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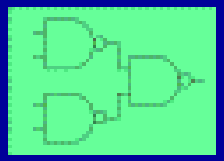

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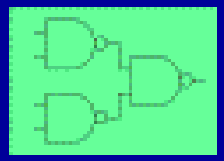


Electronics in High Energy Physics

Winter Term: Introduction to Electronics in HEP

Printed Circuit Boards (PCB) and Hybrids: Part 1 Design and Assembly

Betty Magnin / TS-DEM

3 February 2005

From schematic to assembly

A 3-step process

Design of PCB layout

1. Design steps
2. Tools
3. Good practice

Design of PCB layout

1. Design steps
   - Select and create components
   - Capture schematics
   - Define mechanical layout
   - Place components
   - Define PCB stackup
   - Routing
   - Autorouting
   - Post routing issues
   - Create manufacturing and assembly documents

Design of PCB layout

Select and create components

- Search into libraries
- Select according to electrical requirements
- Select component package (PTH/SMD, QFP/BGA, …)
- Create new components (standardize)

Design of PCB layout

Capture schematics

- Use hierarchical structure (pages, blocks)
- Insert all components (decoupling caps, safety components,..)
- Trace bus and interconnections
- Arrange the presentation
- Verify (NC, all 0V, grounds and power supplies, …)

Design of PCB layout

Define mechanical layout

- Specific or standard formats (3U, 6U, 9U…)
- Mechanical requirements (fixing holes, cooling, ...)
- Position of components on the front panel

Design of PCB layout

Place components

- Electrical constraints (Impedance, EMC, RF, …)
- Mechanical constraints (limited height, cooling…)
- Assembly process (PTH/SMD, top, bottom, clearance for machines,…)

Design of PCB layout

Determine the PCB layer stackup

- Even number of copper layers
- Symmetrical stackup
- Voltage planes next to ground planes to form embedded capacitors
- Impedance requirements

Design of PCB layout

PCB Routing

- Electrical requirements (line spacing and width, impedance, …)
- Iterative process between placing and routing
- Consider manufacturing capabilities
- Add test pads (for automatic test fixture)

Design of PCB layout

Autorouting

- Saves time for simple designs or simple parts of complex designs
- Routes according to specified parameters
- Not always optimum in terms of PCB manufacturing cost and efficiency (increases number of vias and density of lines)
- Suited for small quantities

Design of PCB layout

Post routing issues

- Add identification (part name, number, revision, …)
- Analyze the layout for potential signal integrity problems
- Add copper surfaces to equalize copper density
- Use CAD control tools to verify (minimum line spacing, shorts or not connected, …)

Design of PCB layout

Create specification for manufacturing and assembly

- Generate Gerber files for layers, use Extended Gerber (embedded apertures) format
- Generate drilling files
- Specify stackup and impedance controlled layers, laminate, marking, solder mask, finish required, hole plating requirements
- Create BOM and placing files for assembly
- Create a panel drawing (several PCB’s on one panel)

