,000,000 electrons

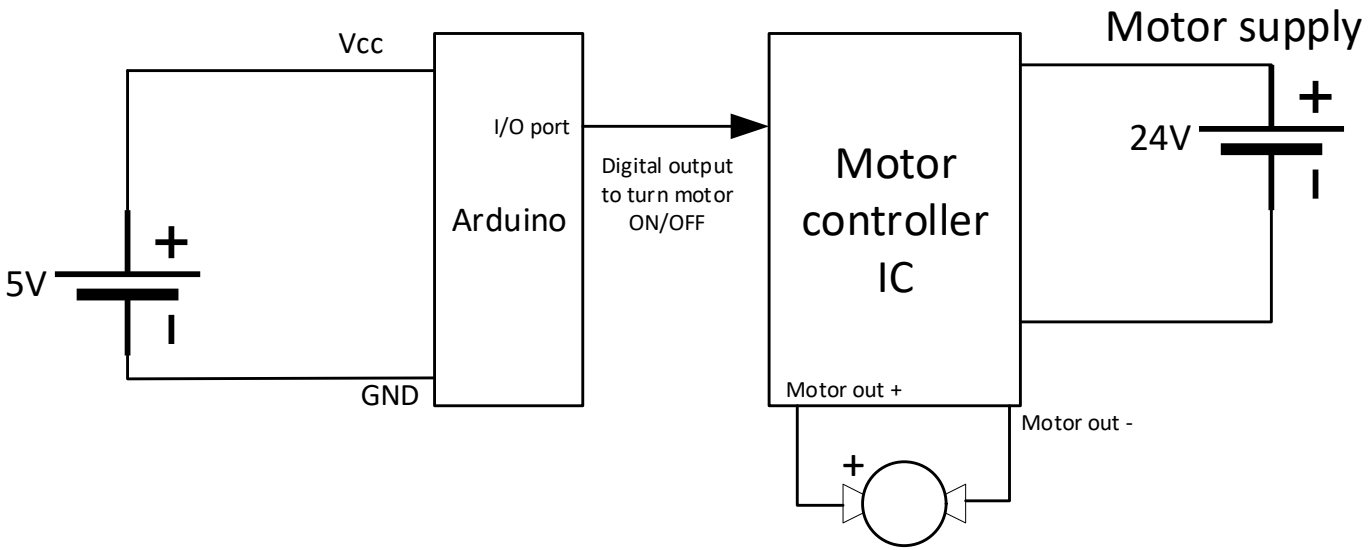
Circuits

Closed Circuit

Allows a complete path for electrons to travel

Open Circuit

Does not allow a complete path for the electrons to travel



Problems?

Current vs Voltage

Current – Flow rate
Measured in Amperes
Amount of flowing water
Voltage – Potential
Measured in Volts
Water Pressure

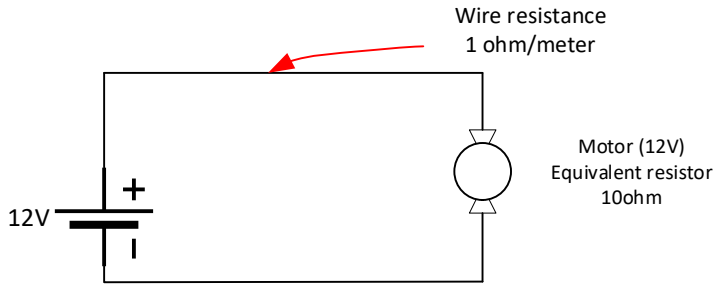
Electric resistance

The ability of a material to resist the flow of charge
Units: Ohms (Ω)
The amount of charge that flows through a circuit depends on two things:

- Voltage provided by source
- Electric resistance of the conductor

Practical things to know

- Thick wires have less resistance than thin wires
- Short wires have less resistance than long wires
- Higher temperatures usually cause more resistance
- The resistance in some materials becomes almost zero at very low temperatures
- The loosely bound outer electrons of conductors carry the charge through circuits



Wire is 10m long, what are the problems?

