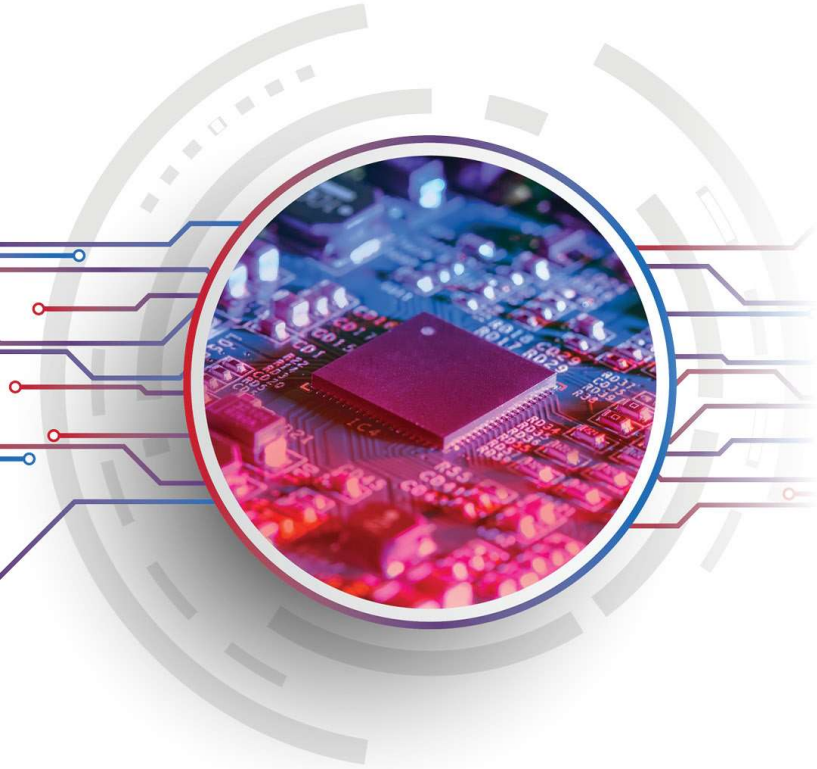


SMT PROCESS TRAINING

Module 1

Jan 2023 V.1

MacDermid Alpha
ELECTRONICS SOLUTIONS

Introduction to Assembly of Electronics Products

The Basics

Major Electronics Trends – Potential New Ecosystems

Increasing complexity of electronic content

Increasing durability and reliability requirements

Emerging Technologies

- Autonomous Transportation
- Flexible and Wearable Electronics
- Smart Homes/IoT
- Cloud Computing

Current Technologies

- Smartphones & Tablets
- Car Infotainment
- Cloud Storage
- Auto Safety and Powertrain Systems

Past Technologies

- Televisions
- Early-Gen Wireless
- Desktops / Laptops
- Analog Cellular Phones

Automotive Electronic Content

- Increasing electronic content in automotive systems compounded by growth in electric vehicle markets

5G Technologies

- Higher density and reliability requirements for 5G technologies in both telecom infrastructure and mobile phone units

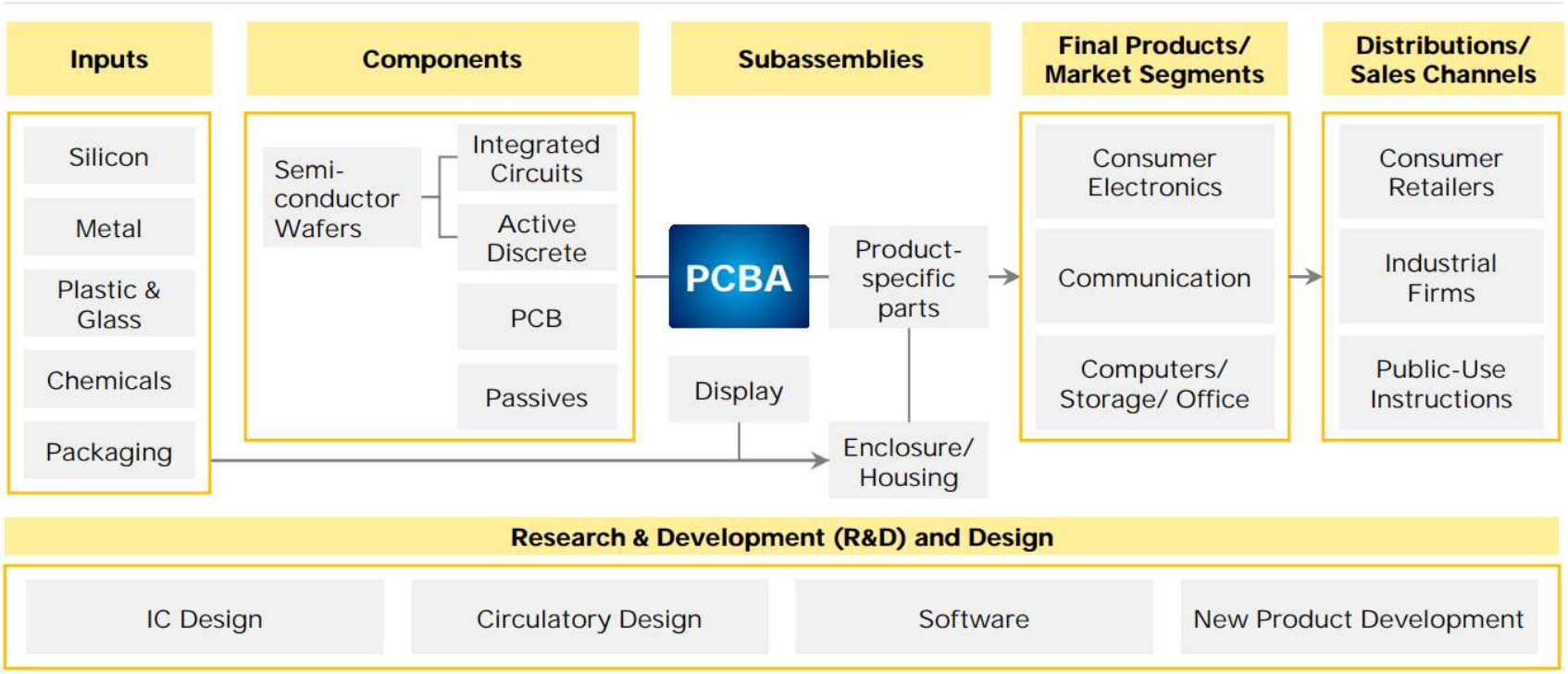
Internet of Things

- Growing focus on connectivity in everyday life through the electrification of consumer goods

Environmental Awareness

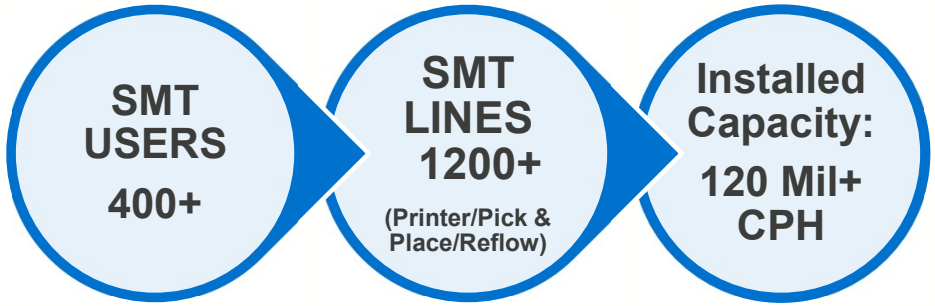
- REACH, custom formulations to enable LED and Photovoltaics, energy efficient electronics, and industry leading recycling programs

Importance of PCBA in the Electronics Value Chain



Source: Duke University Global Value Chains Center

PCBA Capacity in India

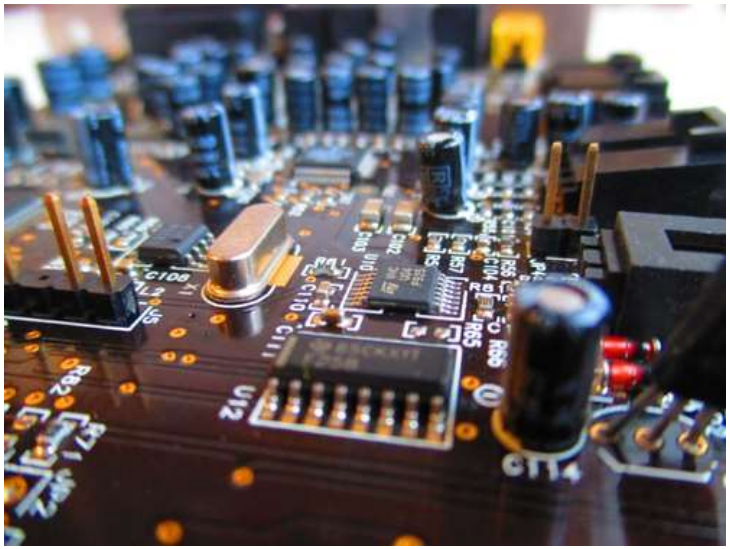


Segment	Telecom	MNC/EMS	Local EMS	Automotive	Govt Org	Energy Meter/LED	Consumer
# of Lines	150+	100+	300+	300+	60+	150+	100+
CPH (Mil)	25	8	20	20	1	7.5	5

Internal update in Dec 2022

What is an Assembly?

- Involves mounting, connecting, assembling and securing parts and components of electronic equipment.
- The assembler either OEM or EMS brings together the pieces of equipment /gadgets we use every day
- Millions of Mobiles, computers, LED TVs, toys and others are assembled every day.
- Aerospace, Automotive, Consumer, Industrial, Lighting, Military, Medical, Mobile, Telecom are some of the major segments in Electronics Industry



Module 1: **Intro to Electronics Assembly**

1.0 Introduction

1.1 State what an assembly is.

1.2 State the goals of a company building electronic assemblies.

1.3 State the documentation used for the assembly processes.

1.4 Describe through-hole parts.

1.5 Describe SMT parts.

1.6 State the basics of how assemblies are built.

1.7 Describe the two different types of assembly methods.

1.8 List the steps in the production process.

1.9 Describe printing.

1.10 Describe pick and place.

1.11 Describe reflow.

1.12 Describe cleaning.

1.13 Describe what manual insertion means.

1.14 Describe wave soldering.

1.15 State when hand soldering is used.

1.16 Describe test.

1.17 Describe flying probe test.

1.18 Describe in-circuit test.

1.19 Describe functional test.

1.20 Describe inspection and how it is performed.

1.21 Describe repair rework.

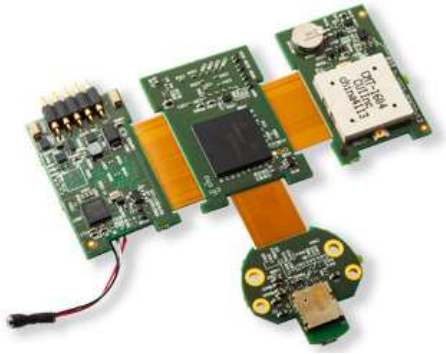
1.22 Describe what final assembly means.

1.23 State how to determine if an assembly should be a reject.

1.24 List some key things to know when handling assemblies

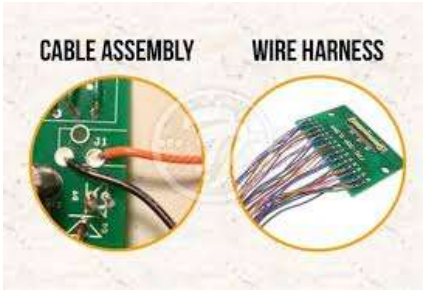
Building an Electronics Assembly

Building an Electronics Assembly



Printed Circuit Board Assembly

Sub-Assembly, Box Build & System Integration



Cable & Wire Harness Assembly

Testing & Calibration

Conformal Coating & Potting

Global Supply Chain Management

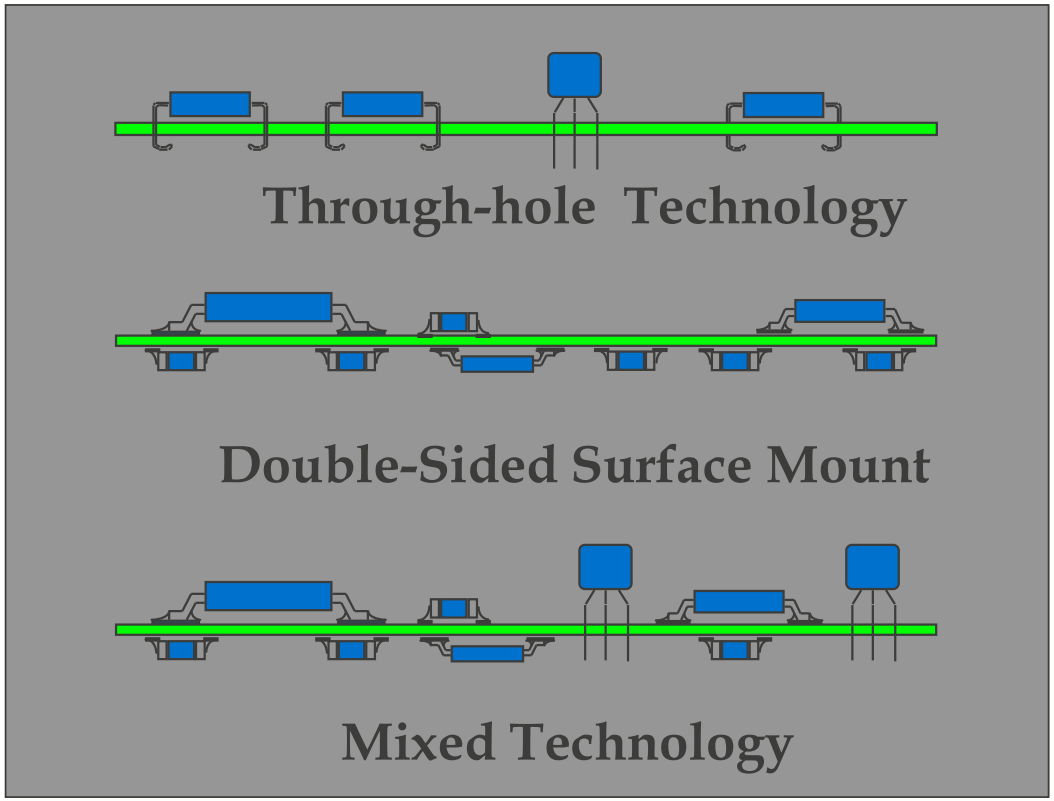
Product Life & Cycle Support

Printed Circuit Assembly Document Package

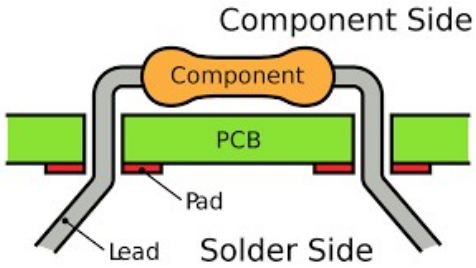
A comprehensive PCB assembly document package typically includes the following:

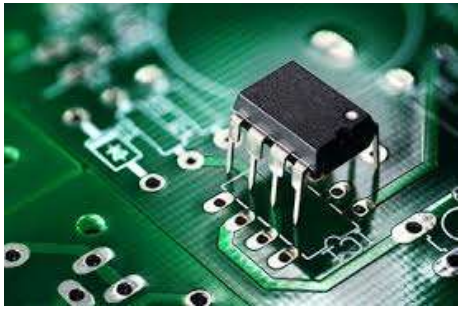
- ✓ Bill of Materials (BOM)
- ✓ Approved Vendor List (AVL)
- ✓ PCB Gerber data (All layers, Drill files, Aperture files)
- ✓ CAD data (ODB++ for example)
- ✓ Centroid file
- ✓ PCB schematic(s)
- ✓ PCB fabrication drawing and notes
- ✓ Assembly drawing(s)
- ✓ Test specifications (ICT, Functional, ESS, Hi-Pot, etc.)
- ✓ Quality specifications
- ✓ Regulatory (UL, TUV, etc.) requirements

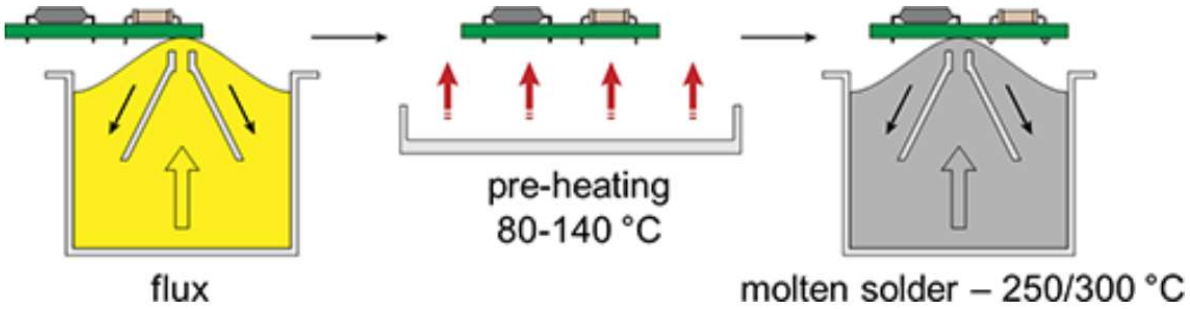
Types of Assembly Technology



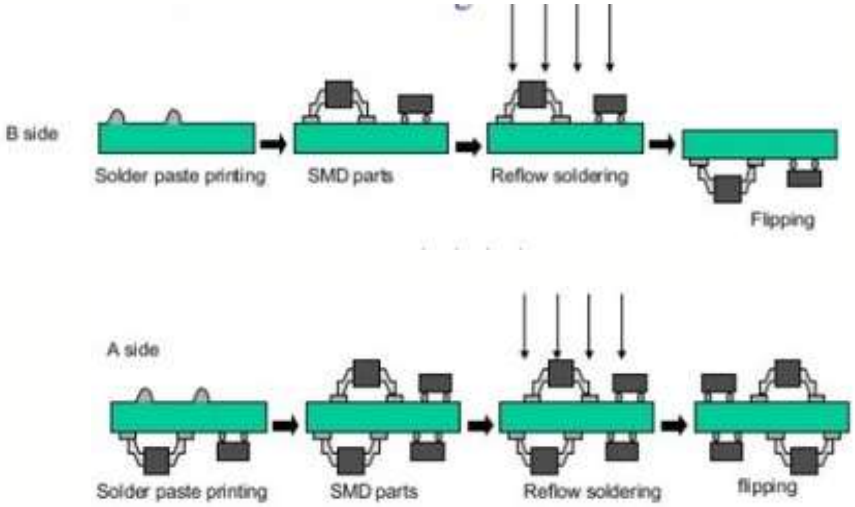
Through Hole Assembly Technology

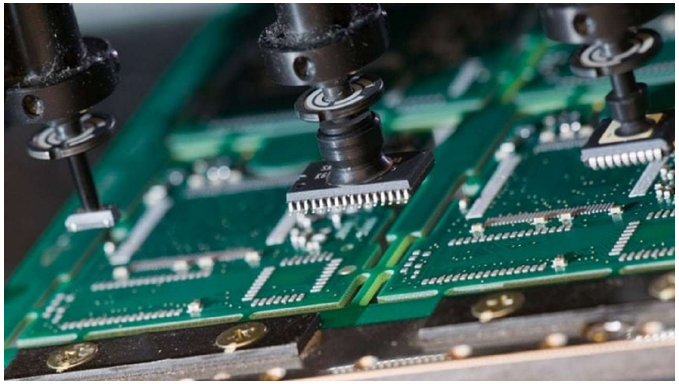


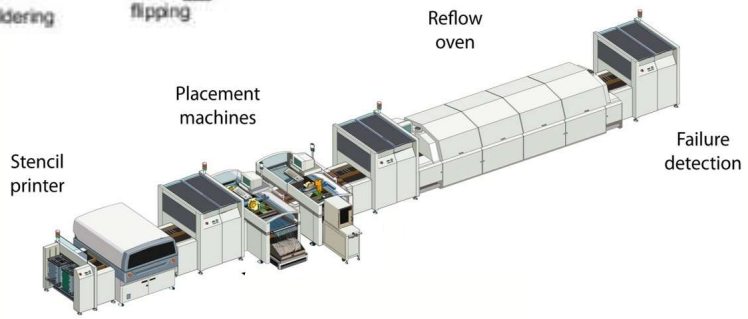




Double Side SMT Assembly Technology

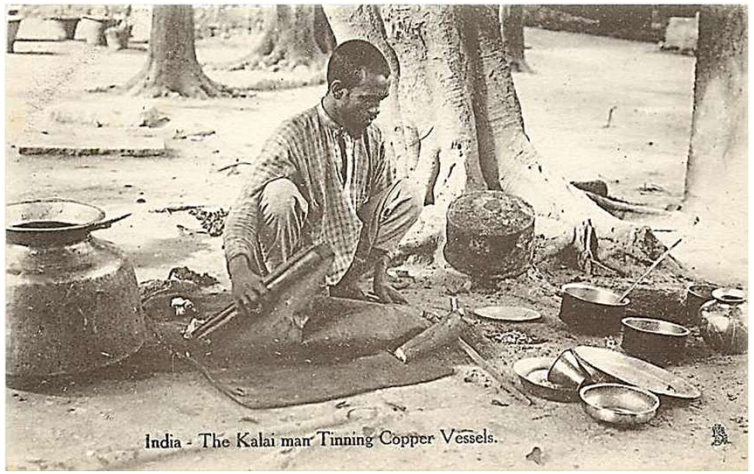






How old is the Soldering?

- There is evidence that soldering was employed as early as 5000 years ago in Mesopotamia.
- Soldering and brazing are thought to have originated very early in the history of metal-working, probably before 4000 BC.
- Sumerian swords from ~3000 BC were assembled using hard soldering.



Isa 41:7
Tools

The craftsman encourages the metalworker; the one who flattens with the hammer [supports] the one who strikes the anvil, saying of the **soldering**, "It is good." He fastens it with nails so that it will not fall over.

What is Soldering?

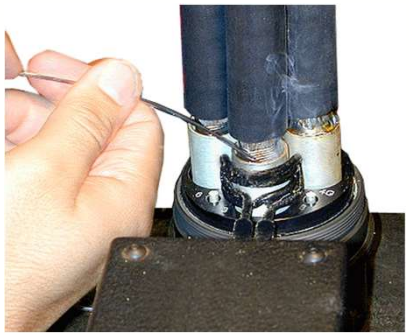
- Soldering is when two metallic workpieces are joined with the aid of molten metallic binding material (solder).
- The trick lies in having the melting point of the solder lower than that of the metal to be joined.
- If this melting point is below 450°C, the process is termed soft soldering. If it is above the value, it is hard soldering.

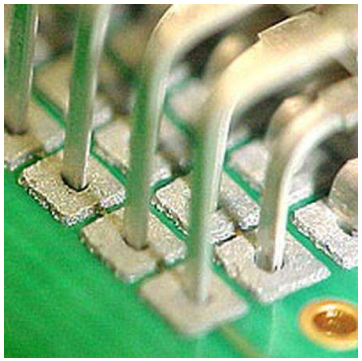
Metal	Melting Point in Celsius
Silver	980
Tin	240
Zinc	419
Lead	328
Copper	1090
Aluminium	665

The most common Lead-Free Solder Alloy is known as SAC. The composition is Sn + Ag + Cu
Sn = 96.5%, Silver = 3.0% & Copper = 0.5%

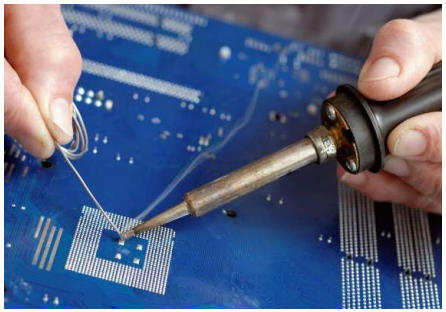
Equipment Used in the Assembly Processes