Design of PCB layout

2. Tools
   - Design
   - Documentation for assembly
   - Archiving

Design of PCB layout

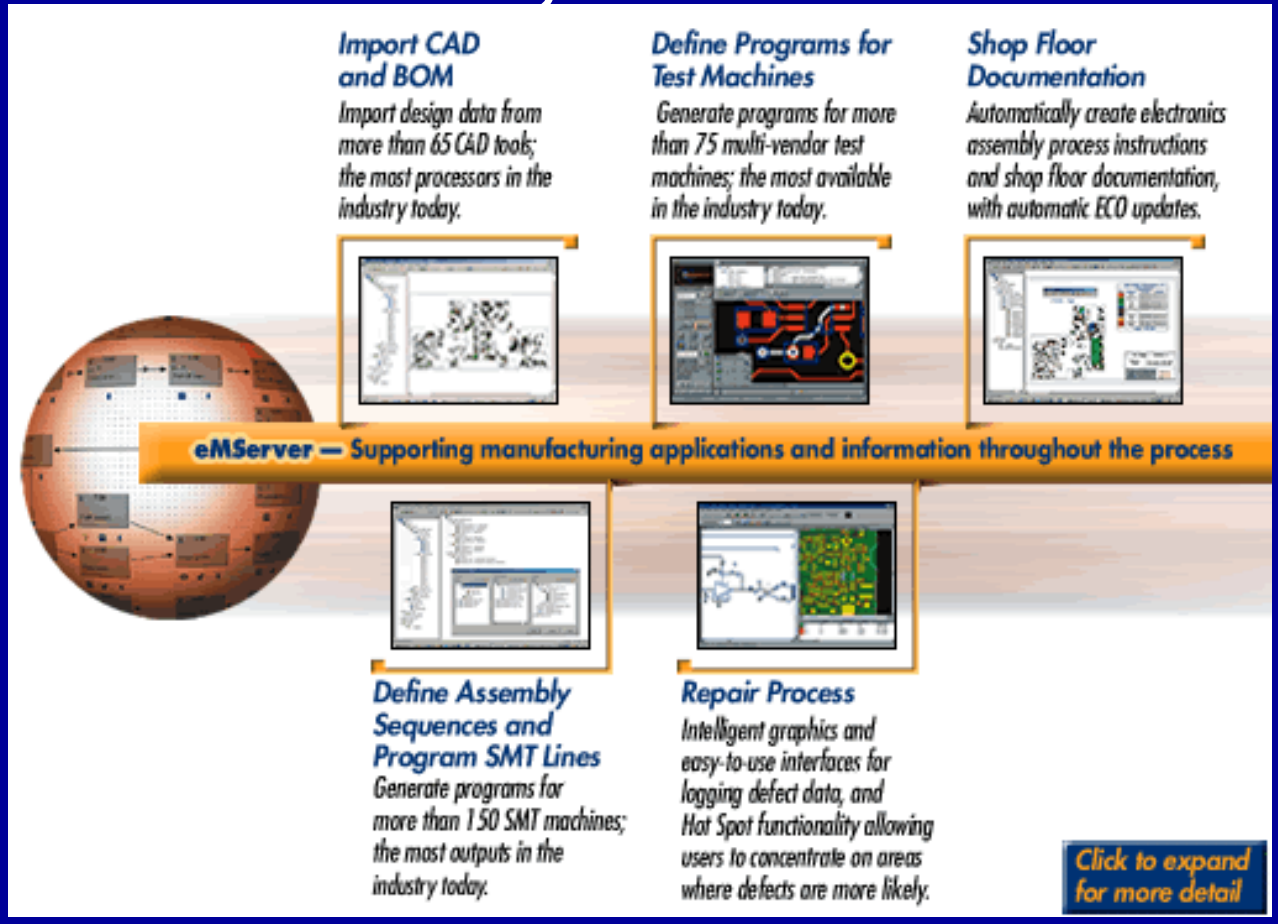
Design

- PCAD, CADENCE : maintained at CERN (training, support by IT and design office, centralized CERN library, …)
- MENTOR, PROTEL, Express PCB, Eagle, WinqCAD, Target 3AD, PCB123, CAD Design,…