Practical things to know

The resistance of the human body could range from 100Ω (soaked in salt water) to 500,000Ω (very dry)
The lower the resistance, the greater the shock

Current	Effect
0.001 A (1 mA)	Can be felt
0.005 A (5 mA)	Painful
0.010 A (10 mA)	Involuntary muscle contractions (spasms)
0.015 A (15 mA)	Loss of muscle control
0.070 A (70 mA)	If through the heart, serious disruption. More than 1 second, probably fatal

POWER

The rate at which electrical energy is converted to other forms

Electric Power = Current x Voltage
P = IV
Units: Watts (W)
1 kilowatt (kW) = 1000 W

Kilowatt-Hour (kWh): The amount of energy consumed in 1 hour at a rate of 1 kW

Example: In a place where energy is 5¢ per kWh, a 100 W light bulb can be lit for 10 hours for 5¢

POWER

Robot below weighs 10kg. In order to move it with 2m/sec speed list down areas of concern from engineering point of view.

VOLTAGE SOURCE

A device that provides a potential difference in order to keep current flowing

Dry/Wet Cells: Converts chemical energy to electrical energy
Generators: Convert mechanical energy to electrical energy

BATTERY CHARACTERISTICS

Size

- Physical: button, AAA, AA, C, D, ...
- Energy density (watts per kg or cm3)

Longevity

- Capacity (Ah drain at 20°C)

Number of recharge cycles

- Discharge characteristics (voltage drop)

Cost

Behavioural factors

- Temperature range (storage, operation)
- Self discharge
- Memory effect

Environmental factors

- Leakage, gassing, toxicity
- Shock resistance

DISPOSABLE BATTERIES

Zinc carbon
Heavy duty zinc chloride
Alkaline
Lithium
Silver, mercury oxide (hearing aid, watches)
Zinc air
…

Zinc (-), manganese dioxide (+)
Potassium hydroxide aqueous electrolyte

More energy than carbon zinc
Low self-discharge (10 year shelf life)
Good for low current (< 400mA), long-life use
Poor discharge curve

RECHARGABLE BATTERIES

Nickel cadmium
Nickel metal hydride
Alkaline
Lithium ion
Lithium ion polymer
Lead acid
…

40% more capacity than NiCd
Flat discharge (like NiCd)
Self-discharge 50% less than NiCd
Expensive
300 cycles
50% capacity at 500 cycles

Slim geometry, flexible shape, light weight
Potentially lower cost
Lower energy density, fewer cycles than Li-ion

LITHIUM ION BATTERIES IN DEVICES

Lithium: greatest electrochemical potential, lightest weight of all metals but explosive

Typical use Lithium-{cobalt, manganese, nickel} dioxide

Overcharging would convert lithium-x dioxide to metallic lithium, with risk of explosion

NEVER LEAVE BATTERY CHARGING UNATTENDED

KEEP LITHIUM BATTERIES IN FIRE PROTECTIVE CASING WHEN NOT IN USE

ELECTRONIC COMPONENTS

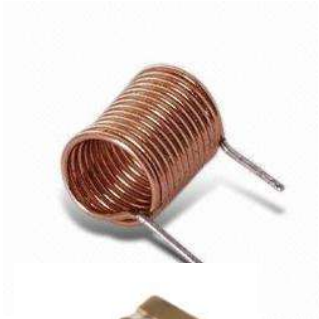
Mechanical and Electro-mechanical:

- PCB mounted DIP switches, mains switches, relays, motors, disc drives, …

ELECTRONIC COMPONENTS

Passive Devices

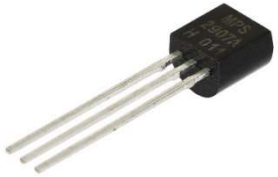
- Resistors, Capacitors, inductors, …



ELECTRONIC COMPONENTS

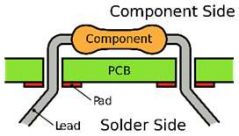
Active Devices

- Transistors, Diodes, FETs, MOSFETs,…

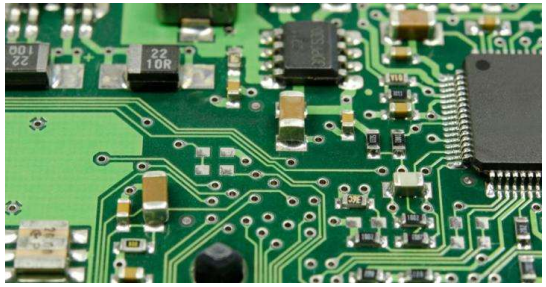


Electronic mounting

- Through hole



- Surface mount

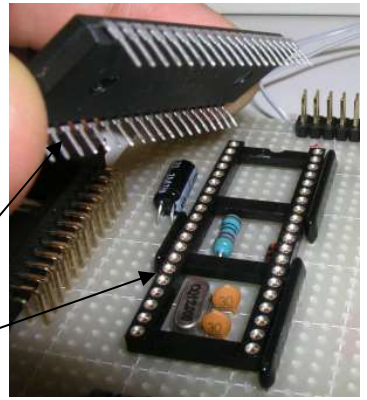


Electronic packaging

- Dual in-line package (DIP)

