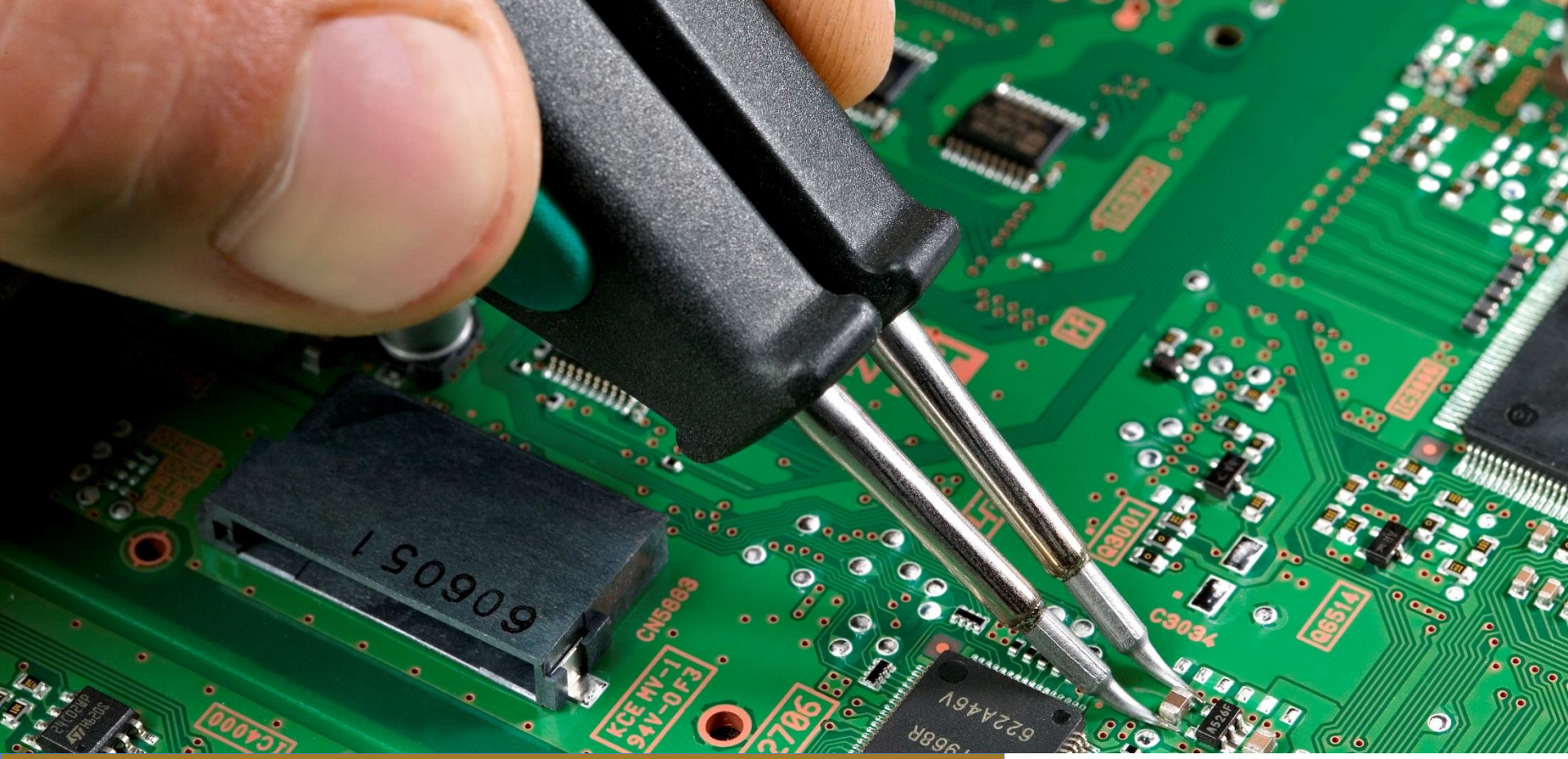

# SOLDERING, ASSEMBLY, AND MANUFACTURING



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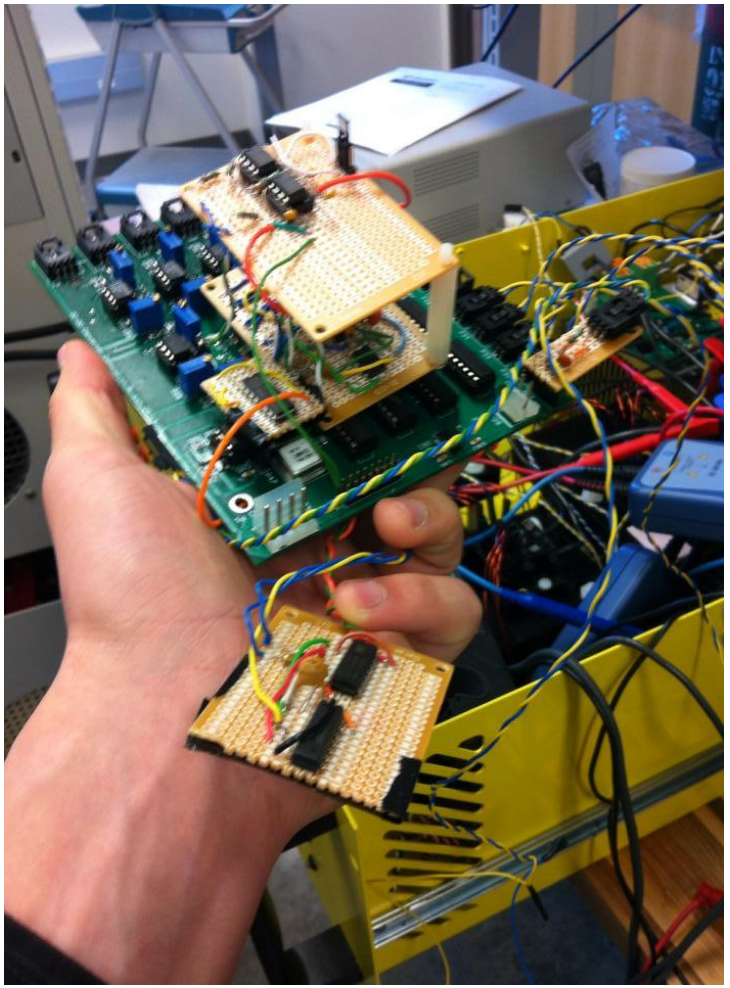
# OUTLINE

- Importance of soldering
- Soldering equipment, tools, and supplies
- How do solder and flux work?
- Electrostatic discharge (ESD) and safety considerations
- Through-hole soldering techniques
- Surface mount soldering techniques