Design of PCB layout

Documentation for assembly

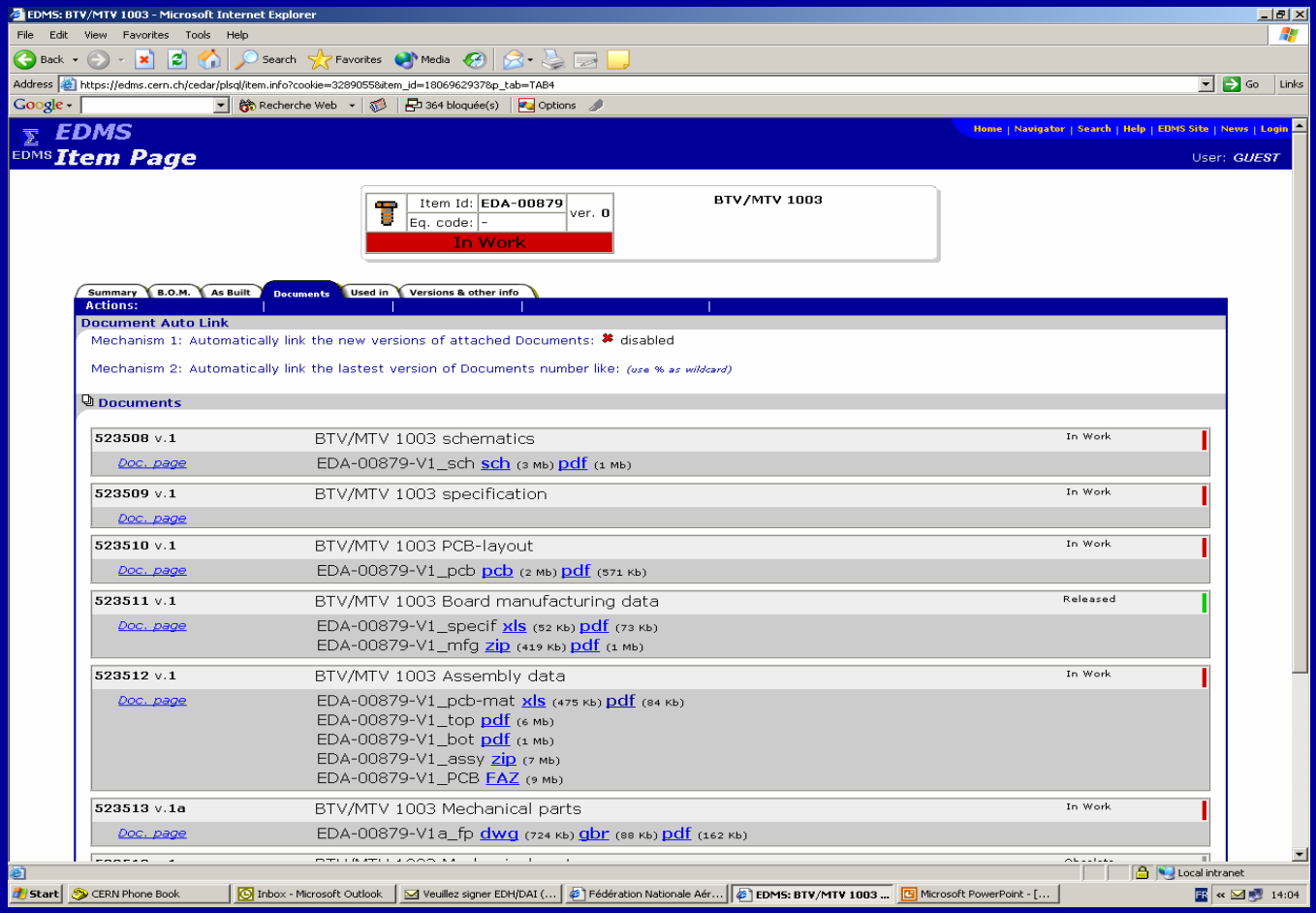
Fabmaster



Design of PCB layout

Archiving

EDMS



Design of PCB layout

3. Good practice

- Clearly specify all requirements before starting a layout: do it right the first time, rather than adding continuous changes will save time and problems (use check-lists and design reviews)
- Comply with manufacturing and assembly design rules when designing libraries and layout: fiducials, locating holes, minimum panel size, pads for wave soldering, distance around a component for inspection and repair, …

Design of PCB layout

3. Good practice

- Keep in touch with progress in technologies: Pb-free will have an influence on a layout !
- Comply with known standards: IPC working groups have already done the job
- Use all possible tools to verify each step (Cadence : Checkplus, ..)
- Provide a clear and complete job to manufacturing and assembly: they cannot guess what you expect if you do not tell them (write instead of say)

From schematic to assembly

A 3-step process

Assembly

- Components
- Variants of layouts
- Assembly steps
- Assembly process: automatic or manual
- Conditions for quality

Assembly

Components

- Through hole (PTH, Trad, …)
- Surface mount (SMD, CMS, …)
- Packaging : row, tape and reels, sticks, trays

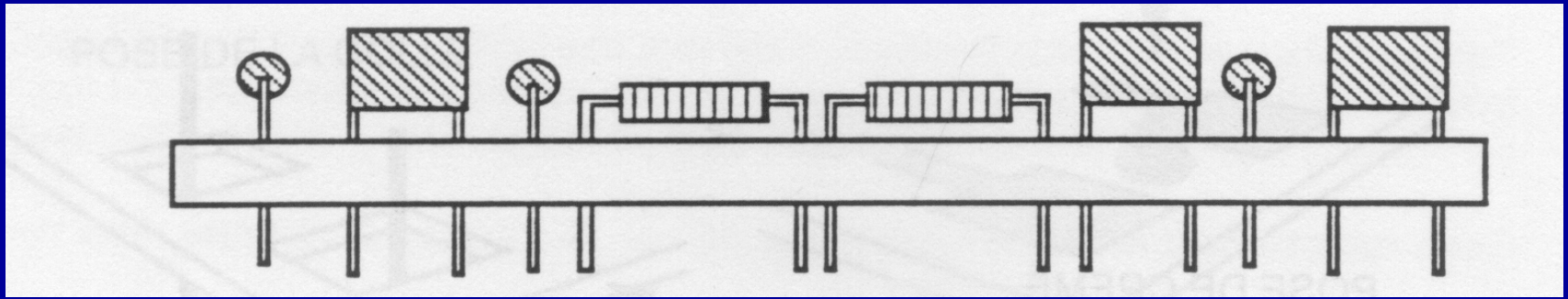
Assembly

Layout

- Components may be placed on several manners
- Each will have an influence on the process to be used