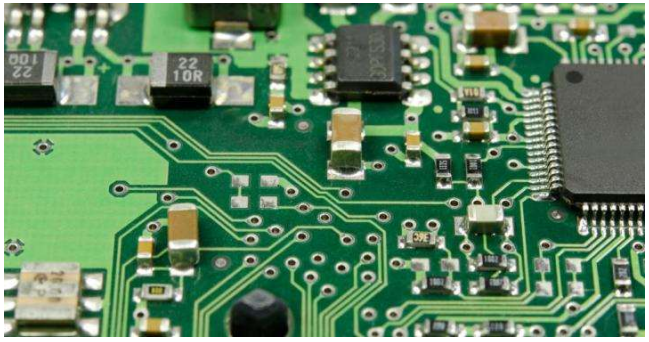
Avoiding possible heat damage to IC during soldering:

- Solder a chip carrier to the PCB
- Insert chip into carrier



Electronic packaging

- Surface-mount device (SMD)
- Advantages
  - Smaller components hence more component density on PCB
  - It can be placed on both sides of the PCB
  - Better mechanical performance under shake and vibration conditions
  - Simpler and faster automated assembly
  - Cost effective
  - Better EMC performance due to the smaller radiation loop area
- Disadvantages
  - Difficult for prototyping and manual assembly
  - Not suitable for high power

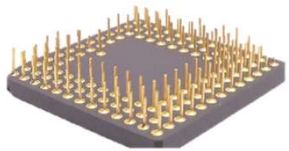


Electronic packaging

- SOIC package (Small Outline IC)
- Area 30–50% less and thickness 70% less than DIP

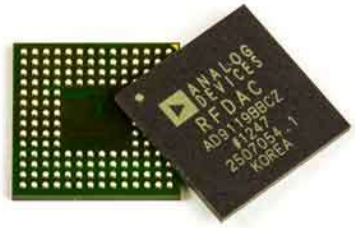
Electronic packaging

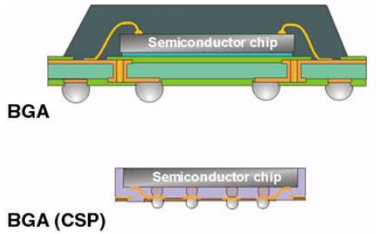
- Pin grid array (PGA)



- Quad Flat Package

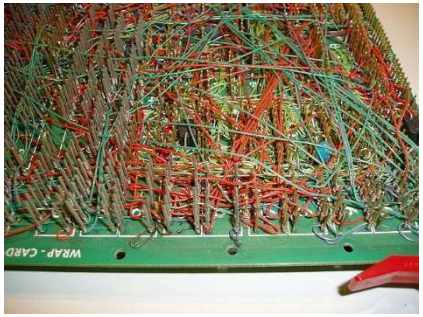
- Ball grid array

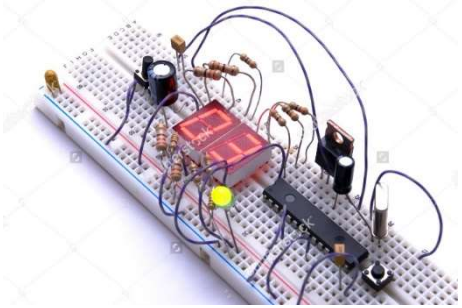


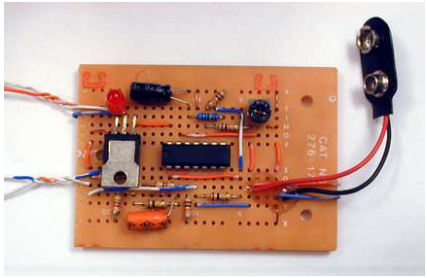


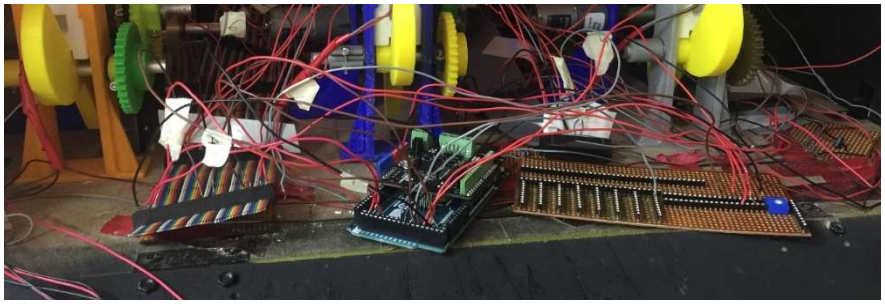
- ….