- Hot air rework
- Common soldering pitfalls

# IMPORTANCE OF SOLDERING

- Valuable engineering skill (in research, entrepreneurship, or industry)
- Able to correct minor hardware issues discovered after PCB is received (“flywiring”)
- Able to fabricate one-off prototypes, designs, and proof-of-concepts



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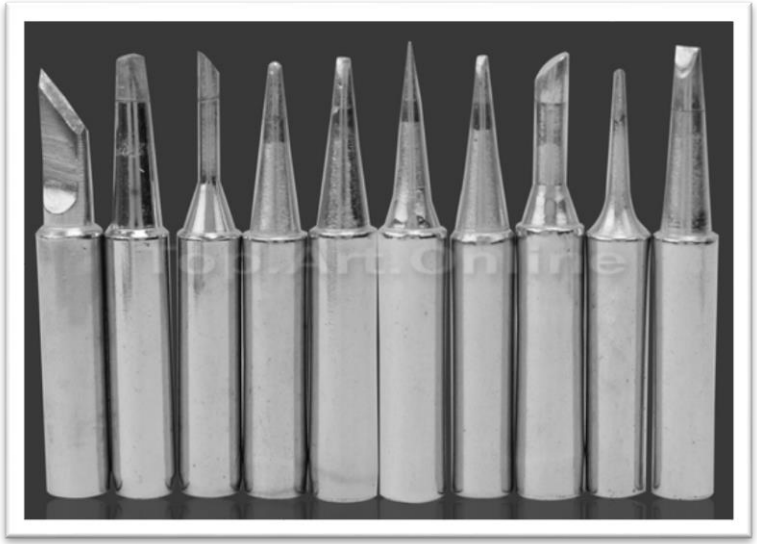
# SOLDERING EQUIPMENT AND TOOLS