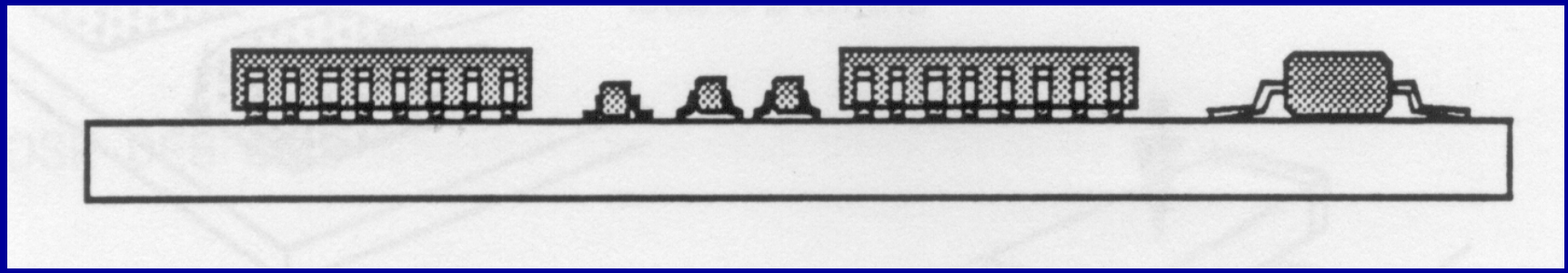
Assembly

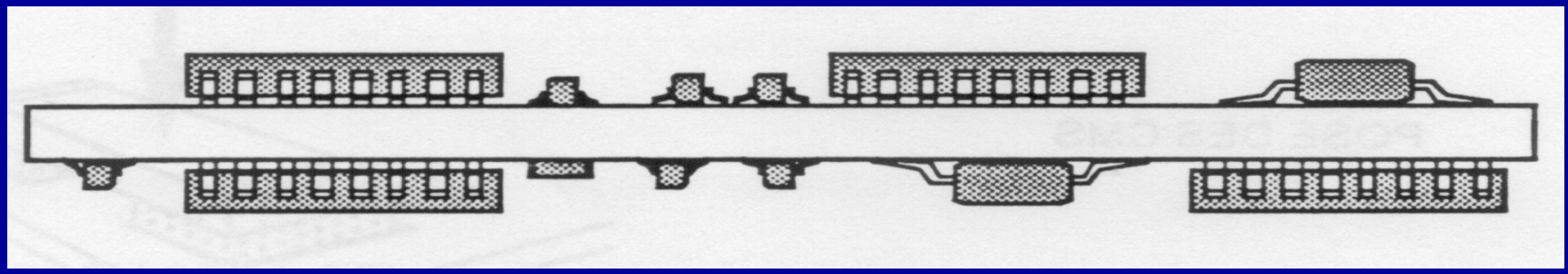
Through hole



Assembly

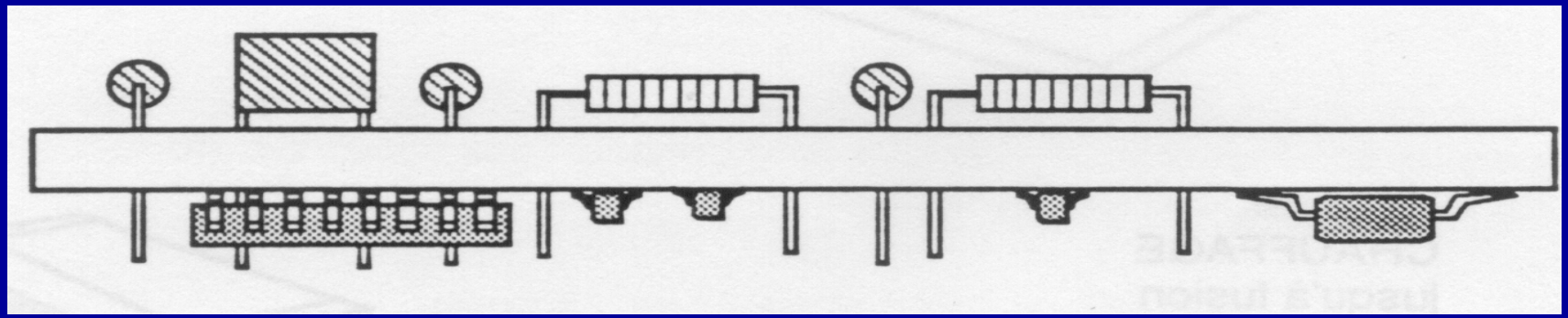
SMD, single side or both sides





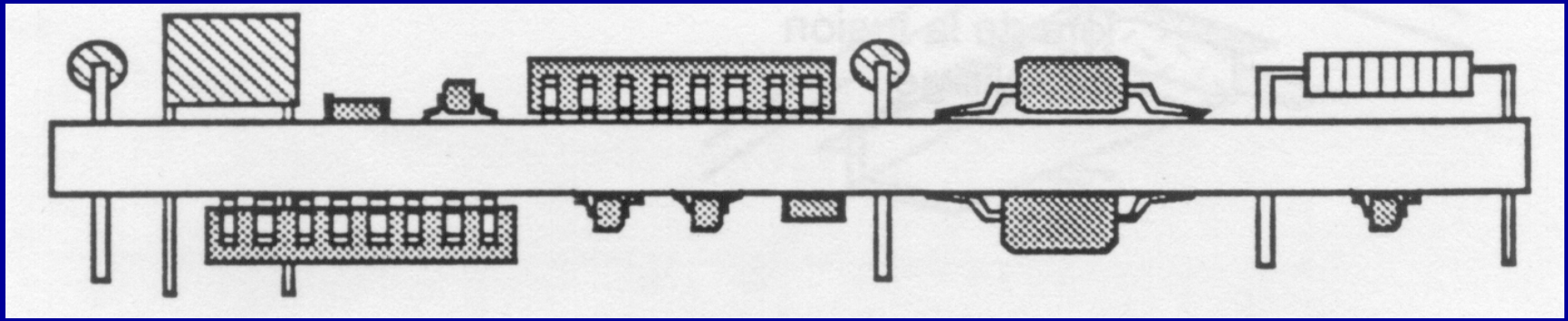
Assembly

Trad + SMD-bottom



Assembly

Trad + SMD-top + SMD-bottom



Assembly

Assembly steps

- Prepare components
- Mount
- Solder
- Clean
- Inspect
- Repair

Assembly

Assembly processes

- 100% machine
- 100% manual
- Mixed (used at CERN)