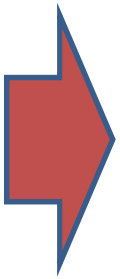
Printed circuit board (PCB)





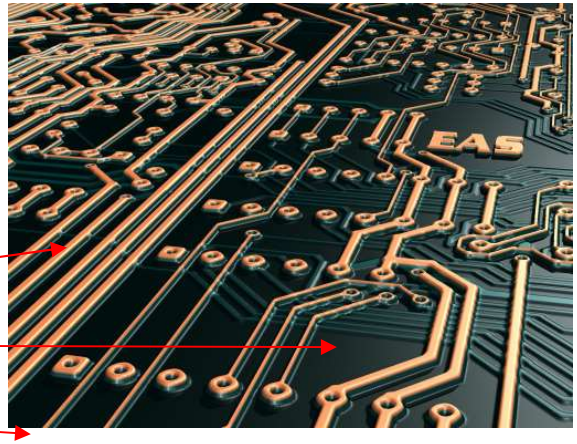






PCB manufacture

Typical PCB



Types of PCB's

single-side, double-side and multi-layer

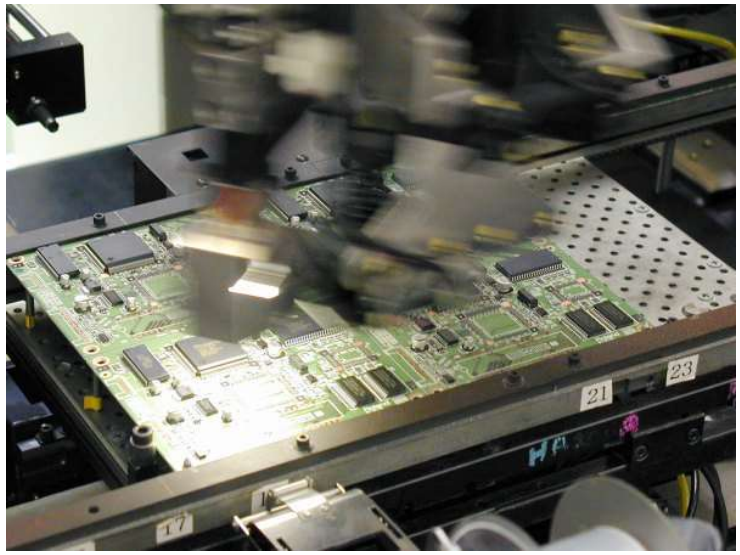
Which type to use ?

(a) Circuit complexity
(b) Available space
(c) Cost

PCB manufacture

- Insert leaded component into holes on PCB
- Solder
- Apply protective coating

Manual electronics assembly

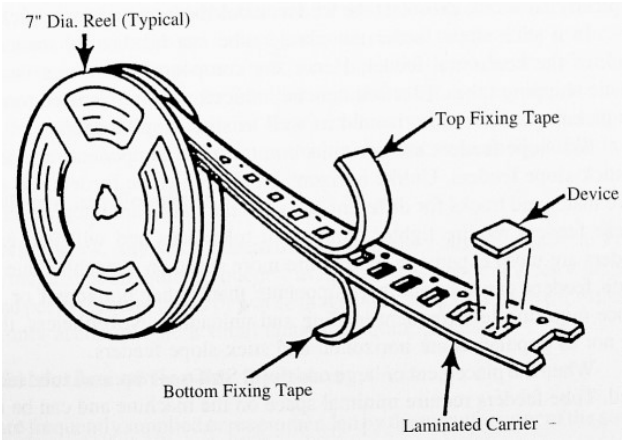


Automated electronics assembly

Automated PCB assembly

Component inputs:

Leaded Component



IC’s, components with no wire leads

PCB manufacture

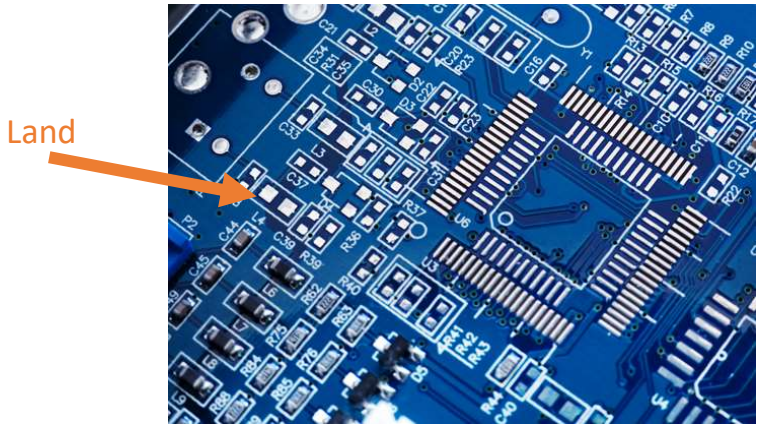
Surface mount chip assembly:

- Silk-screening to apply solder paste on the board
- Automated assembly of components (>30,000 components per hour)
- IR or Wave soldering

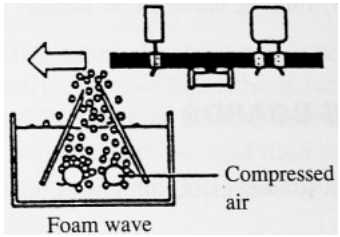
Automatic soldering

Step 1. Application of the solder resist

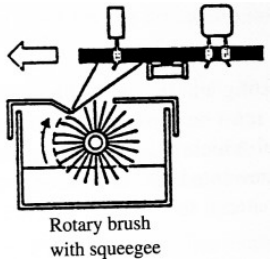
Cover PCB with solder resist except Lands



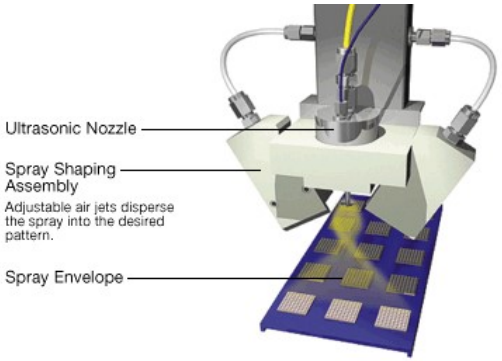
Step 2. Flux application



Foam fluxing



Spray fluxing



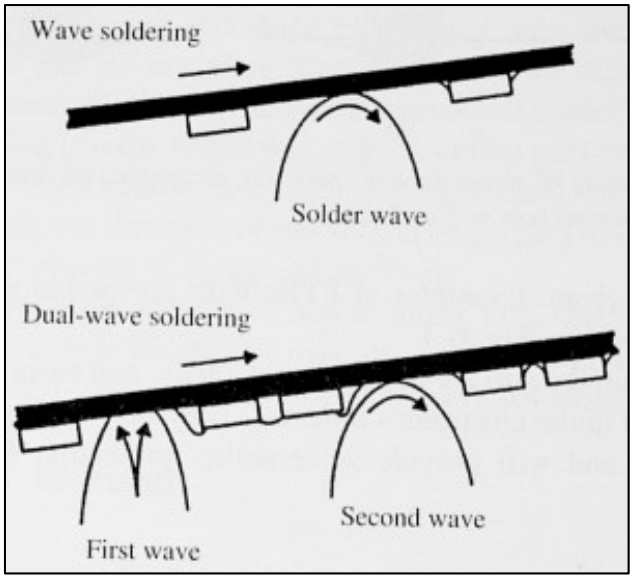
Ultrasonic Spray fluxing

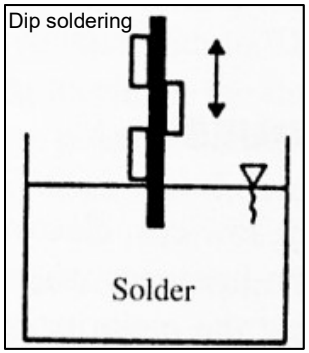
Solder flux prepares the copper soldering pads of PCBs and the leads of components so the applied molten solder will bond properly.