Multiple Soldering Equipment


Induction


Intrusive or Pin in Paste

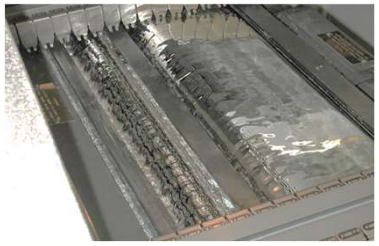

Laser Beam

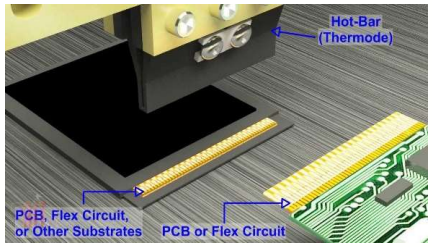

Manual


DIP Soldering

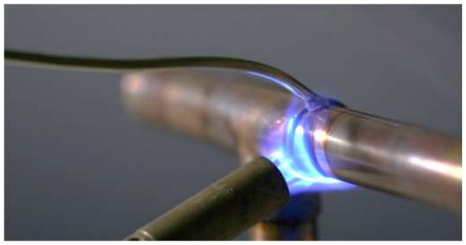
Reflow


Selective


Wave

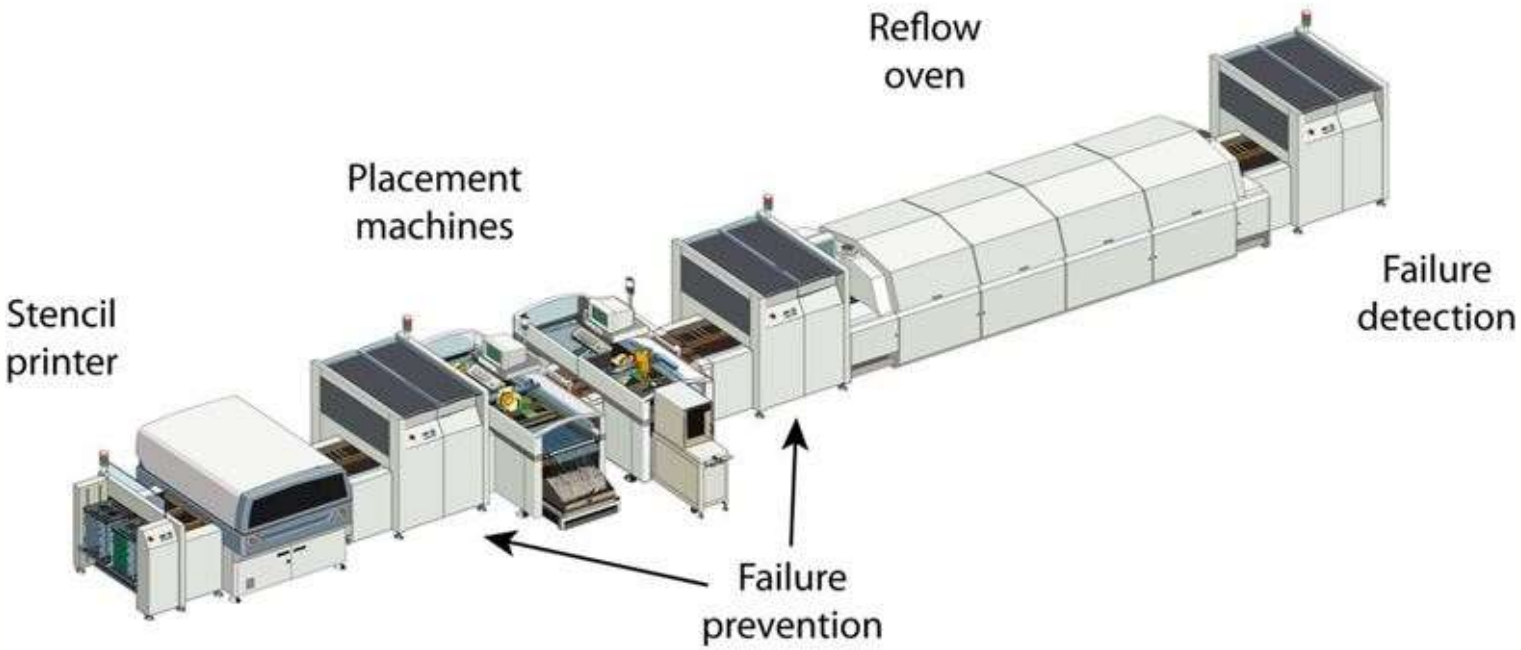


HOT BAR


Gas Flame Torch


Infra Red

SMT Production Process Steps



Equipment used for Mass Soldering

SMT Glue Printing

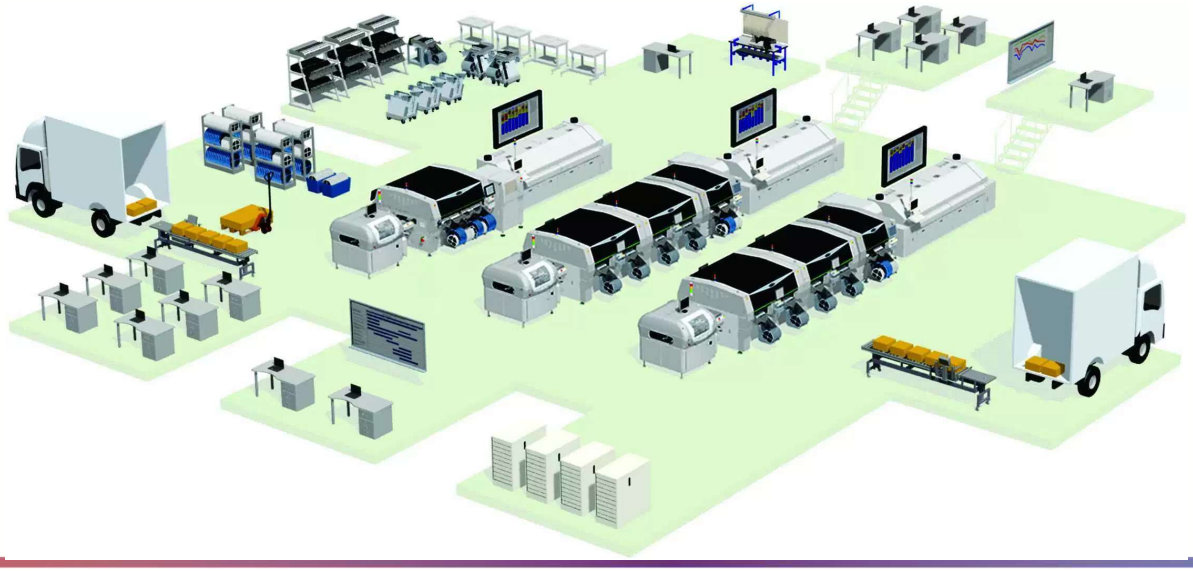
SMDs Placement

Reflow

PTH Components Manual Insertion

Wave Soldering

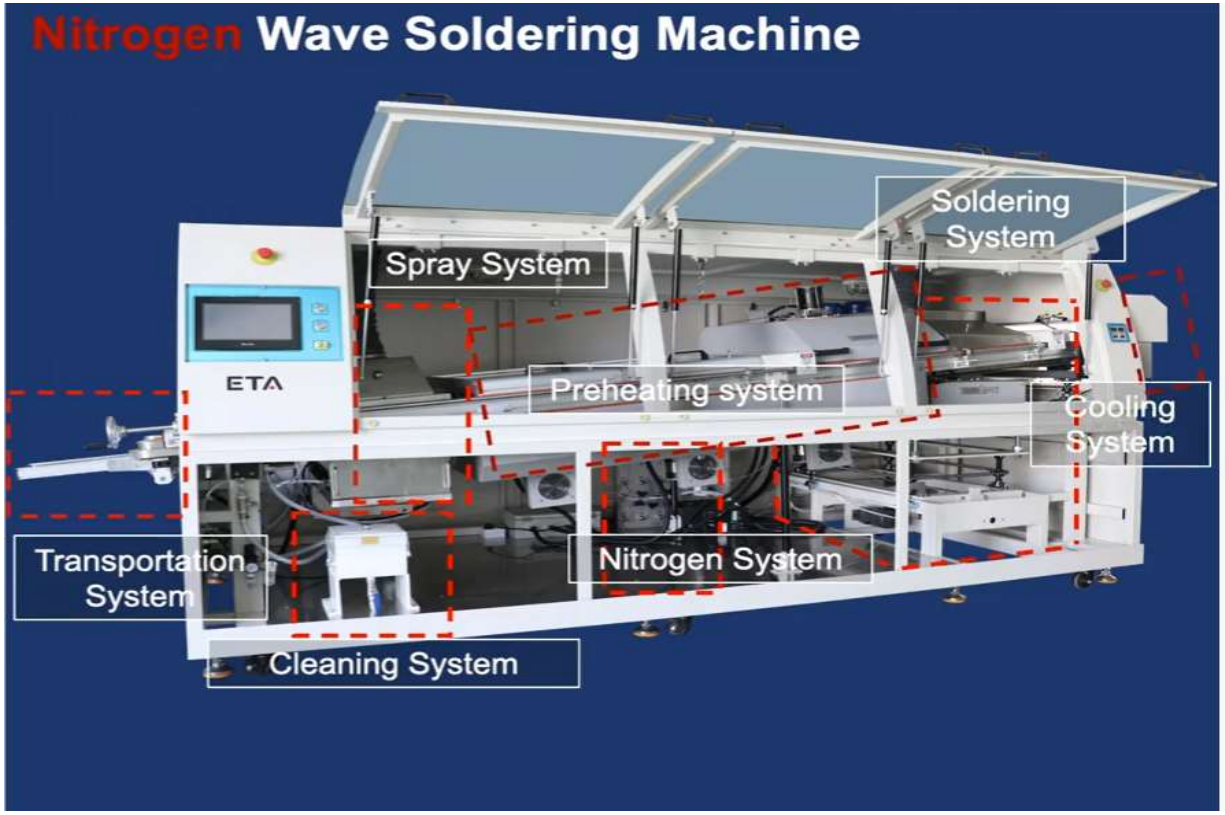
Repair



Print - Pick n Place & Reflow Soldering

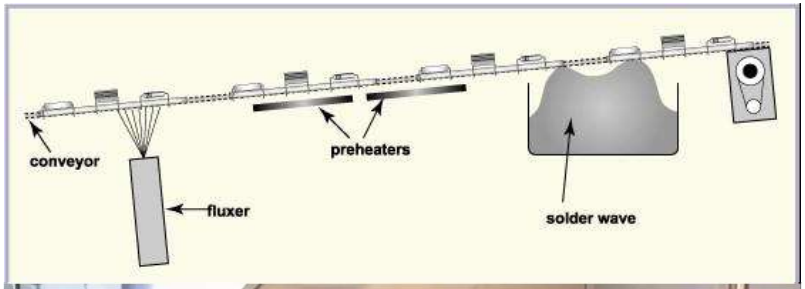
Video

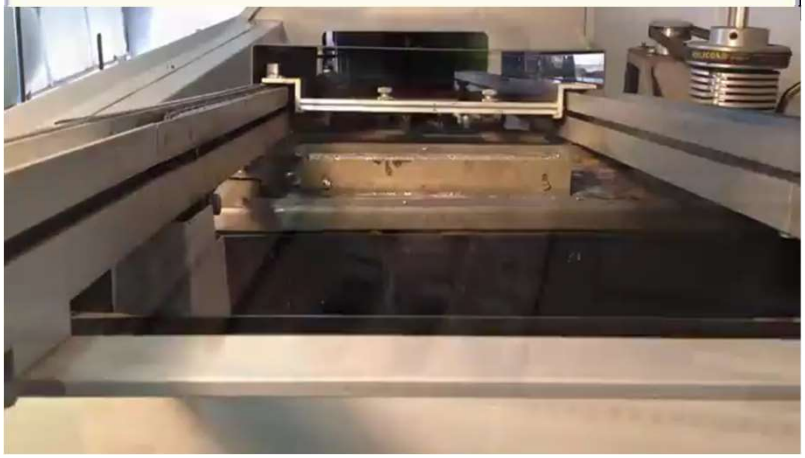
Wave Soldering Machine



https://youtu.be/Dt9eoUQAvOw

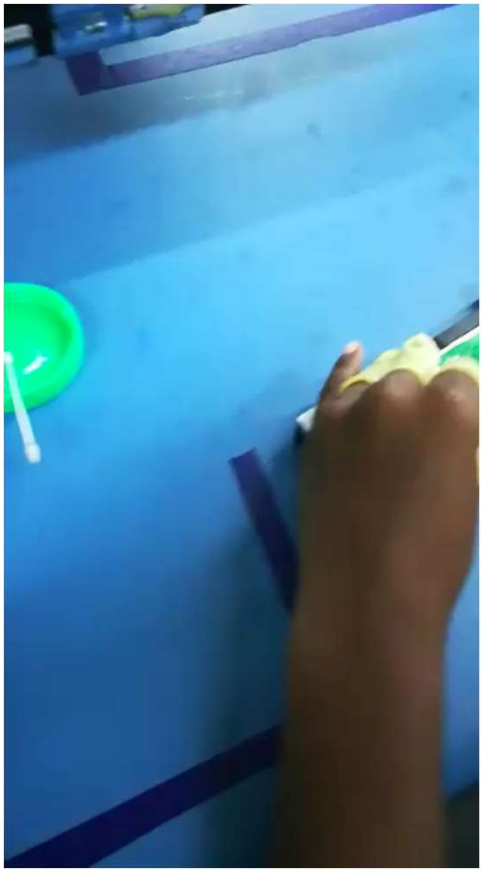
Wave Soldering



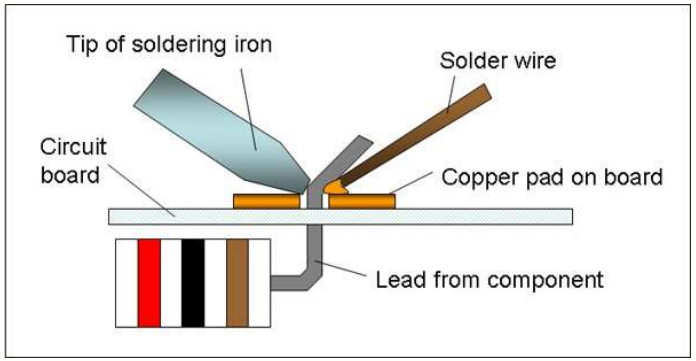


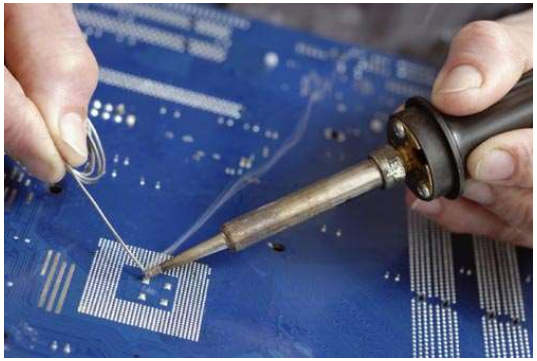
Video

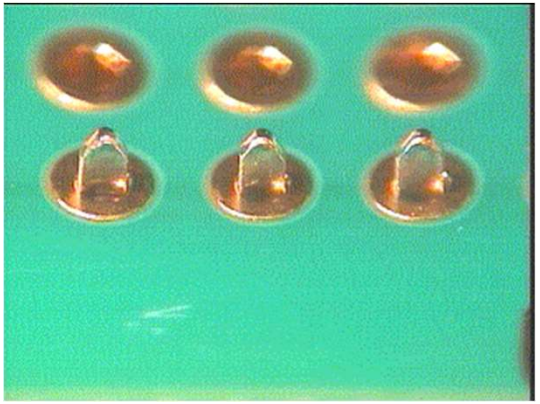