Assembly

100% machine

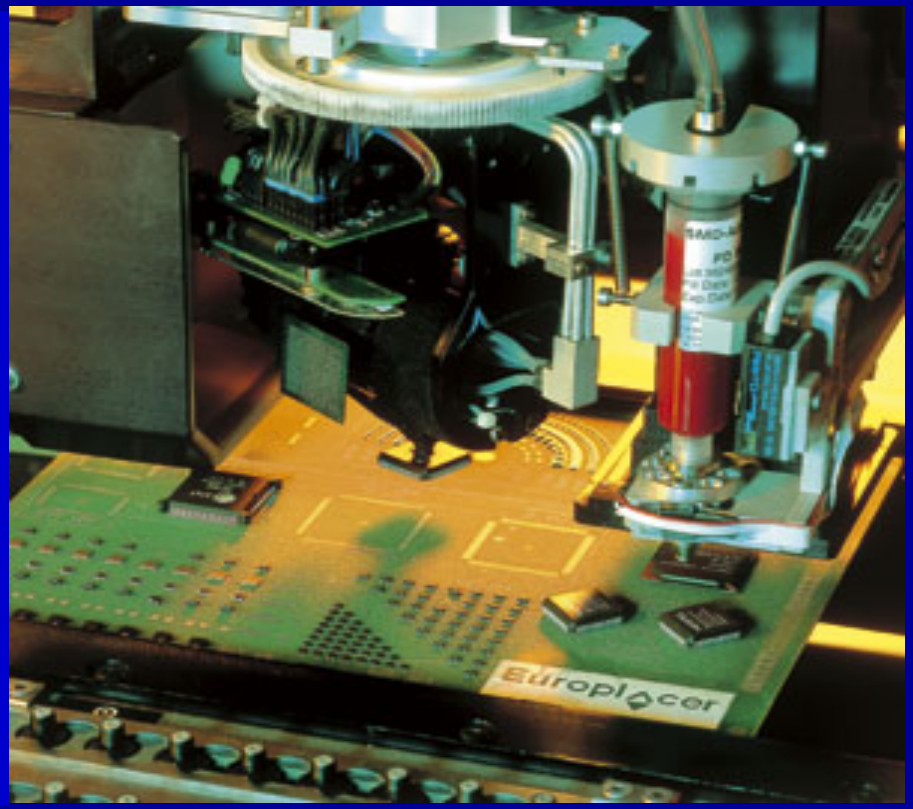
- Process for series (>30 pieces)
- Manufacturing price is important for large quantities
- Components on tapes and reels or trays
- Board design must respect design rules (solder pads, fiducials, board sizes, spacing around components, …)