## Soldering Iron, Sponge, Tips

- Soldering Iron:
  - Temperature controlled, heats soldering probe
- Soldering Probe:
  - Detachable probe, used for probing in circuit; transfers heat to board
- Soldering Tips:
  - Interchangeable tips; changes heat profile at board contact point (different tips for different jobs)
- Soldering Base/Holder:
  - Holds soldering probe when not in use
- Soldering Sponge/Brass:
  - Used for cleaning solder, oxidation, and impurities from tip

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# SOLDERING EQUIPMENT AND TOOLS

## Materials

- Solder:
  - Used to form electrical connections
  - Available in various widths, materials (lead, lead-free, etc.), and core materials (rosin core, solid core, etc.)
- Flux:
  - Used to break surface tension and help solder flow
  - Available in various types (rosin-based, water-based, no clean)
  - Many varieties are conductive or corrosive
- Distilled Water:
  - Used for dampening solder sponge and removing water-soluble flux




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# SOLDERING EQUIPMENT AND TOOLS

## Material Removal

- Desoldering Braid:
  - Braided material (usually copper) that flux adheres to when heat is applied
  - Used to remove excess solder from circuits, clear solder bridges, and correct mistakes
- Desoldering Pump:
  - Alternative to desoldering wick
  - Press button, apply to excess solder region, and depress button
- Flux Remover:
  - Used for removing certain fluxes (particularly rosin-based fluxes)
  - Cleans circuit, removes corrosive/conductive flux



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# SOLDERING EQUIPMENT AND TOOLS

## Other Tools

- SMT Tweezers and Picks:
  - Fine point tools used for careful placement and manipulation of electronic components
- Board Clamps:
  - Used to hold board in fixed, stable position for soldering or inspection
- Magnification and Illumination:
  - Various options (loupes, microscopes, cameras)
  - Used to get a better view of circuit board being soldered as well as visual inspection of board

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# HOW DOES SOLDER WORK?

- Solder contains an alloyed metal (common alloy elements: Sn, Pb, Sb, Bi, In, Au, Ag, Zn, Cu)
- The alloyed metals in a solder form a eutectic mixture (that is, the mixture possesses a single melting/cooling point rather than a range)
- When solder is heated to its melting point, it quickly turns liquid and spreads to other heated areas
- The solder can only spread to areas of sufficient heat; cold areas cause the solder to quickly cool and solidify
- Heated solder interacts with the air, forming oxides on its surface
- Many solders contain flux to help solder flow and protect the solder from oxidation

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# HOW DOES FLUX WORK?

- Flux is generally used to promote solder flow in a region
- Flux consists of a number of important chemicals:
  - Activators: Chemical agents designed to dissolve metal oxides formed at the surface of the solder
  - Vehicles: Chemicals designed to serve as a barrier between the solder and the oxygen and carry oxides and activator reaction products away from the metal surface
  - Solvents: Added to aid in processing/cleaning of solder joint
  - Additives: Corrosion inhibitors, stabilizers, antioxidants, thickeners, dyes, etc.

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# ELECTROSTATIC DISCHARGE

- The human body is a large, moving object that can accumulate static electricity (shocks from door knobs)
- The static electricity buildup can damage or destroy electronic components
- Static electricity and ESD worsen as the air becomes dryer (such as in winter)
- ESD can be mitigated by:
  - Frequent contact with large grounded metal objects
  - ESD protection equipment, such as mats and straps
  - Controlling the humidity in an environment

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# SAFETY CONSIDERATIONS

- NEVER, EVER solder an electrical circuit which is powered (soldering iron tip is grounded)
- Wear proper safety gear (eye protection)
- Be wary of soldering fumes (use fans or fume extraction)
- Do not disturb or interfere with other individuals who are soldering
- When soldering is finished (or won't resume for > 10 minutes), turn the soldering iron off (heated irons are fire hazards)
- Wash hands after soldering (lead and other chemicals from solder and flux likely present on hands)

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# SOLDERING TECHNIQUES

## Before Starting

1. Select solder alloy/type:
   - Leaded solders – lower temperature requirements, improved reliability
   - Lead-free/ROHS compliant solders – higher temperature requirements, more environmentally friendly, necessary for products bound for Europe (ROHS regulations)

2. Select flux type:
   - Water-soluble flux – Good in many situations, easy cleaning (corrosive and conductive, so cleaning is mandatory)
   - Rosin-based flux – High performance, though cleaning is much more challenging
   - "No-clean" flux – Misnomer; leaves less residue than other fluxes

# SOLDERING TECHNIQUES

## Before Starting

3. Select tip for application:
   - Conical – Useful for applying point-heat to a region, good for soldering individual leads and heat transfer
   - Chisel – Spreads heat over a wider area than conical, good for wider pads and some IC lead-work
   - Hook – Similar properties to chisel, but contains bend. Useful for through-hole components and some SMD soldering
   - Blade – Spreads heat over thin, wide area. Useful for soldering leads of IC packages (esp. SSOP, QFP, etc.)