Hot Bar Soldering



Repair / Rework





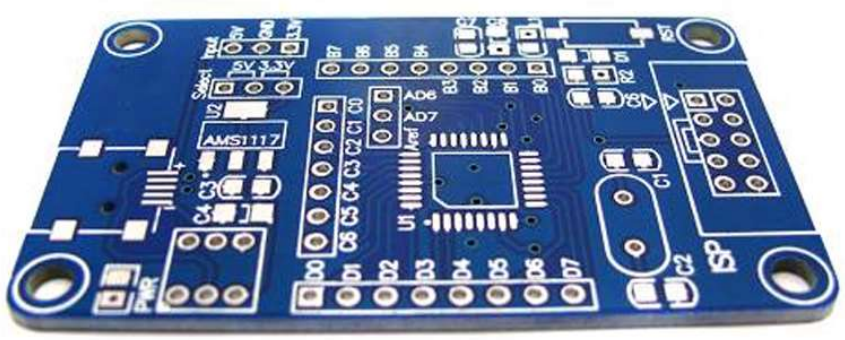


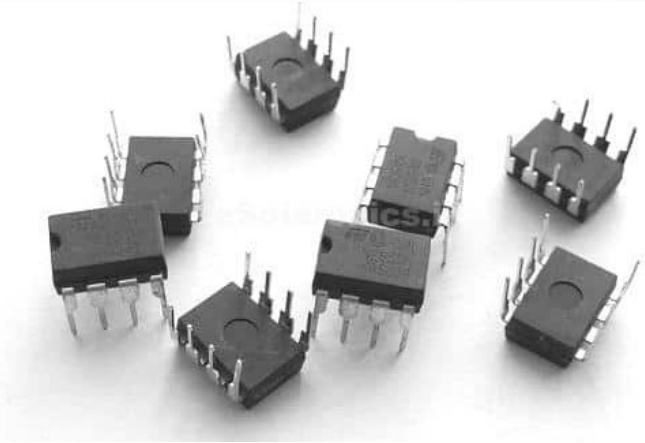
PCBs & Components

Printed Circuit Board (PCB)

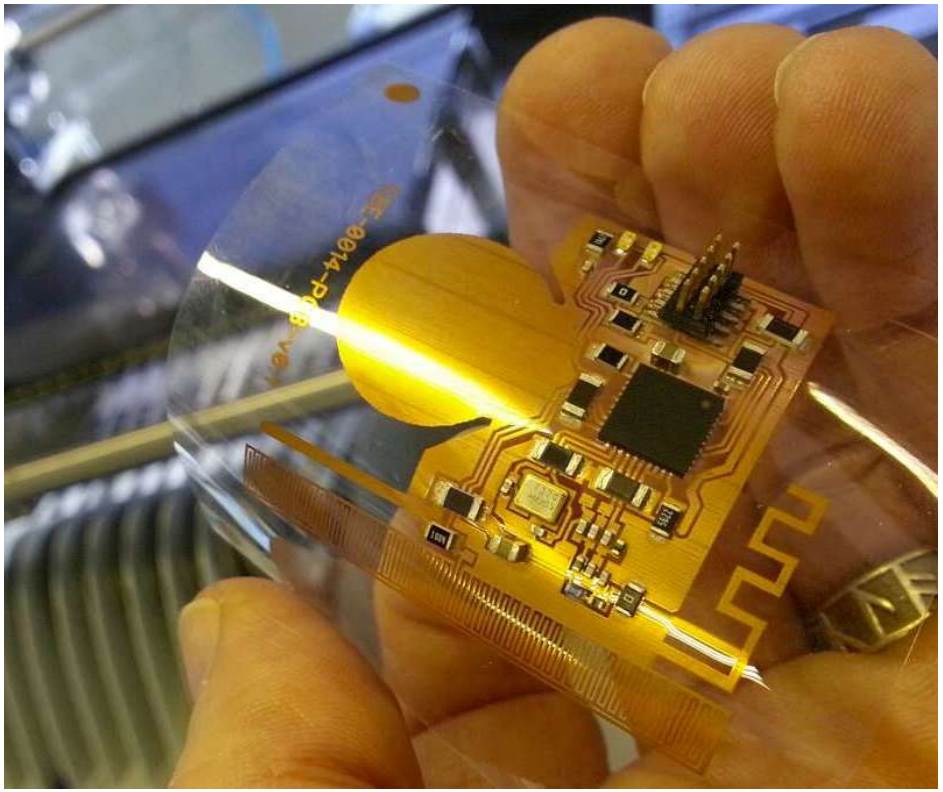
- A Printed Circuit Board or PCB is a board with the purpose of connecting electronic components.
- It consists of alternating layers of conductive copper and layers with non-conductive material for insulation purposes.
- Mechanically formed fine holes plated are called PTH
- The interconnect traces between the layers
- Component leads are inserted in the PTH for soldering
- Surface mount pads are formed to solder SMDs
- A PCB mechanically supports and electrically connects electronics components

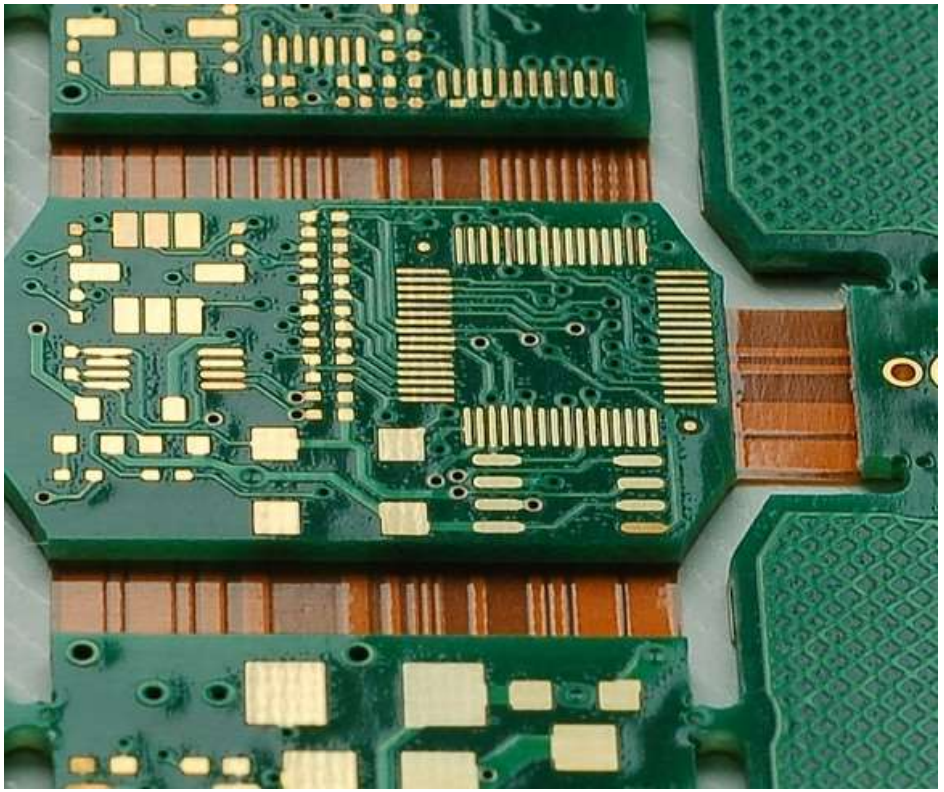
PCB & Components to be Soldered





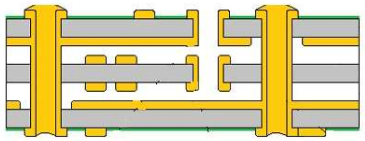
Printed Circuit Boards - Example





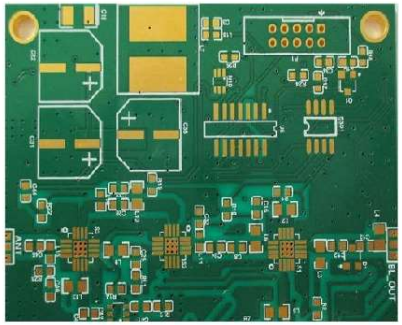
Types of PCB (Printed Circuit Board)