Assembly

Screen printing of solder paste

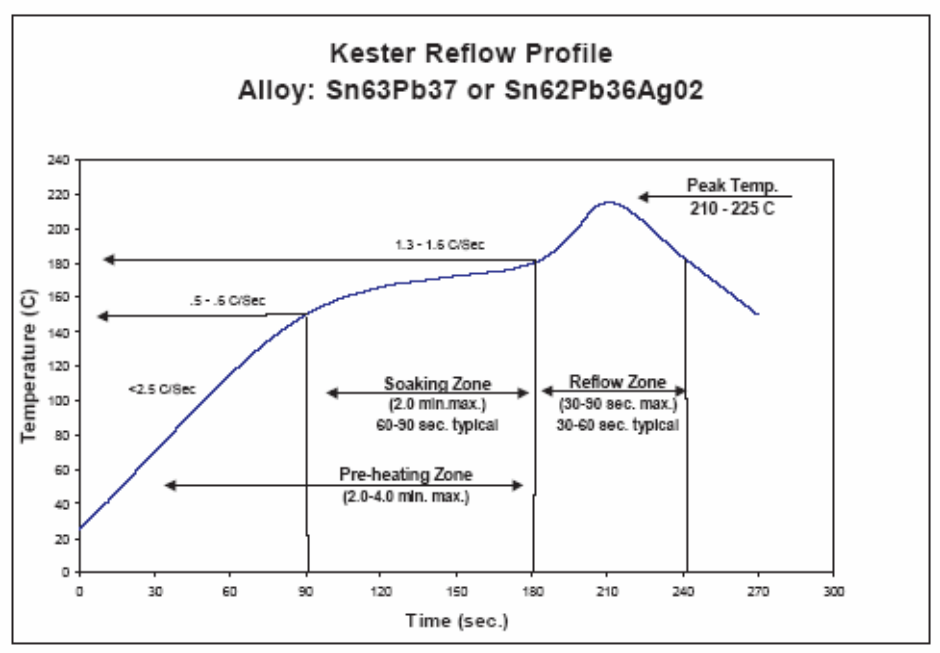
Assembly

Placement of SMD components



Assembly

Reflow soldering: convection, IR, vapor phase

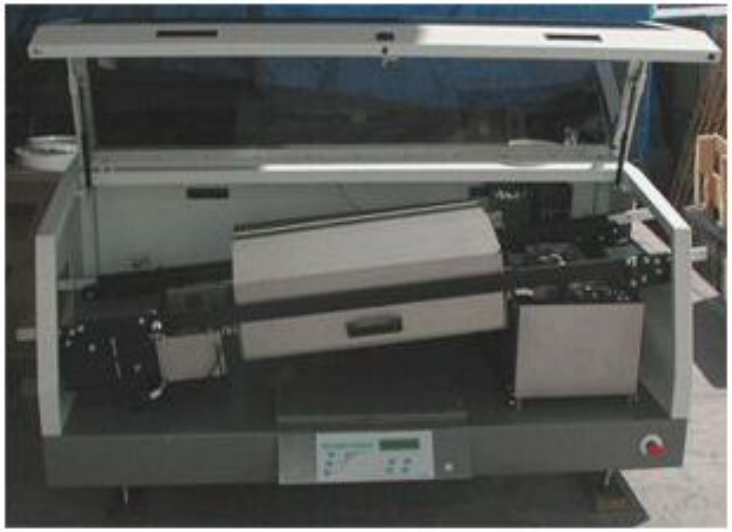


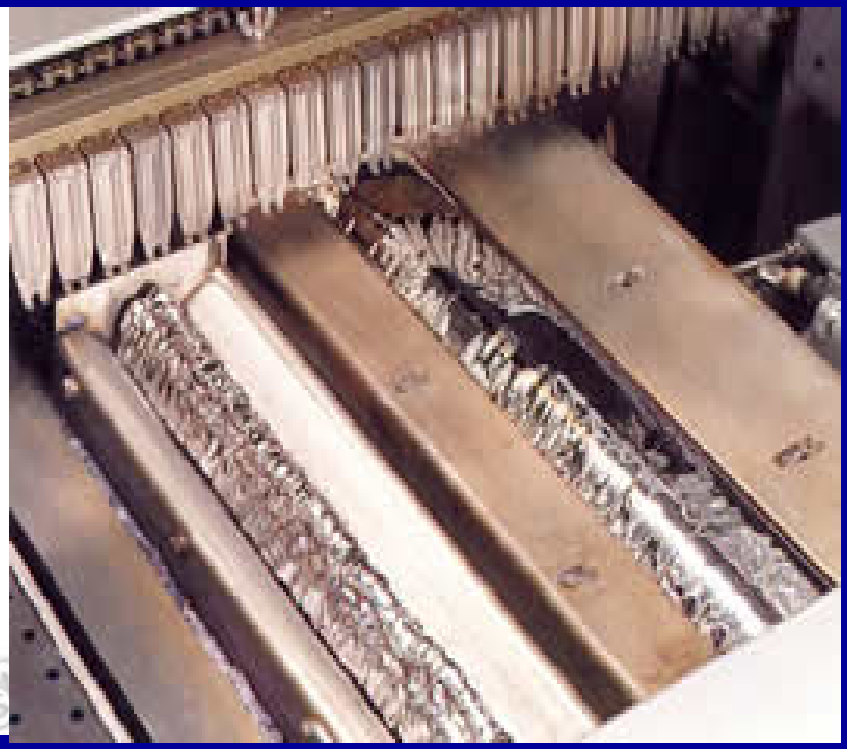
Assembly

Insertion of through hole components, automatic or manual

Assembly

Wave soldering



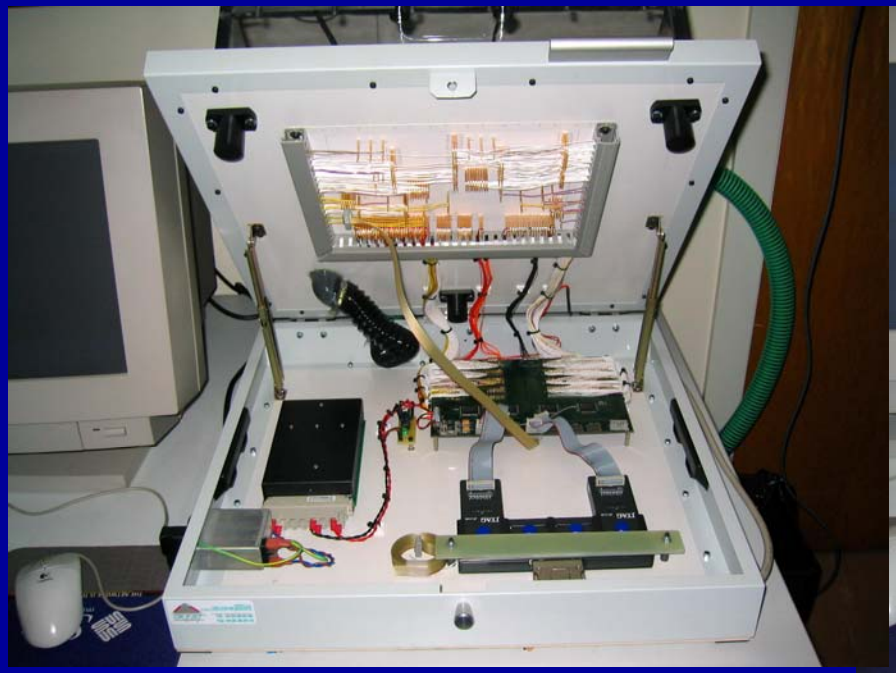


Assembly

Inspection
AOI

Assembly

Test: In-Circuit, flying probe, dedicated functional



Assembly

Manual or semi-manual process

- Process for prototypes or small series
- Handling of bulk components or parts of tapes is possible, but not preferable (risk in handling and placement of polarized components, …)
- May use parts of automatic process (i.e.: placement of 100 coupling caps on 3 boards, reflow soldering, …)
- Board design must respect design rules (SMD pads, free space around components, fiducial for solder paste dispensing or machine placement, …)
- Expensive process