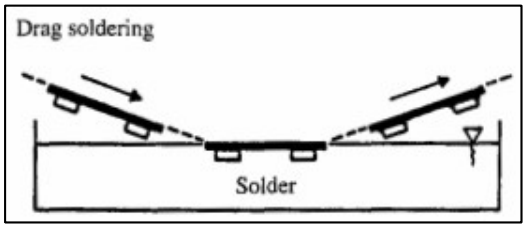
Automatic soldering

Step 3. Solder Application

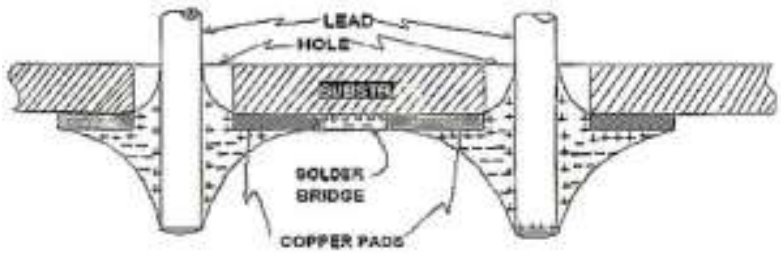
Dual wave solder bath







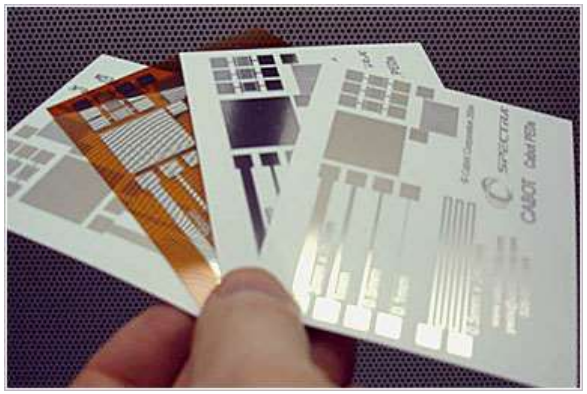
Automatic soldering



Step 4. Automatic removal of solder bridges: Hot air-jet knives

Future of manufacturing

Ink jets for PCB



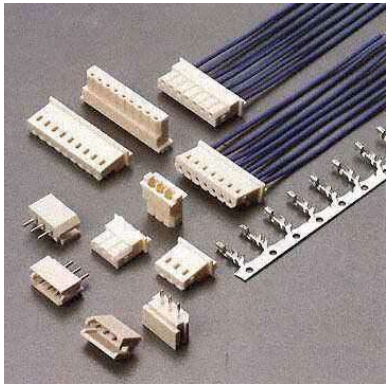
Additive technology for manufacturing electronic boards

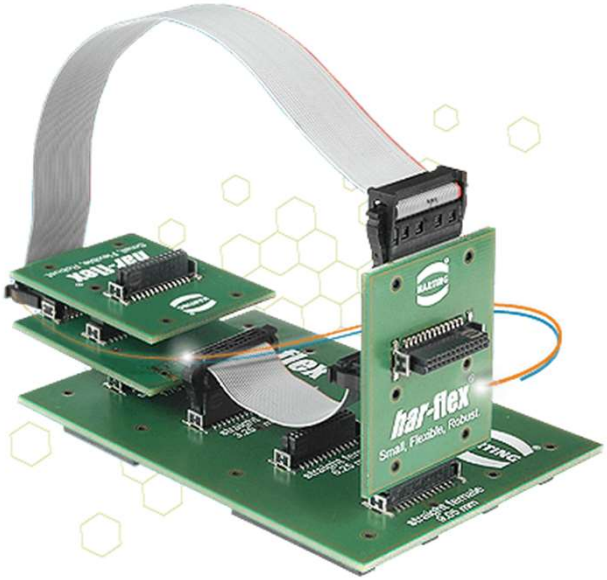
CONNECTIONS

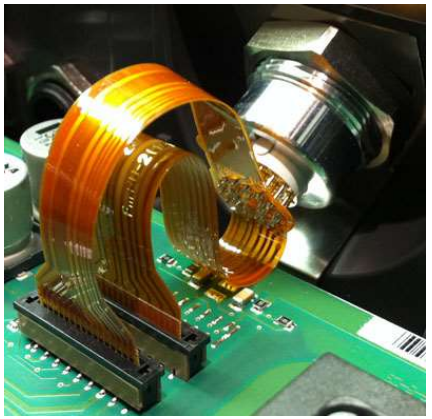
Connecting multiple circuit boards

Backplanes: Buses, backplane or stacking

Board-to-Board Connectors







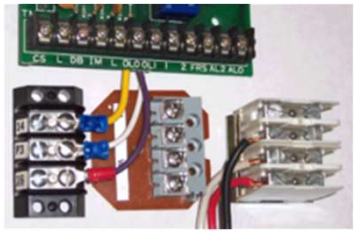
More on connectors

- Keying (mechanically enforces correctly oriented matching)