Double Lyer PCB



Multi-Sided PCB

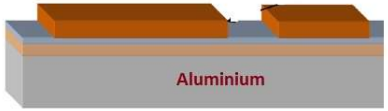
Rigid Flex PCB



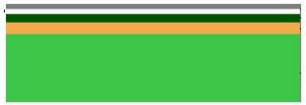
High Frequency PCB

Rigid PCB

Flexible PCB



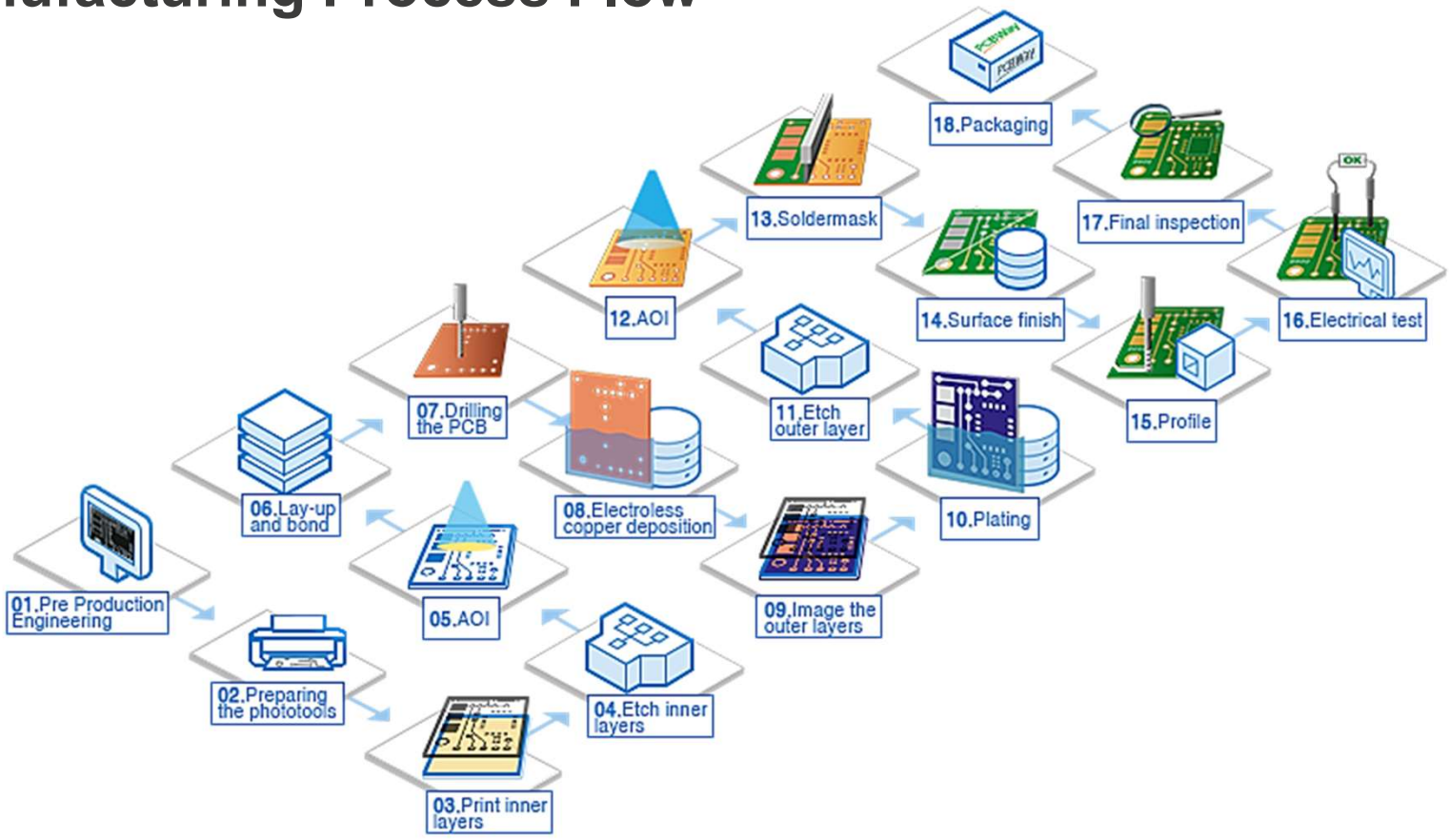
Aluminium Backed PCB



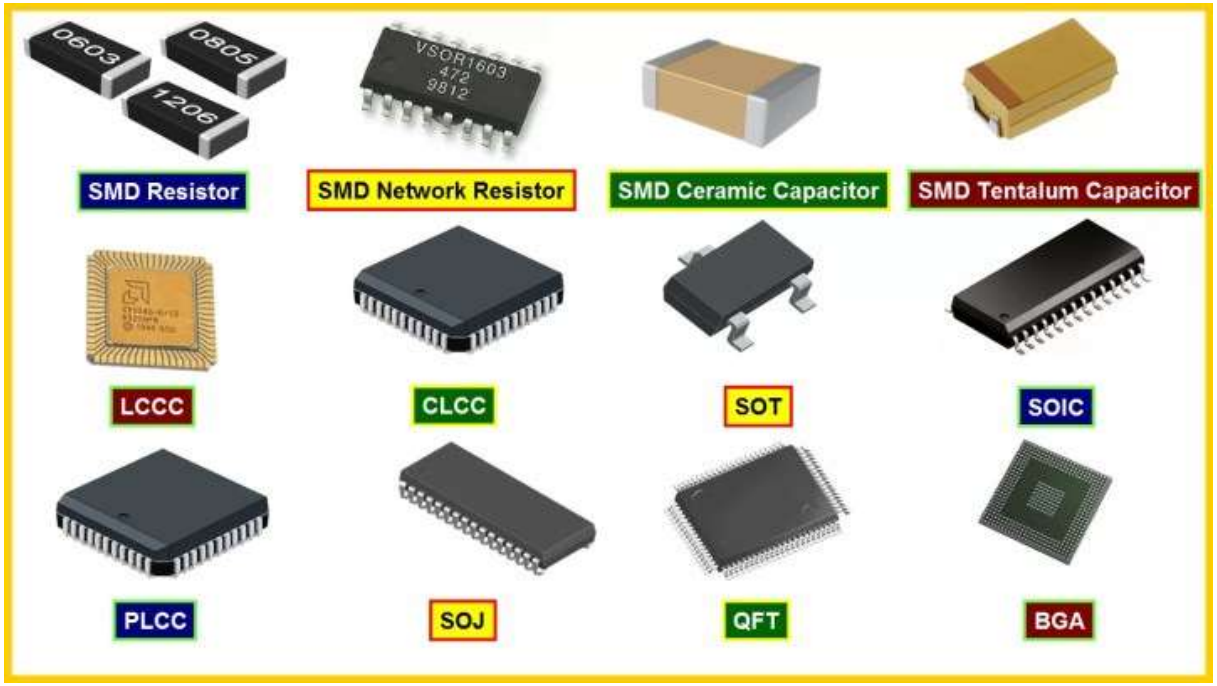
Single Sided PCB

www.TheEngineeringKnowledge.com

PCB Manufacturing Process Flow

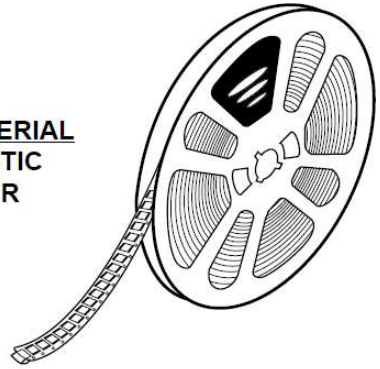


Various Surface Mount Devices



REEL MATERIAL

- PLASTIC
- PAPER



Chip Components

A chip component's size is described by a four-digit size code.

In the U.S., the size code is in inches. Outside the U.S., the size code is usually in millimeters, but may also be in inches.

It is important to be certain of which measurement system a component size code is in.

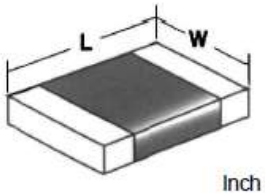
The first two digits in the size code are the components length, the second two digits are width.

Below are the most common size codes for capacitors and resistors:

Size Code		Approximate Size (LxW)	
Inch	Metric	Inch	Metric
0402	1005*	.04" x .02"	1.0 x 0.5mm
0504	1210*	.05" x .04"	1.2 x 1.0mm
0603	1508	.06" x .03"	1.5 x 0.8mm
0805	2012	.08" x .05"	2.0 x 1.2mm
1005*	2512	.10" x .05"	2.5 x 1.2mm
1206	3216	.12" x .06"	3.2 x 1.6mm
1210*	3225	.12" x .10"	3.2 x 2.5mm
1812	4532	.18" x .12"	4.5 x 3.2mm
2225	5664	.22" x .25"	5.6 x 6.4mm

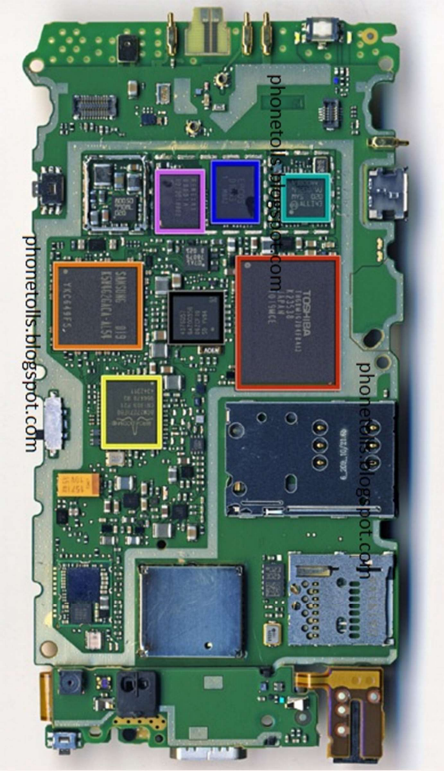
* *Caution: Overlapping size codes. Metric appears same as inches.*

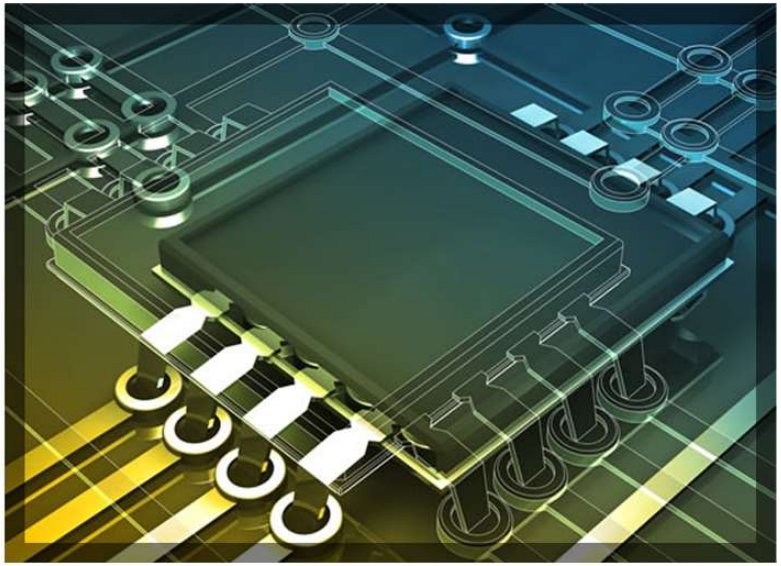
In metric size codes, the numbers have a decimal point between them.

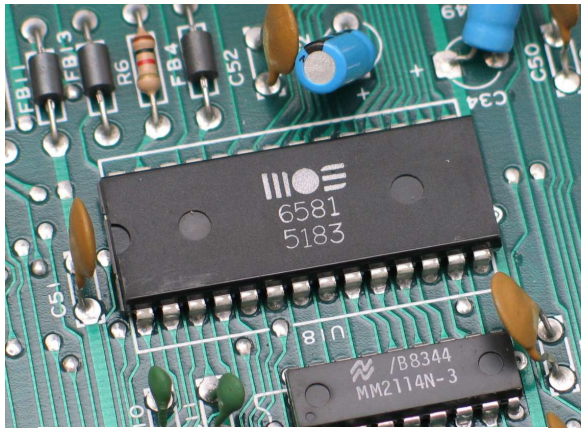


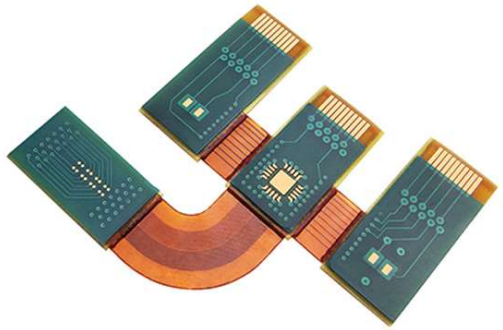
Inch size code = 1210

Soldered / Assembled PCBs









Assembly Materials to form interconnections (soldering)

Soldering

‘’ a soft metal that is melted in order to join together pieces of metal so that they stick together when it cools and becomes hard again ‘’

- Spreading
- Base-metal dissolution, and
- formation of an intermetallic compound layer

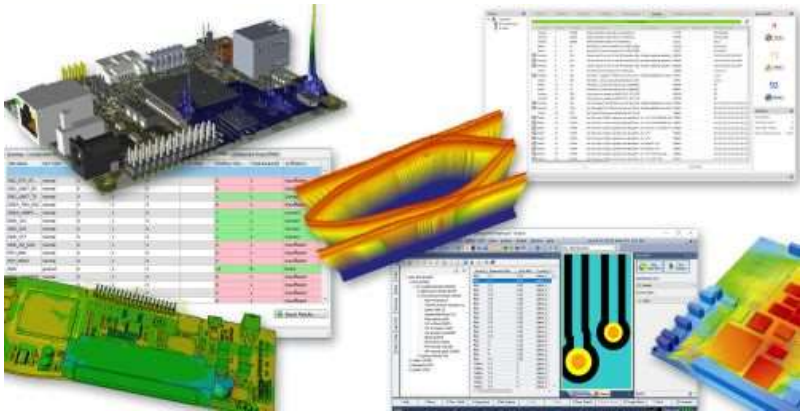
Soldering Materials

Alloys Widely Used for Making Paste

Name	Sn	Ag	CU	Sb	Bi	Zn	Ni	Pb	Solidus	Liquidus	Comments
Tin Silver Eutectic	96.5	3.5							221	221	
Tin Copper Eutectic	99.3		0.7						228	228	
Tin Copper	97		3						228	310	
Tin Antimony	95			5					236	243	
Tin Zinc Eutectic	91					9			198	198	
SAC305	96.5	3	0.5						217	220	Copper free variants may be available to control copper level in wave
SAC405	95.5	4	0.5						217	225	
SAC396	95.5	3.9	0.6						217	217	
SAC387	95.5	3.8	0.7						217	220	
SACX0107 Plus	99.2	0.1	0.7						217	227	
SACX0307 Plus	99	0.3	0.7						217	227	
SACX0807 Plus	98.5	0.8	0.7						217	225	
SnCX Plus 07	99.26		0.7				0.04		227	229	
Innolot	90.95	3.8	0.7	1.4	3		0.15		206	218	
Sn100C	99.26		0.7				0.04		228	228	
SnBiAg	42	0.4			57.6				138	138	
Sn63/Pb37	63							37	183	183	
Sn62/Pb36/Ag2	62	2						36	179	180	
Sn60/Pb40	60							40	183	188	

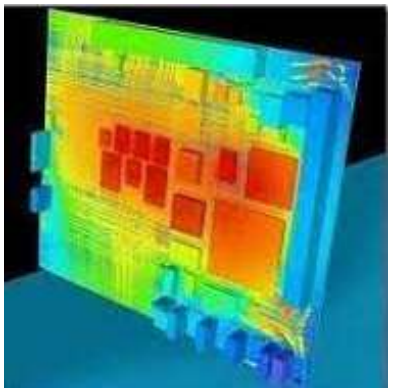
Importance of Pre-Engineering

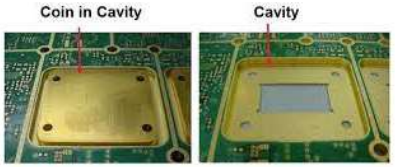
- The DFM check looks at all the design specifications of a PCB.
- Looks for any missing, redundant or potentially problematic features.
- If not, may severely and negatively influence the functionality
- DFM checks can cut manufacturing costs
- Eliminate unforeseen expenses.
- Cuts down on the number of scrapped boards.
- It is the commitment to quality at a low cost