Assembly

Solder paste dispensing

Assembly

Placement

Assembly

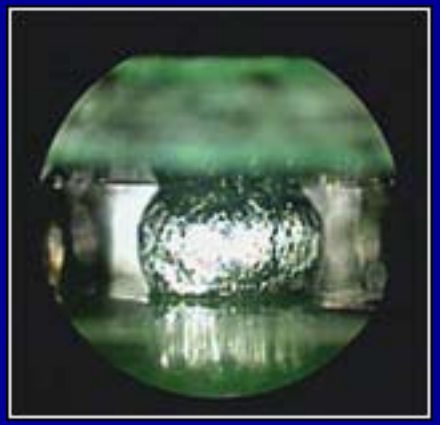
Hand soldering

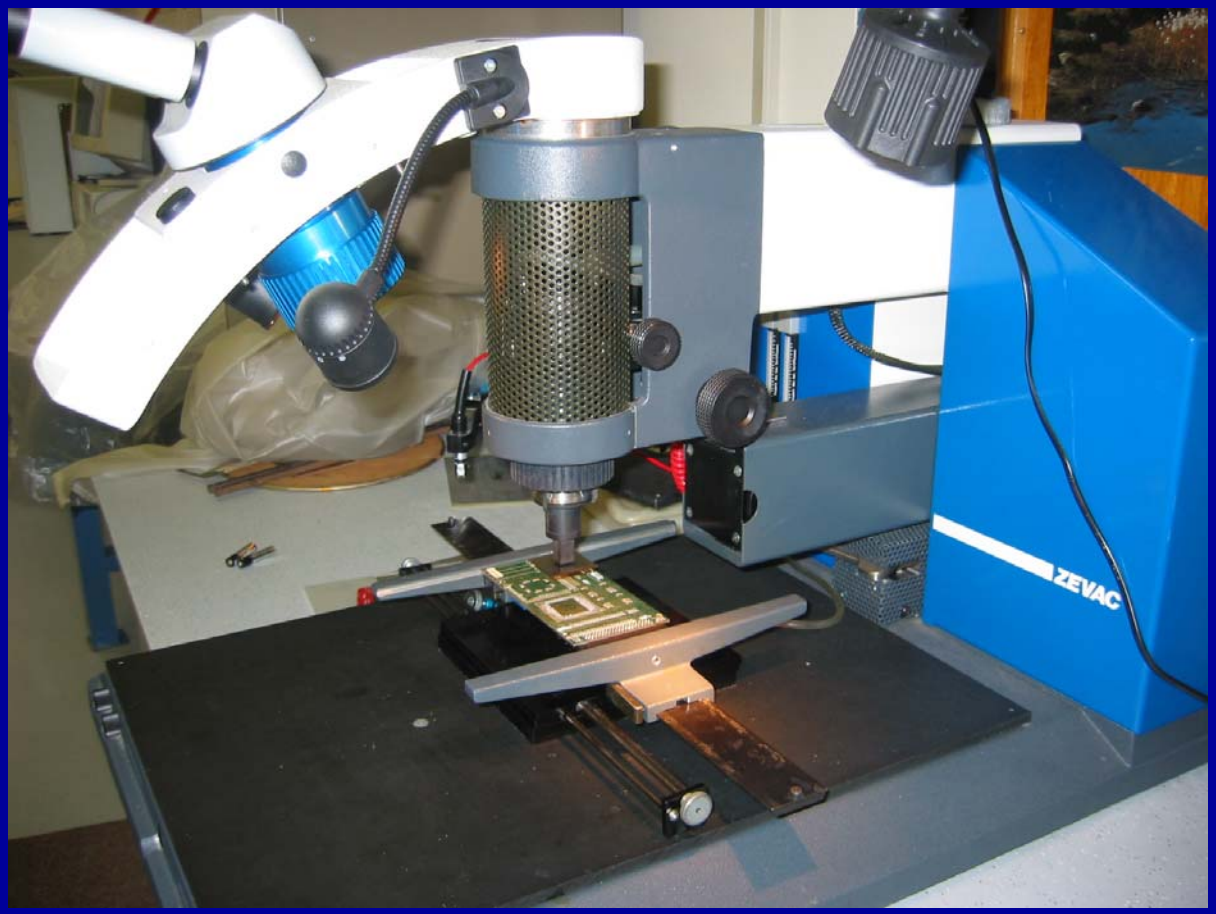
Assembly

Visual inspection

Assembly

Repair

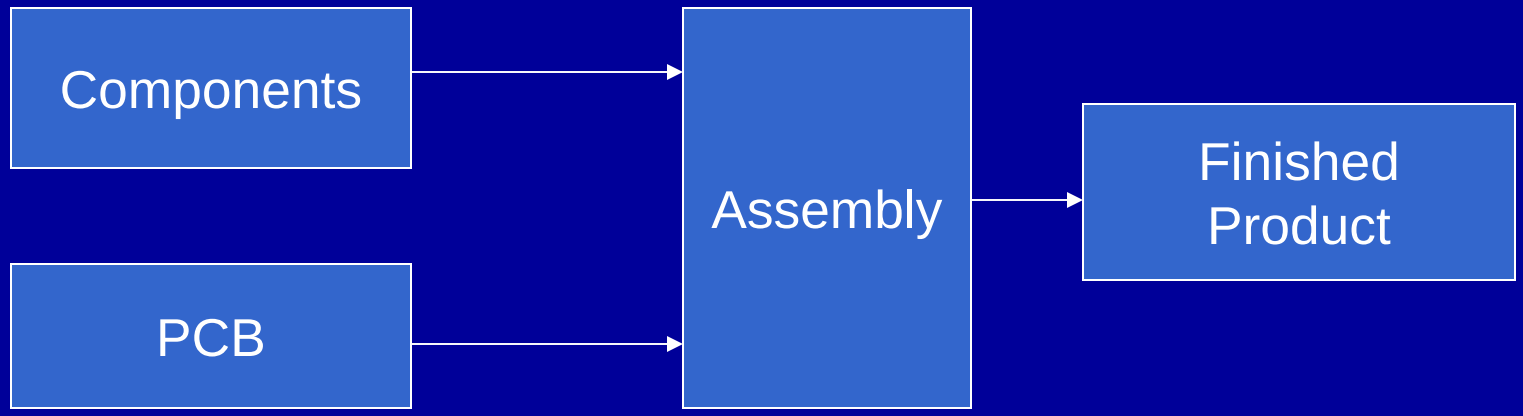




Assembly

Conditions for quality

- Quality of assembly process
- Quality of components
- Quality of design



Assembly

Quality of assembly process

- Machines and processes understood and under control
- Trained operators
- Repetitive results
- Cleanliness is mandatory for reliability

Assembly

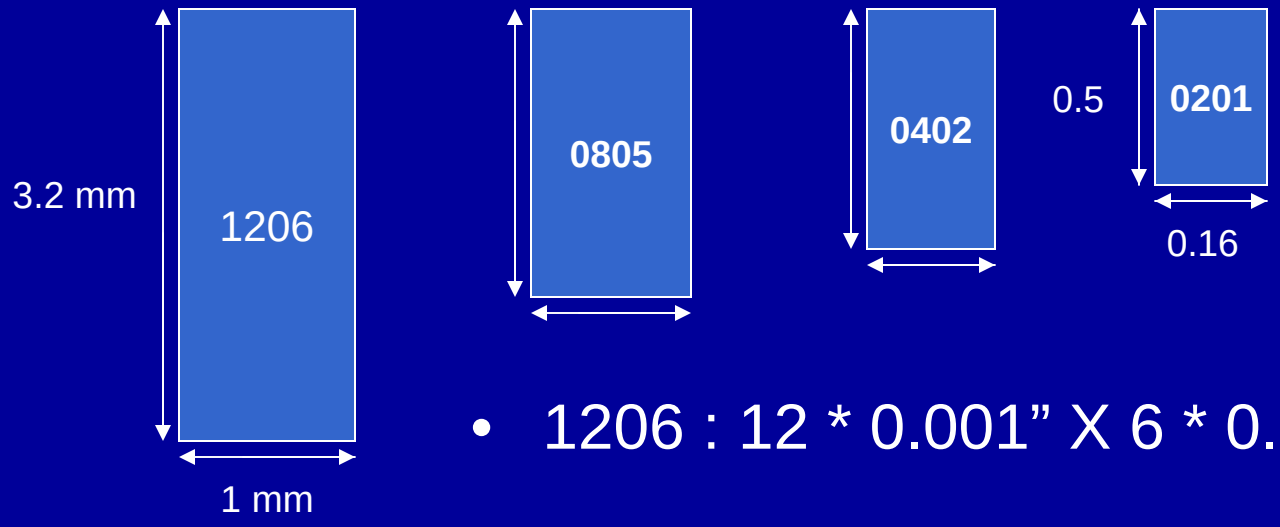
Quality of components

- Protect from
  - Humidity
  - Static discharge
  - Mechanical damage (bent pins)
  - Oxidation
- Allow automatic handling
  - Even for manual process

Assembly

Quality of components

- PCB is the most important component
- Adapted to controlled process



- 1206 : 12 * 0.001” X 6 * 0.001”

Assembly

Quality of design

- Designer's functional requirements
- Manufacturing requirements
- Assembly requirements
- Compliance with tested standards (IPC)
- In phase with current technologies (lead-free)

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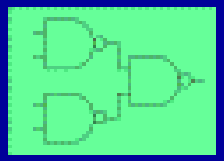

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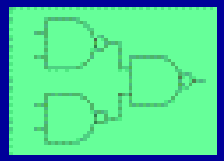

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