   - Thickness – Thicker tips have better thermal mass/heat transfer while smaller leads allow precision application of heat
   - Changing Tips – Can be done during soldering, but be careful (solder probe, sleeve, iron tips are HOT!!!)

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# SOLDERING TECHNIQUES

## Before Starting

4. Select operating temperature:
   - Lead-based solders have lower melting points (400ºF/200ºC range)
   - ROHS solders have higher melting points (700ºF/375ºC range)
   - Excessively heating a part may cause traces/pads to “lift” (become unglued from board substrate)
   - Sometimes higher iron temperatures are used to reduce total heat applied to board

5. “Tin the tip” – Apply solder to iron tip, then use solder sponge to remove excess solder. Cleans tip, removes oxidation, improves performance.
   - Tin iron tip at least every 5-10 solder joints and when finished soldering.
   - Use rosin core solder when tinning the tip at the end of a soldering session

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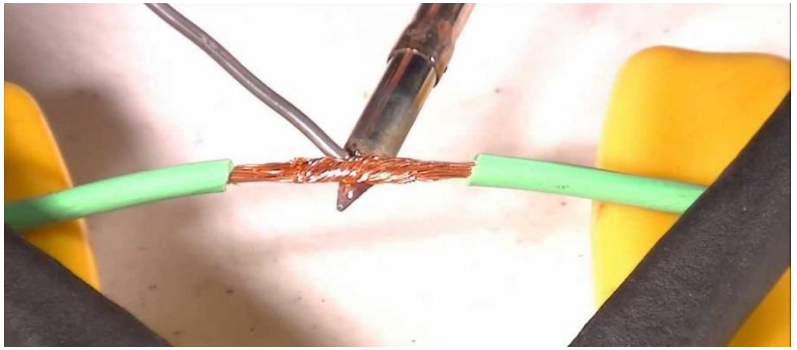
# SOLDERING TECHNIQUES

## Hand Soldering Free Wire

1. Choose wire type:
   - Solid – Easier to work with but easier to break
   - Stranded – Harder to break, slightly harder to work with
2. If heat shrink tubing is being used add this to wires prior to connecting
3. Twist wires together to form mechanical connection, apply flux as appropriate (solder can be twisted around the exposed mechanical connection for reinforcement)
4. Form electrical connection using soldering iron
5. Insulate connection with heat shrink tubing, electrical tape, etc.

NOTE: In most cases, physical connectors may provide a superior alternative to soldering wires



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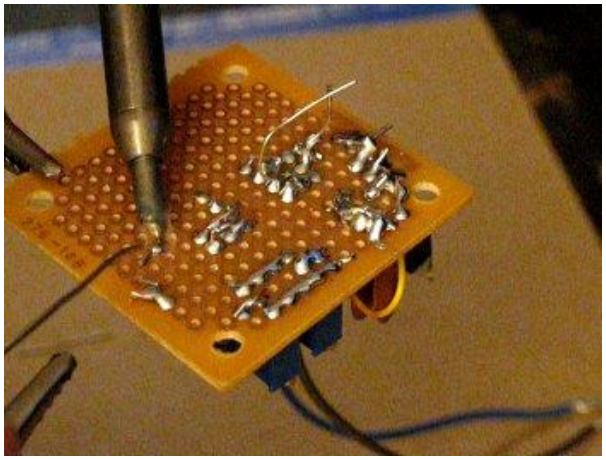
# SOLDERING TECHNIQUES

## Hand Soldering Through Hole

1. Insert component into plated circuit board holes so that part is flush with the board, secure in place (bend leads, clamp, etc.)