Importance of Pre-Engineering

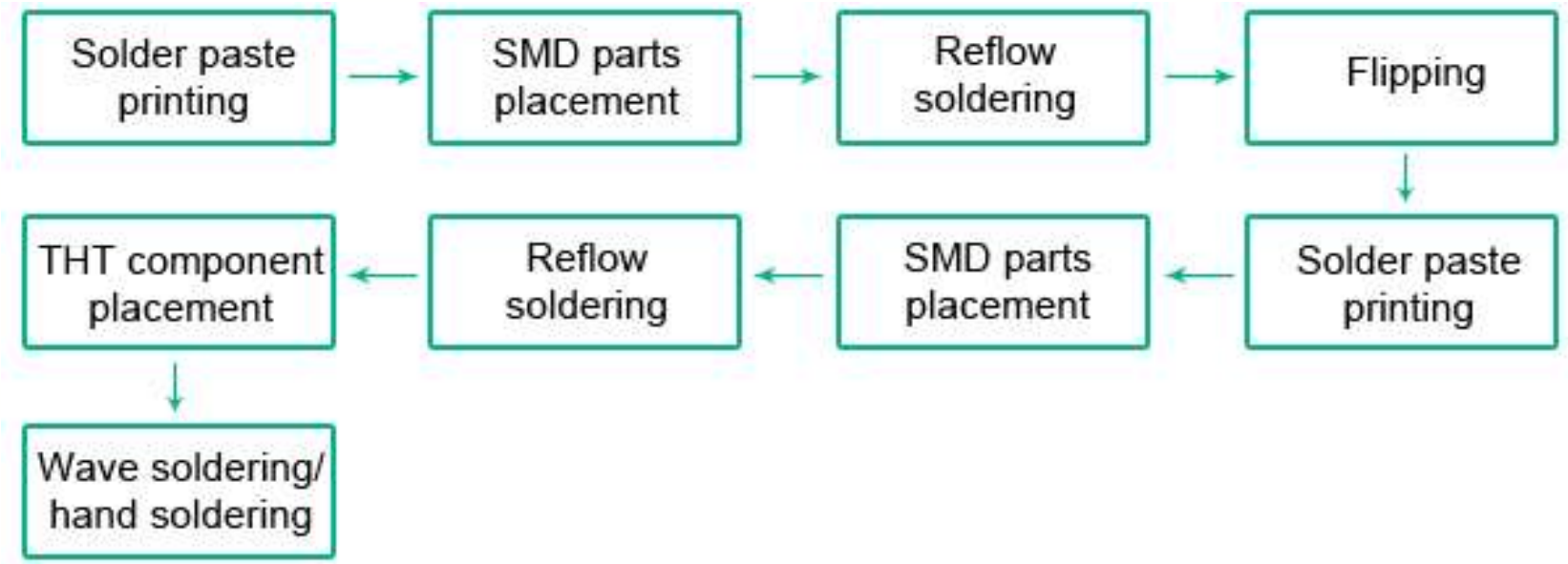
- Modern electronics use high power components
- High-performance processors, MOSFETs, high power LEDs, IGBTs, etc.
- Trapped in a trend to make these components smaller
- This results in the creation of thermal hotspots.
- High temperatures at PCB thermal hotspots result in device failure.
- Thermal performance is one of the most critical factors
- Designers to understand techniques to reduce heat dissipation



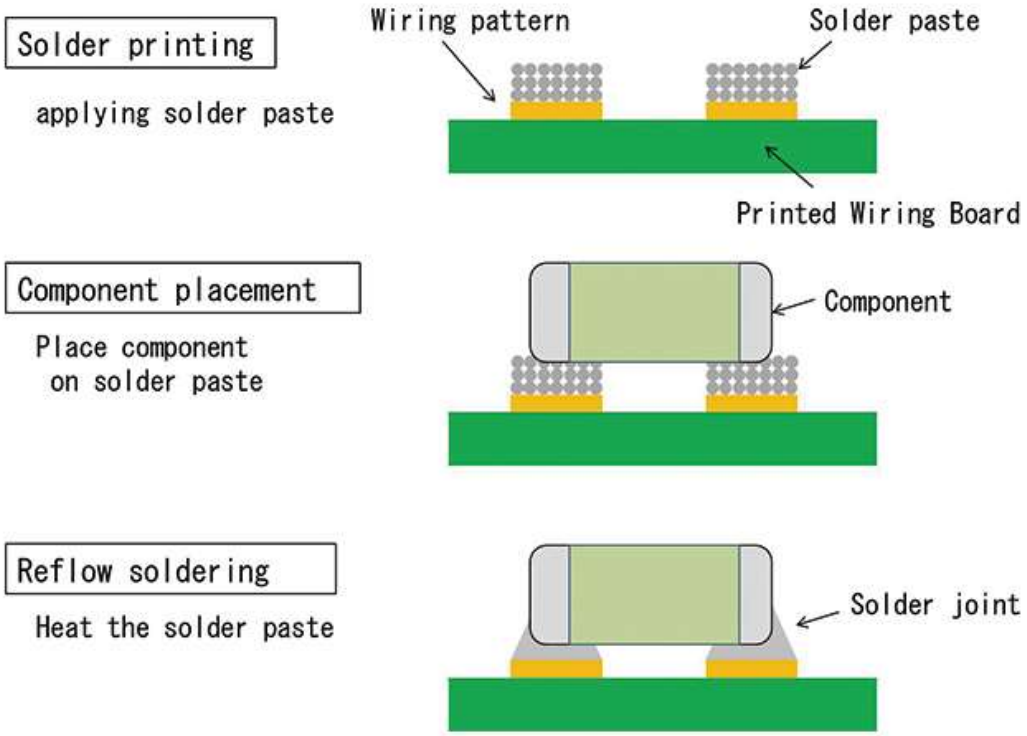


https://www.protoexpress.com/blog/12-pcb-thermal-management-techniques-to-reduce-pcb-heating/?utm_source=linkedin&utm_medium=social&utm_campaign=blog%2B2021

SMT Production Process Steps

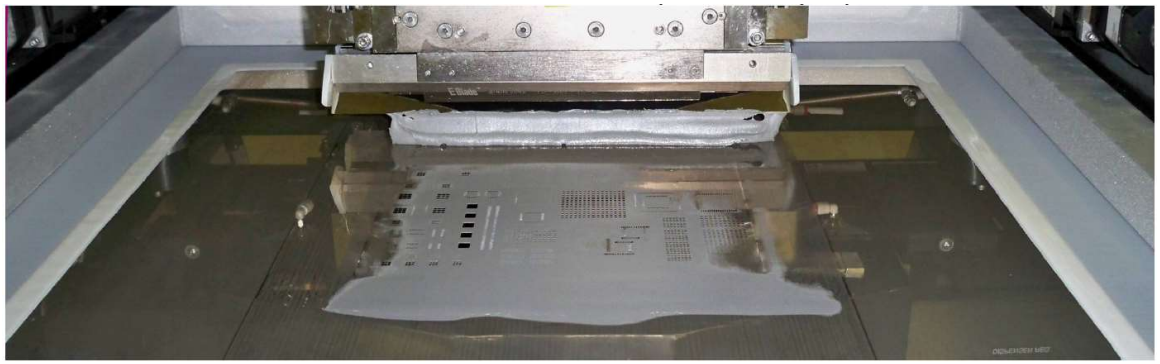


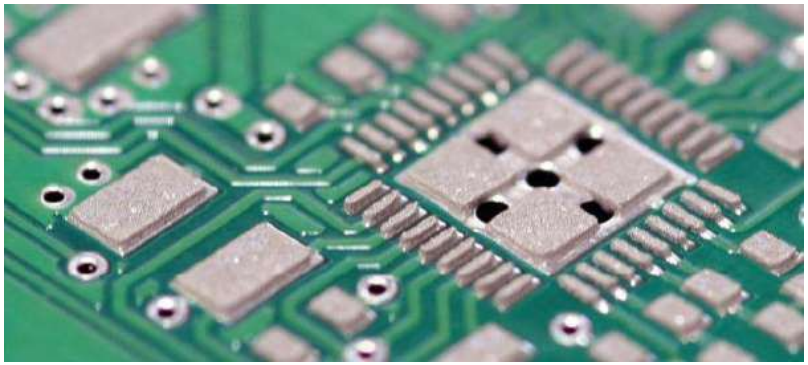
Major Steps in the Assembly



Solder Paste printing process

- The most common way of applying **solder paste** onto a **PCB**
- Performed by **Printing solder paste** through apertures in a stencil.
- It is very Important of SMT Assembly **process**
- **A**lso known as **screen Printing**

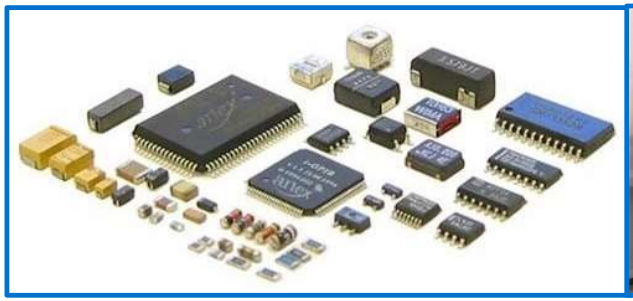


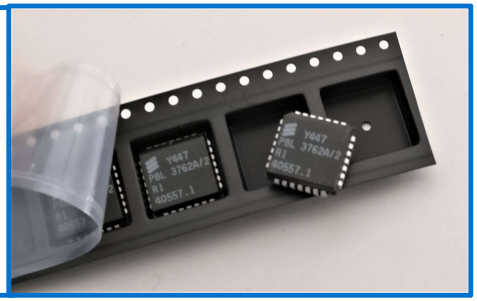


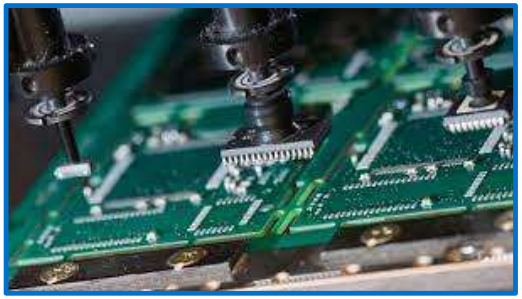
Components Pick n Place

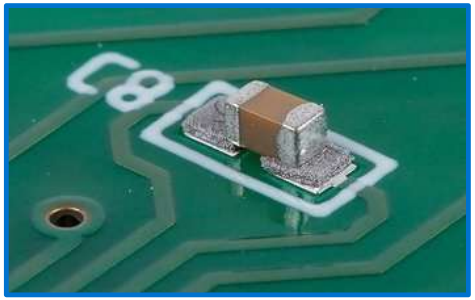
- Automated Component Placement on to the PCB
- High Speed / High Precision Placement by Robotic M/c
- Placement rate is measured as CPH
- Different Nozzles used to place various sizes of Components

Key Words:
- **CPH**
- **Reel**
- **Feeder**
- **Nozzle**







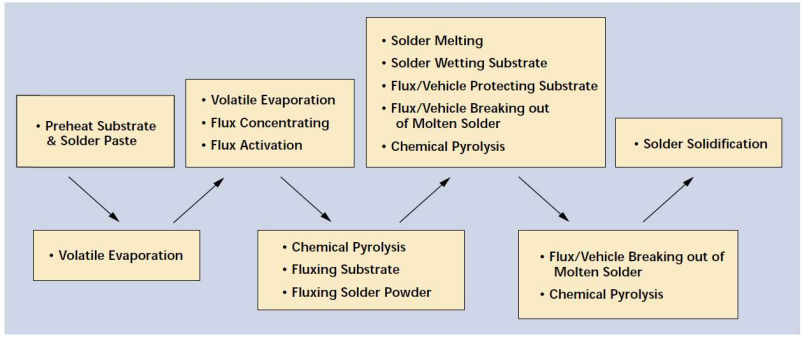


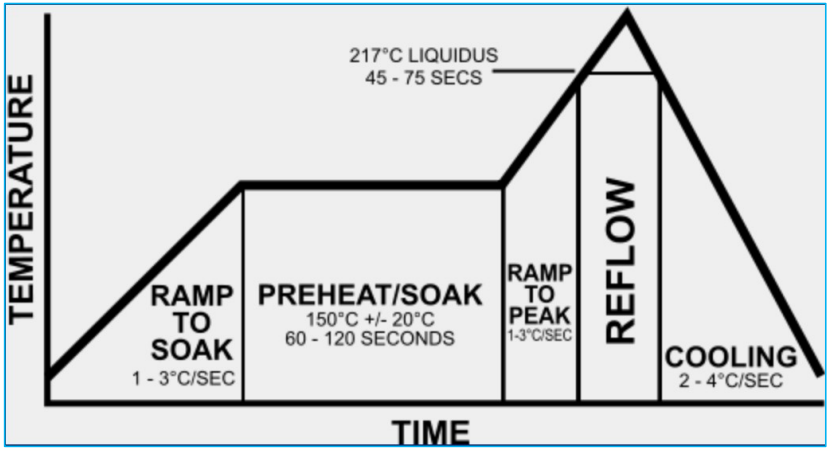
The **New Equipment** high-speed head achieves 37,500 **cph** (chips per hour)

Reflow soldering

Types Reflow soldering
Infrared (IR)
Convective IR
Convection
Vapor Phase
Conduction
Vacuum

- It is the most widely used method
- Series of Reactions & Interactions Happen in Sequence or Parallel
- These can be Chemical, Metallurgical or Physical in nature
- The Key Process parameters that affects integrity of the joints are
  - Pre-heat temp,
  - Pre-heat time,
  - Peak temperature,
  - Dwell time at peak temp &
  - Cooling rate
- The aim of the process is to form acceptable solder joints





https://youtu.be/W2JNsZfRRdc

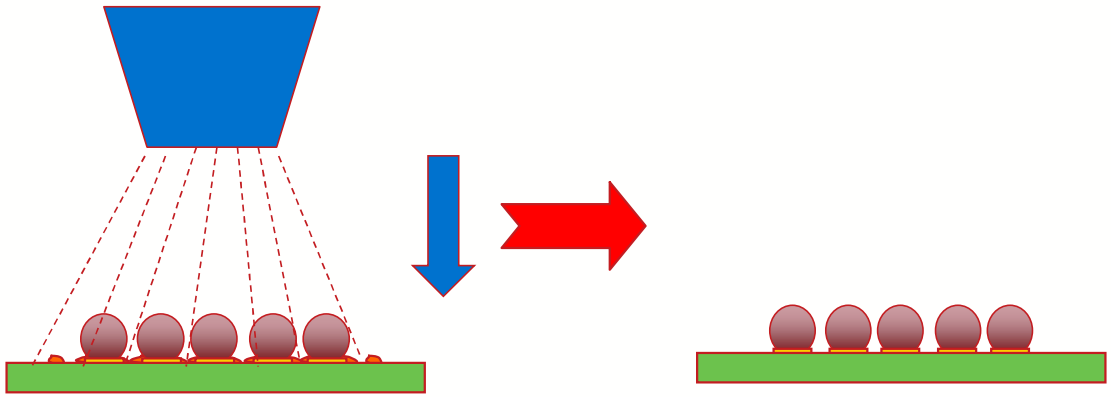
Cleaning PCB Assembly

Electronic assemblies are

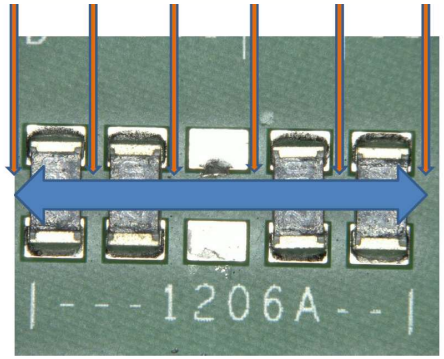
- –Smaller
- –More densely populated
- –Populated with bottom termination components
- –Soldered at higher reflow temperatures