- Locking

44-854

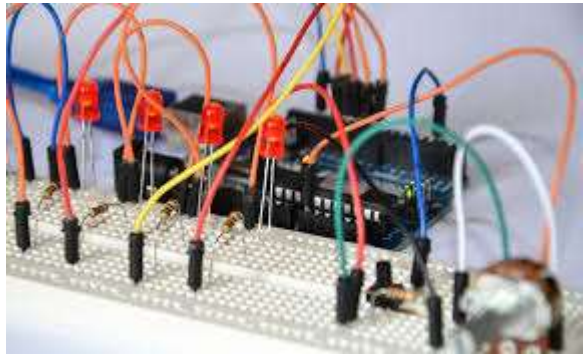
- Terminal blocks

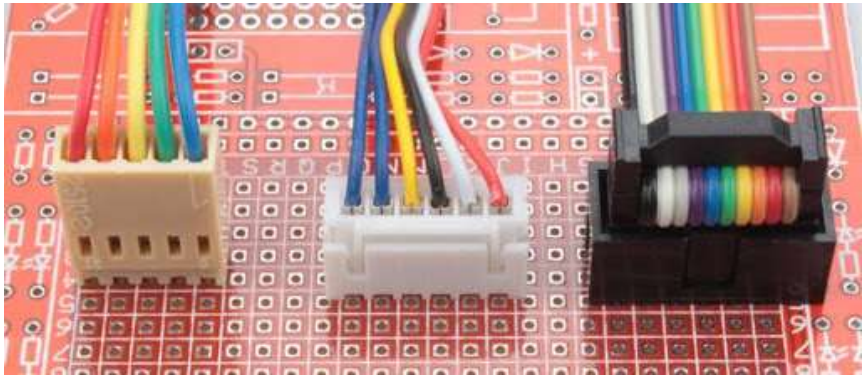


- Crimp connection

- Plug and socket connectors

Use proper connector and cables



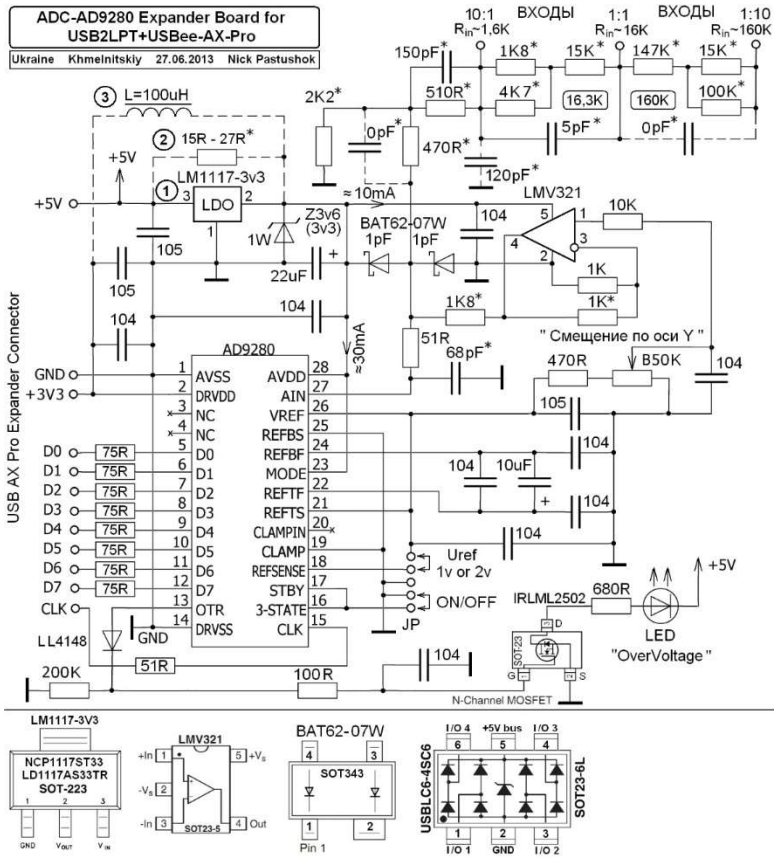


Documentation

- Circuit diagram
- Bill of materials
- User manual
- Certification

Circuits diagram

It is a graphical representation of an electrical circuit



Bill of materials

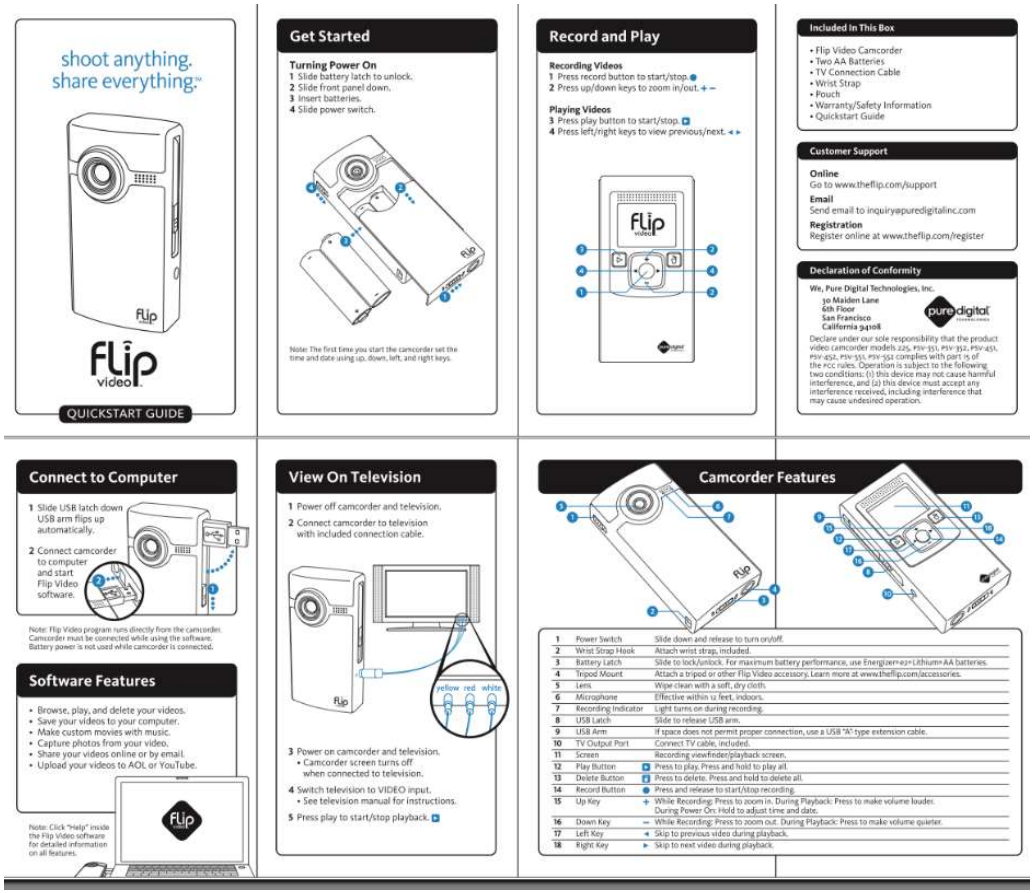
A bill of materials (BOM) is a list of materials, components, subassemblies, parts and their quantities to manufacture a product.

ITEM	QUANTITY	PRICE (US $)
6" channel, 7/16" thick	20 feet	182
Grade 8 bolts, washers, nuts, 1/2"x2"	48	20
Main cylinder[1], 5", surplus	1	125[2]
Hopper cylinder, 1.5"x15"[3]	1	65
Control Valve, open center, 2 spool[4]	1	75[5]
Hopper sheet metal, 3/16"	24 square feet	62
Hydraulic fittings	various	81
Hydraulic hoses[6]	4	61
Cylinder mounting metal rods and angle	various	46
Main press plates, 1"x6", 1"x8"	3 pieces, 3 feet total	47
Pressing plate sides, 1/2"x6"	3 feet	18
Nylon 6/6 liner	5 square feet	50
Rubber for press plate[7], 6"X12"	1	7
Hopper table 1/4" steel: 2" tubing and plate	10' & 6 square feet	60
Hopper alignment rail: 2"x1/4" angle	2 feet	4
3-point mount for a tractor, 2"x4"x1/4" tubing	4 feet	50
Legs, 2"x1/4" square tubing	12 feet	40
TOTAL		**$993**

Table 1. Bill of Materials for the first prototype CEB machine built by OSE.

User manual

User's guide to how to use a particular system



Certification

Product certification (qualification) means it has passed performance tests and quality assurance tests, and meets qualification criteria stipulated in contracts, regulations, or specifications.

- FCC mark for electronic products manufactured or sold in the United States

- CE for electronic products manufactured or sold in Europe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