2. Touch tip of soldering iron to the lead and annular ring of the opposite side of the board (IMPORTANT: the lead, annular ring, and solder must all be hot to form a reliable connection)



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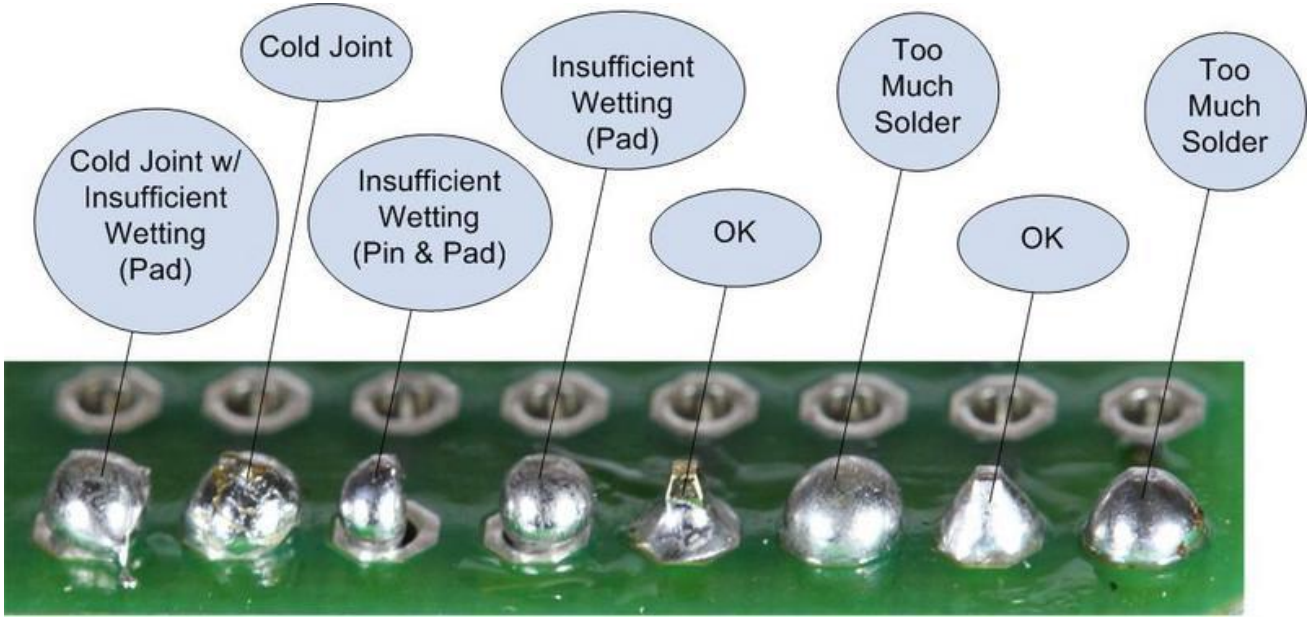
# SOLDERING TECHNIQUES

## Hand Soldering Through Hole

3. Inspect solder joints to ensure that a good connection has been made (good through-hole solder joints have a “volcano” shape). Apply additional heat and flux or remove excess solder as necessary

4. Clip off excess leads using a small pair of diagonal cutters or something similar

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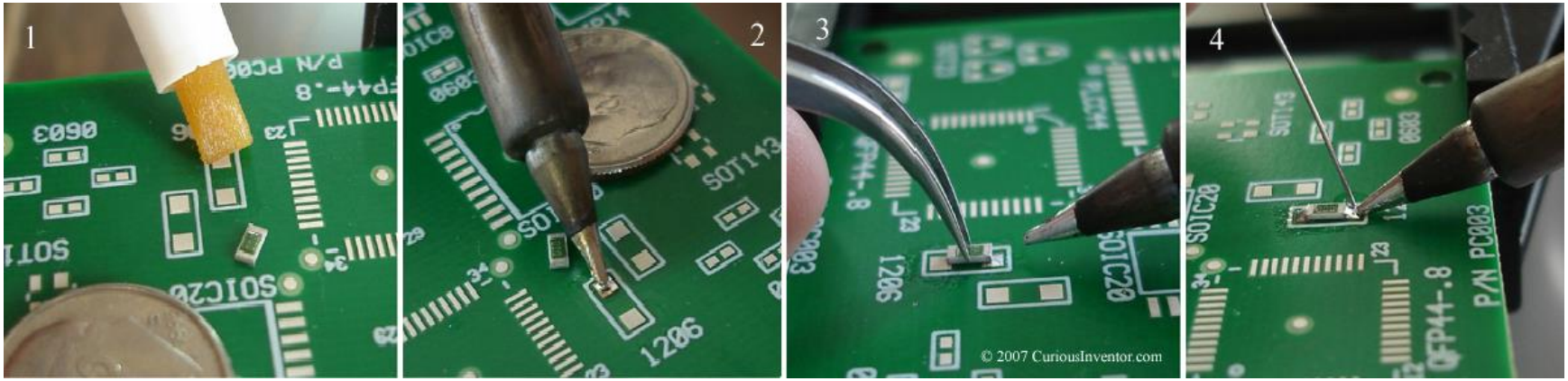
# SOLDERING TECHNIQUES