- Trends increase cleaning difficulty
- It is not always required but MUST in certain specific end use assemblies
- Adds time and cost to the production
- Cleaning is required for Water based assembly materials
- Improves post soldering reliability

Cleaning Process



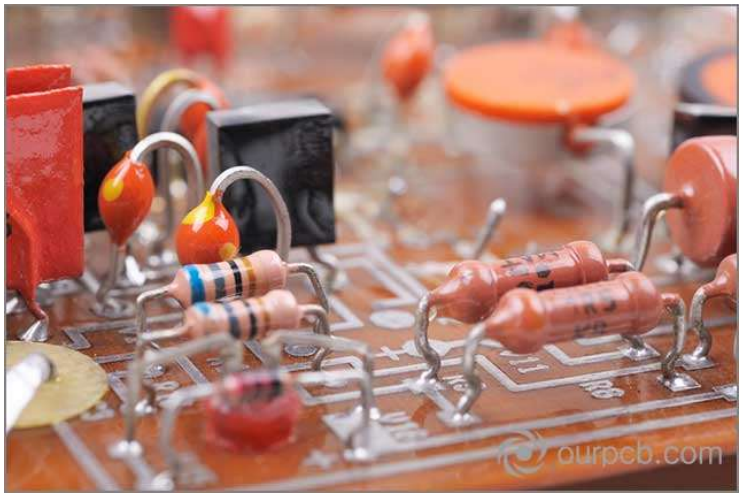
- LED packages demand robust cleaning solutions.
- Cleaning chemistries and processes must remove flux remains and residues without damaging or disturbing materials exposed in the process.



Manual Insertion of TH Components

- Manually fixing different electronic components into the PCB
- Known as stuffing especially, in through-hole assembly
- Those components which cannot be inserted using pick-and-place
- TH components are of inconsistent shape or size

However auto insertion equipment for through hole components are available today custom designed



The Soldering Process

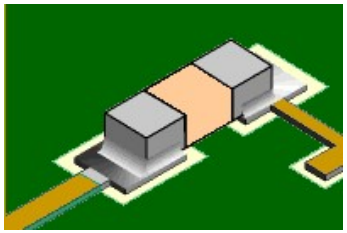
Soldering Explained

A. Solder is used to hold two (or more) conductors in electrical contact with each other.

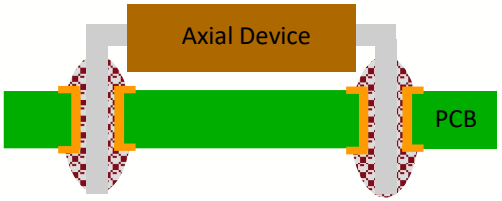
B. Solder is not used to make the electrical contact.

C. Solder is not used to provide the main mechanical support for a joint.

D. Solder is used to encapsulate a joint, prevent oxidation of the joint, and provide minor mechanical support for a connection

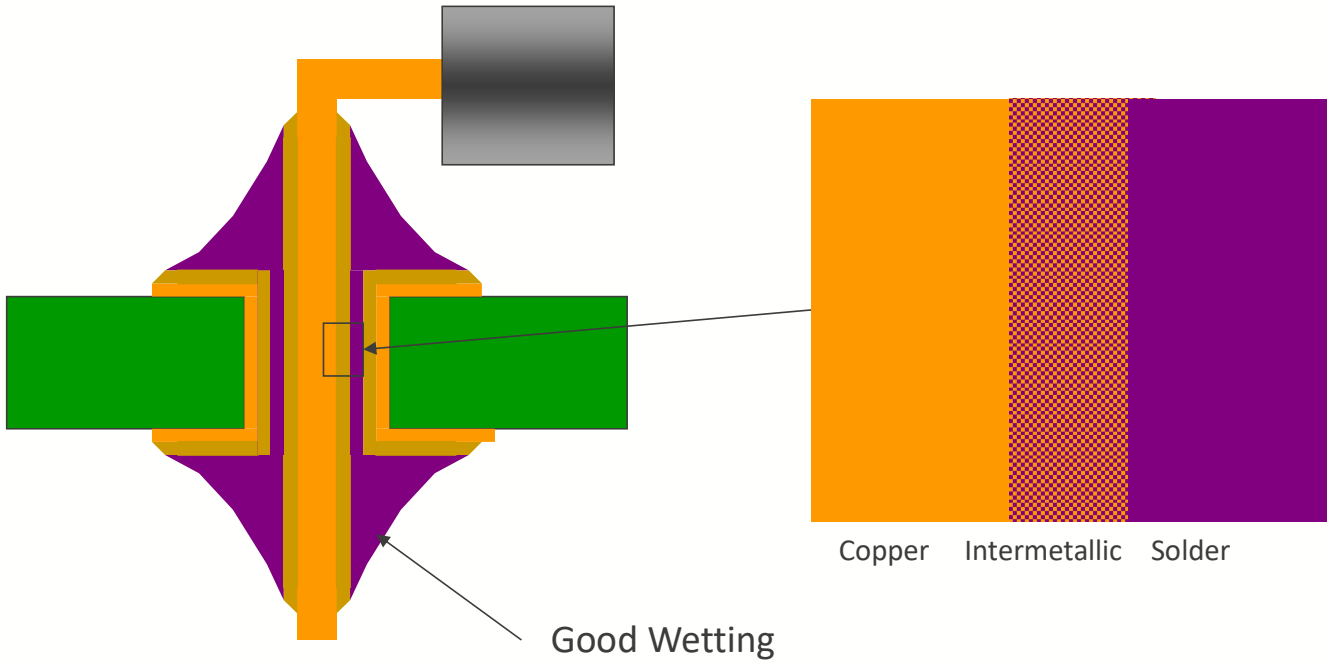


Surface Mount Technology (SMT)



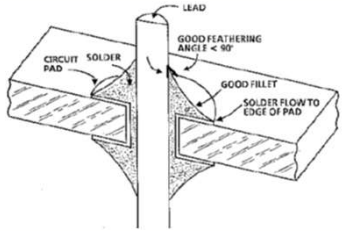
Through hole (TH)

Inter-metallics

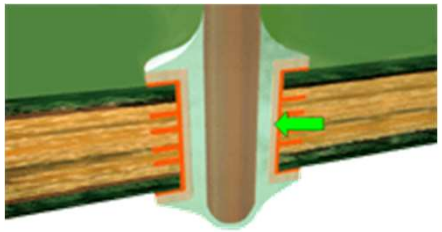


Wetting

- **Solder wetting** is the part of the process in which metal in the **solder** bonds with metal on the printed circuit board (PCB) or component.
- A surface is wetted when the solder flows well, forming a continuous, unbroken film, free of pinholes and depressions.
- It is the formation of a relatively uniform, smooth, unbroken and adherent film of solder to the base metal. Base metal not exposed upon soldering.
- Populated plated through holes (PTH) should exhibit a vertical solder fill of 100%, with a fully formed fillet on the solder side, and evidence of 100% wetting on the component side lead, barrel and pad.

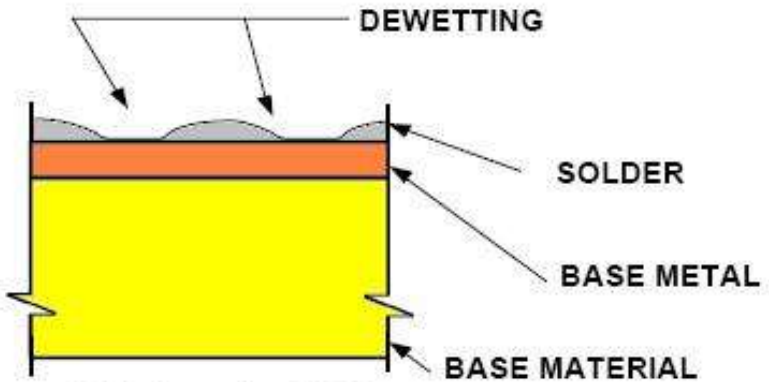


Schematic view of good wetting of a lead



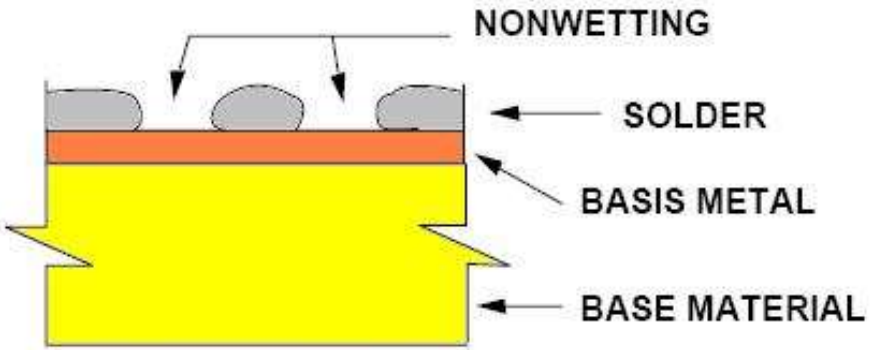
Wetting

Base Metal NOT EXPOSED



Solder dewetting. *(IPC.)*

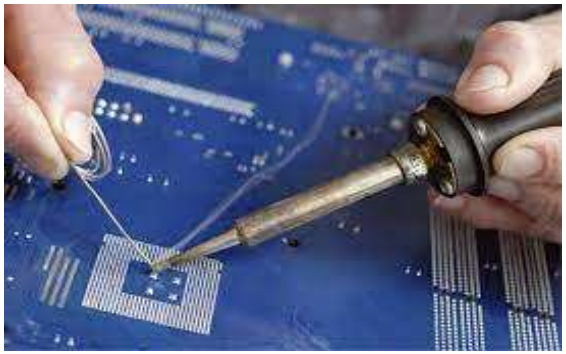
Base Metal EXPOSED

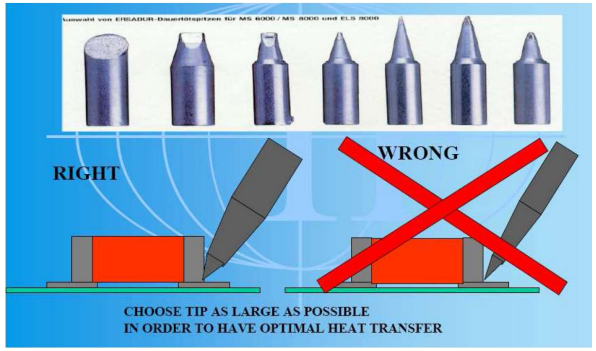


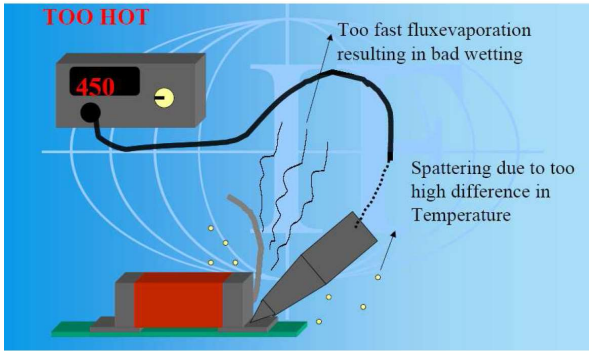
Solder nonwetting. *(IPC.)*

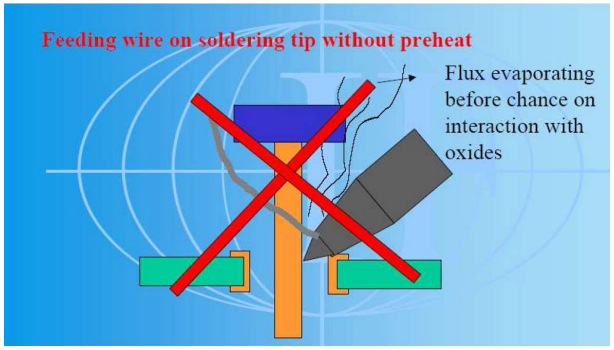
Hand / manual Soldering

- Manual soldering is a bit outdated and is not used anymore for batch production.
- In automotive it's even not allowed anymore for reasons of quality assurance.
- It is done for components with special requirements or repair
- In cases where the selective soldering robot cannot be used
- The skills and expertise of the soldering operator is crucial









https://www.eurocircuits.com/assembly-manufacturing-technology/manual-soldering/

PCBA tests mainly include:

ICT test, FCT test, burn-in test, fatigue test, and test in harsh environment.

- The ICT (In Circuit) test mainly includes the circuit's on/off, voltage and current values and fluctuation curves, amplitude, and noise.
- FCT (Functional) test requires IC program firing, simulates the function of the entire PCBA board, finds problems in hardware and software, and equips with necessary chip processing to produce fixtures and test stands.
- The fatigue test is mainly to sample the PCBA board, and perform high-frequency and long-term operation of the function
- It is to observe whether there is a failure and judge the probability of the test failure, so as to feedback the working performance of the PCBA board in the electronic product.

Functional Test

- The functional test after assembly of the PCBA circuit board is generally called FVT (Function Verification Test) or FCT (Function Test).
- Its purpose is to capture the poorly assembled board and install it through the analogue circuit board.
- Full-featured testing to be done in order to capture the circuit assembly board that may be defective before assembling into the final box build
- If found defective after assembling into the final product, it has to be completely dismantled
- It is a waste of time & Loss of material.

Testing in Harsh Environment

- The test is mainly to expose the PCBA board to the
  - limit temperature,
  - humidity, drop,
  - splashing water and
  - vibration
- This kind of test is done to obtain the test result of a random sample
- To infer the reliability of the entire PCBA board batch product.
- The aging test is mainly to energize the PCBA board and electronic products for a long time, keep them working to observe whether there is any failure.
- After the aging test, the electronic products can be sold in batches.

Final Assembly

- "**Box build''** - also known as systems integration, is the complete assembly of a customer's finished product.

- The process goes beyond the production of printed circuit boards (PCBs), extending to
  - *electro-mechanical assembly that includes enclosure fabrication,*
  - *installation and routing of cables or wire harnesses, and*
  - *installation of sub-assemblies and components.*

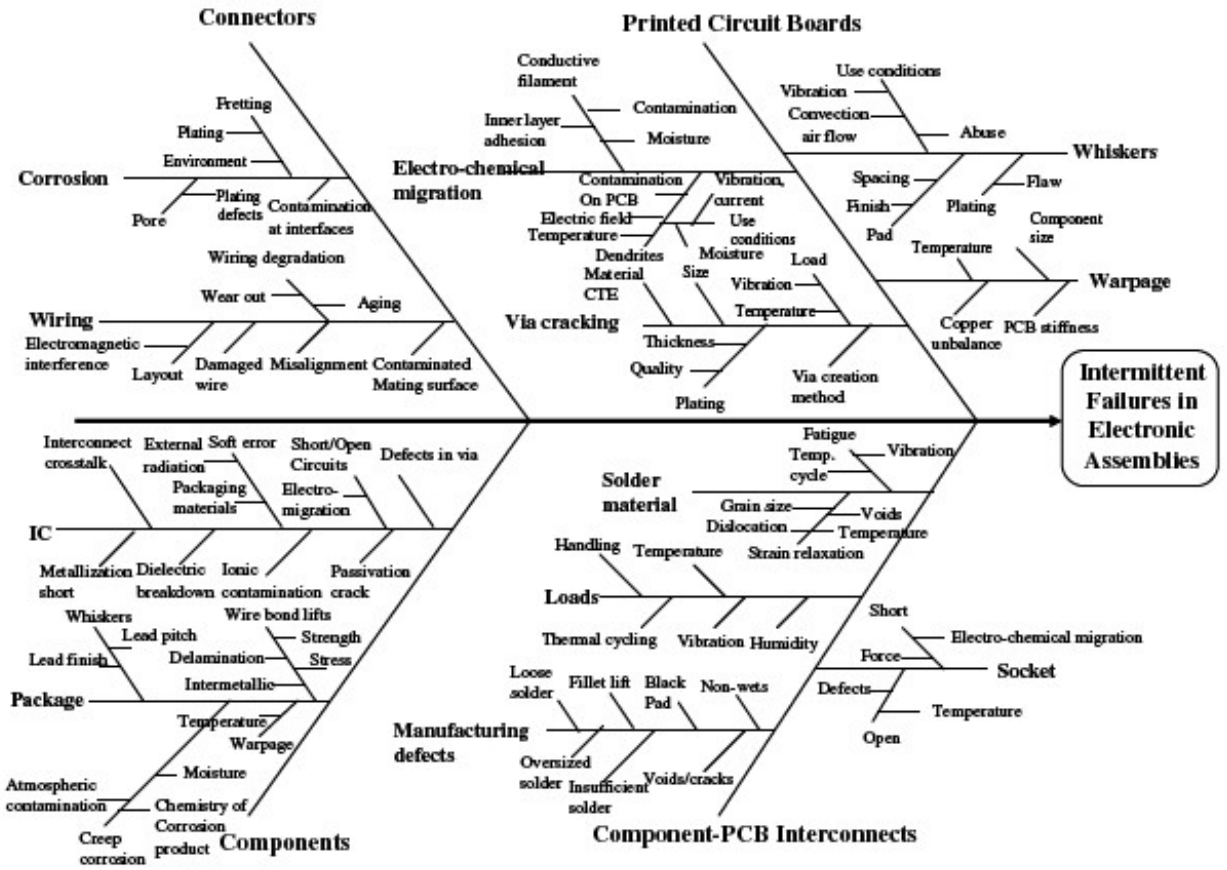
The box can refer to a PCB Assembly (PCBA) in a cabinet full of wires, a small enclosure, or a complex, fully integrated electro-mechanical system with pneumatics and electronics.

Final Assembly

These include the following components of box build assembly:

- Product assembly
- System-level assembly
- Sub-level product assembly
- Packaging and labelling
- Testing
- Software loading and product configuration
- Aftermarket service
- Warehousing and traceability

Assembly Issues



IPC STD

It is the industry-adopted IPC standards that govern every step related to the design, assembly, inspection, testing, and documentation of printed circuit boards (PCBs).

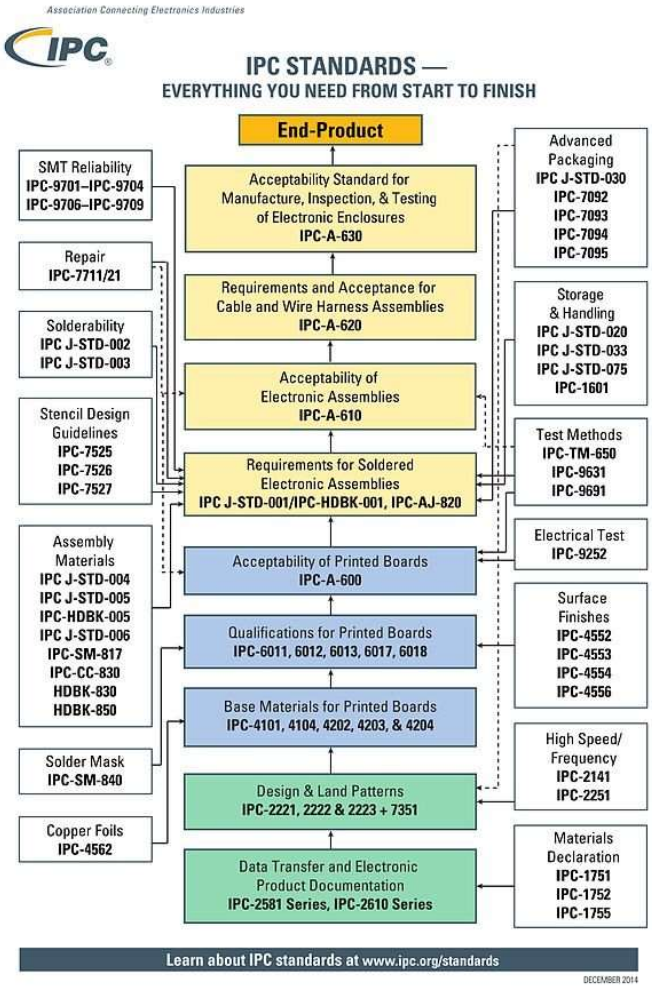
IPC is the official name of the association which produces PCB-related standards.

The association was formerly called the Institute for Printed Circuits (hence the acronym "IPC"), but is presently called the Association Connecting Electronics Industries—even though it retains the IPC moniker.

What Are IPC Standards?

IPC, itself, is an international industry association consisting of more than 4,000 member companies that make, use, specify, and design PCBs and assemblies, including:

- advanced microelectronics
- aerospace and military
- Automotive
- Computer
- industrial equipment
- medical equipment and devices
- telecommunications industry


Association Connecting Electronics Industries
IPC
IPC STANDARDS —
EVERYTHING YOU NEED FROM START TO FINISH
End-Product
SMT Reliability
IPC-9701–IPC-9704
IPC-9706–IPC-9709
Repair
IPC-7711/21
Solderability
IPC J-STD-002
IPC J-STD-003
Stencil Design Guidelines
IPC-7525
IPC-7526
IPC-7527
Assembly Materials
IPC J-STD-004
IPC J-STD-005
IPC-HDBK-005
IPC J-STD-006
IPC-SM-817
IPC-CC-830
HDBK-830
HDBK-850
Solder Mask
IPC-SM-840
Copper Foils
IPC-4562
Acceptability Standard for Manufacture, Inspection, & Testing of Electronic Enclosures
IPC-A-630
Requirements and Acceptance for Cable and Wire Harness Assemblies
IPC-A-620
Acceptability of Electronic Assemblies
IPC-A-610
Requirements for Soldered Electronic Assemblies
IPC J-STD-001/IPC-HDBK-001, IPC-AJ-820
Acceptability of Printed Boards
IPC-A-600
Qualifications for Printed Boards
IPC-6011, 6012, 6013, 6017, 6018
Base Materials for Printed Boards
IPC-4101, 4104, 4202, 4203, & 4204
Design & Land Patterns
IPC-2221, 2222 & 2223 + 7351
Data Transfer and Electronic Product Documentation
IPC-2581 Series, IPC-2610 Series
Advanced Packaging
IPC J-STD-030
IPC-7092
IPC-7093
IPC-7094
IPC-7095
Storage & Handling
IPC J-STD-020
IPC J-STD-033
IPC J-STD-075
IPC-1601
Test Methods
IPC-TM-650
IPC-9631
IPC-9691
Electrical Test
IPC-9252
Surface Finishes
IPC-4552
IPC-4553
IPC-4554
IPC-4556
High Speed/ Frequency
IPC-2141
IPC-2251
Materials Declaration
IPC-1751
IPC-1752
IPC-1755
Learn about IPC standards at www.ipc.org/standards
DECEMBER 2014

Key safety Methods

Electrostatic Discharge (ESD)

- Certain components used in electronic assemblies are **sensitive to static electricity**
- Can be damaged by its discharge.
- Destructive static charges are induced on nearby conductors,
  - **human skin, and delivered in the form of sparks passing between conductors**,
  - when the surface of the assembly is touched by a person having a static charge potential.
- If touched at the right solder joint or conductive pattern, the circuit board assembly can be damaged
- The discharge passes through the conductive pattern to a static sensitive component.
- The static damage level for components cannot be felt by humans. (Less than 3,000 volts.)

Electrical Overstress (EOS)

- Damage caused by generation of unwanted energy;
- Spikes occurring within soldering irons,
- Solder extractors,
- Testing instruments and other electrically operated equipment.

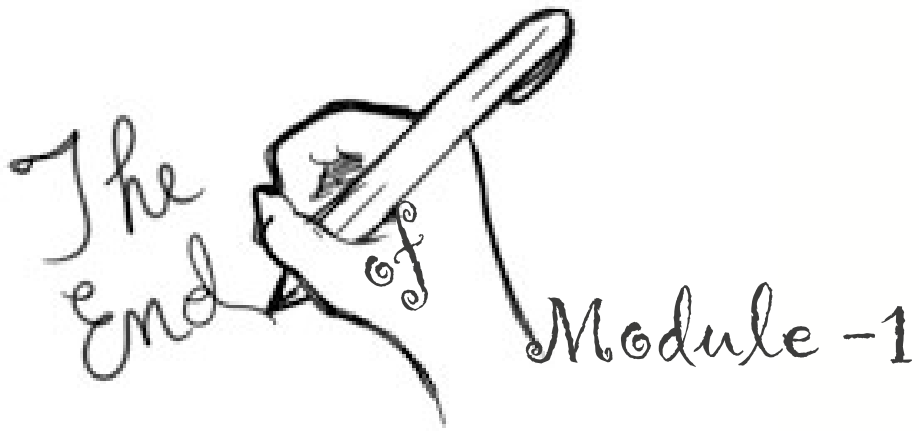
ESD/EOS Safe Work Areas

- It is to prevent damage to sensitive components from spikes and static discharges.
- These areas must be designed and maintained to prevent ESD/EOS damage.

Handling the PCBA

- A circuit board assembly the operator must be properly grounded
  a. Wearing a wrist strap connected to earth ground.
  b. Wearing 2 heel grounders and have both feet on a static dissipative floor surface.

- Circuit board assemblies should be handled by the edges.
- Avoid touching the circuits or components.
- Components should be handled by the edges when possible.
- Avoid touching the component leads.
- Hand creams and lotions containing silicone must not be used
- Stacking of circuit boards and assemblies should be avoided
- Special racks and trays are available for handling.



ANY QUESTIONS?