## Hand Soldering Surface Mount

Simple Passive Components:

1. Apply flux to passive component pads
2. Apply solder to ONE component pad
3. Add passive component, connect component at pad containing solder (often known as “tacking” a component). Soldered component should be flush with board
4. Solder remaining pads/leads of component, remove excess solder as necessary

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# SOLDERING TECHNIQUES

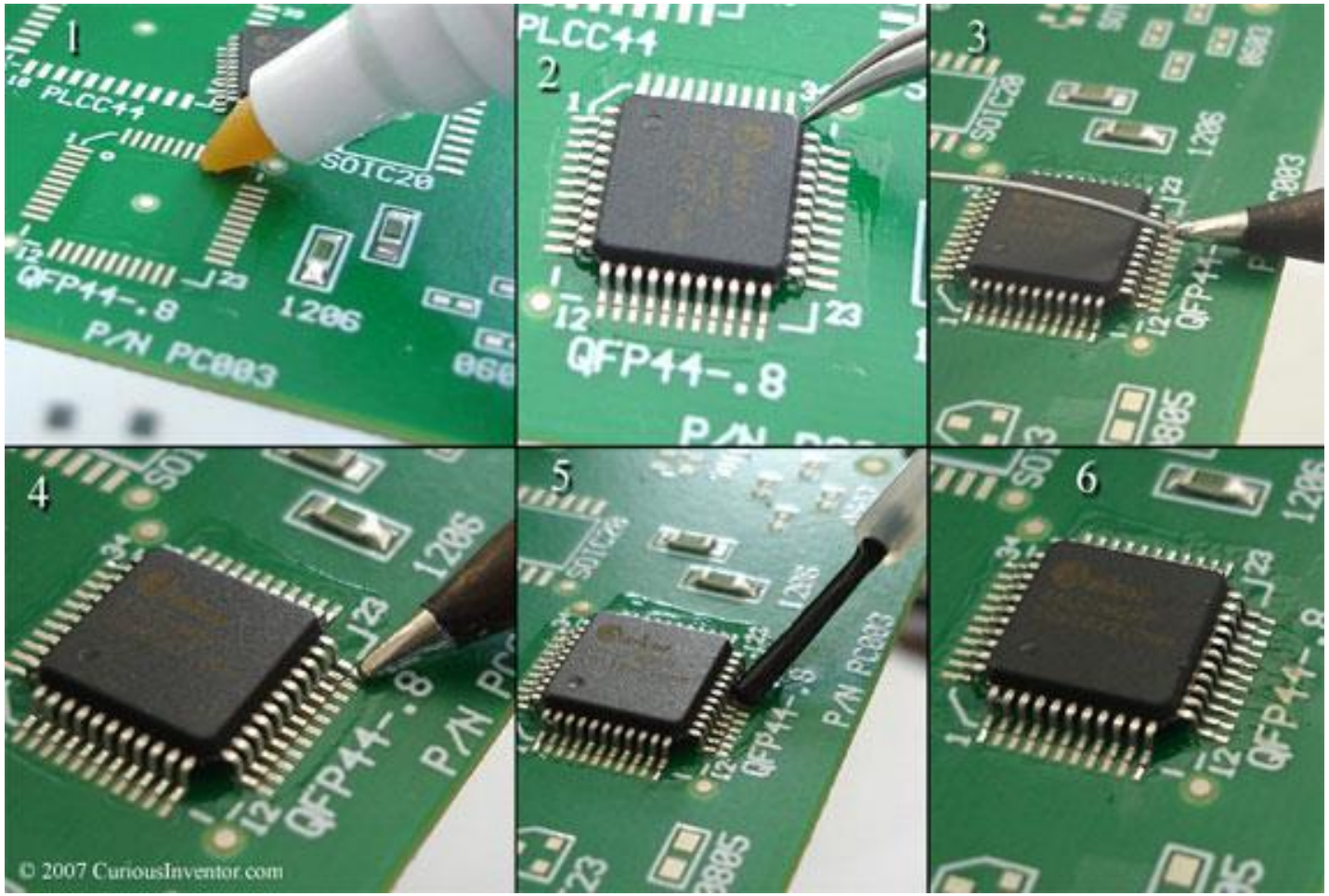
## Hand Soldering Surface Mount

Surface Mount ICs:

1. Apply flux to surface mount IC pads
2. Add solder to tip of soldering iron
3. Place IC on the board. Careful alignment is needed to ensure all PCB pads line up with component leads
4. While holding the component in place, apply soldering iron tip to one of the lead corners. The solder should solder that connection
5. Tack all other corners of the IC (do this prior to soldering interior leads of the part). Make sure alignment is correct before step 6!
6. Apply solder to the remaining pads/leads of the IC. Blade tips are very useful here. Solder bridges may form in this stage, that is okay
7. Once all leads are soldered, apply desoldering braid to remove any solder bridges that may have formed in step 6
8. Carefully visually inspect the board for solder bridges or pads where all solder was removed in step 7; correct as necessary

# SOLDERING TECHNIQUES

## Hand Soldering Surface Mount

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# SOLDERING TECHNIQUES

## Reflow Soldering

- Reflow soldering is an alternative to hand soldering
- Advantages:
  - Able to solder many components at once
  - Ideal for production/manufacturing (able to solder multiple boards simultaneously)
  - Able to solder advanced packages (QFN, BGA, LGA, etc.) which cannot be hand soldered
- Disadvantages:
  - Requires additional materials (board stencil, solder paste, hotplate/oven, placement tools)
  - Can only reflow solder a board once
  - Heats entire board at once – care must be made to avoid thermal damage to components

# SOLDERING TECHNIQUES

## Reflow Soldering Process

The Reflow Soldering Process:

1. Place board into secure mounting bracket and secure solder stencil
2. Apply solder paste to board and spread using thin card or squeegee
3. If necessary, parts can be further secured through the addition of tacky flux (flux w/ mild adhesive additive)
4. Carefully place components on pasted pads, using hand tools or automated SMD placement tools
5. Using a hotplate or a reflow oven, bring the board to the necessary temperature for solder reflow, then gradually cool board back to room temperature
6. Inspect boards visually (possibly with x-rays for advanced parts), and perform necessary corrections

# SOLDERING TECHNIQUES

## Reflow Soldering and Moisture Sensitivity Levels (MSLs)

- The casing on some electronic components may be semi-porous, allowing moisture and water vapor to impregnate components
- These pockets of trapped moisture can expand during reflow soldering, damaging components
- To counter these issues, components may need to be baked prior to soldering
- MSLs are defined for components on DigiKey and other online sources

IPC/JEDEC Moisture Sensitivity Levels:

- MSL 6 – Mandatory Bake before use
- MSL 5A – 24 hours
- MSL 5 – 48 hours
- MSL 4 – 72 hours
- MSL 3 – 168 hours
- MSL 2A – 4 weeks
- MSL 2 – 1 year
- MSL 1 - Unlimited

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# HOT AIR REWORK

- Sometimes components are soldered incorrectly or are damaged in the course of electrical manufacture and test. It may be necessary to remove components from circuit boards (for realignment, replacement, etc.)
- Hot air rework stations can provide heated air to regions to heat up many solder connections simultaneously, causing them to “reflow” and allow parts to be easily removed
- Care is needed so that heat doesn’t cause traces/pads to lift from board (alternative method: sever leads from component body using exacto knife and remove each lead individually)


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# COMMON SOLDERING PITFALLS

- When in doubt, add more flux (it can always be cleaned off later)
- Solder parts in such an order that soldering future parts may be accessed unobstructed
- When applying solder to the iron tip, act quickly. Better joints can be made when some of the flux from the solder core hasn’t evaporated
- Make sure pin 1 of any IC is in the correct position (avoid soldering parts which are rotated 90, 180, or 270 degrees from correct orientation)
- When soldering, always use electrical solders (as opposed to other solders designed for other applications, such as plumbing)

# Questions?

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