Electrical Connections Learning Objectives

- In this lesson you will:
- see different methods of making electrical connections.
- learn a procedure for making soldered connections.
- see commonly used mechanical splices for wires.
- see different types of crimp connectors and application tools.
- learn how wire nuts are applied to make solderless connections.
- learn the steps used to make printed circuit boards.
Electrical Connections

Components and wiring in electrical/electronic systems must be connected properly to operate correctly and safely.

Connection Methods

- Soldering
- Mechanical Connectors
  - Splices
  - Crimp Connectors
  - Wire Nuts
- Printed Circuits

Electrical Connections - Soldering

**Soldering** – bonding metals with a dissimilar alloy of metals

**Solder:**

- provides strong electrical and mechanical connection.
- is an alloy of tin (Sb) and lead (Pb) with given proportions
  - Example: 60/40, 50/50 (tin/lead).
- has a melting point of approximately 400 F.
Electrical Connections-Soldering

Good solder joints require sufficient heat to bring parts up to temperature

Heat sources for electronic/electrical connections

Soldering irons  (20-250 Watts rating)
Soldering guns  (100-250 Watts rating)

Preparing a solder joint

All parts should be clean
free of corrosion, dirt, grease/oil
copper should be cleaned until bright

Make good mechanical connection between parts
twist wires together
wrap wire around connector lugs

Use soldering flux to keep joint clear while heating
flux prevents oxide formation
use only rosin flux for electrical/electronic work
**Electrical Connections-Soldering**

### Soldering Procedure

Apply iron/gun to joint

Allow joint to heat up

Apply solder to joint not tip of iron/gun

- Solder should flow
- Good joint will be smooth and shiny

Let joint cool before moving

- Let solder harden
- Don’t touch! Still very hot

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**Electrical Connections-Soldering**

Melting and working temperatures of different alloy solders

(All temperatures in degrees F)

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Tin %</th>
<th>Lead %</th>
<th>Solid to</th>
<th>Liquid at</th>
<th>Pasty Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>50/50</td>
<td>50</td>
<td>50</td>
<td>361°</td>
<td>421°</td>
<td>60°</td>
</tr>
<tr>
<td>60/40</td>
<td>60</td>
<td>40</td>
<td>361°</td>
<td>374°</td>
<td>13°</td>
</tr>
<tr>
<td>63/37</td>
<td>63</td>
<td>37</td>
<td>361°</td>
<td>361°</td>
<td>0°</td>
</tr>
</tbody>
</table>

50/50 has wide pasty range. 63/37 goes from solid to liquid very quickly
Soldering Electronic Components

Transistors, diodes, and integrated circuits can be damaged by excessive heat while soldering.

- Use appropriately sized heat source. (Lower wattage)
  - Use soldering station with temperature control if available

- Use heat sinks on component leads
  - Hold lead with needle nose pliers
  - Use commercial heat sink clips

- Use component sockets
  - Use caution sockets can also be damaged by excessive heat

Soldering Equipment Maintenance & Safety

**Maintenance**

- Keep iron/gun tip clean and tinned (coated with solder)
- Wipe tip with damp sponge or cloth
- Use flux or liquid tip cleaner
Soldering Equipment Maintenance & Safety

Safety
- Iron/gun is very hot! Keep all flammable materials from soldering area
- Always assume iron/gun is hot to avoid burns
- Do not cool iron by dipping it in any liquid or water
- Do not let iron/gun contact electrical cords
- Solder contains lead – wash hands after handling
- Fluxes can be toxic and/or corrosive – read all instructions and warnings before using
- Hot rosins and fluxes give off fumes, solder in well ventilated area

Wire Splices

Splice - Mechanical connections of two wires made by twisting the conductors tightly together

Give good mechanical strength and electrical conductivity

Western Union Splice
Works best with solid wire

Splicing multi-conductor cables using offset Western Union splices

Make 5 to 10 tight turns on each side
Wire Splices

**Tap Splice**

- MAIN WIRE
- BRANCH WIRE

**Rat Tail Splice**

- BARE WIRES
- WIRES TWISTED

All splices can be soldered to add strength and conductivity.

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Wire Splices

**Fixture Splice**

- BARE WIRES
- BRANCH WIRE
- MAIN WIRE BENT OVER
- FIXTURE WIRE WRAPPED AROUND HOOK

Use needle-nose pliers to make tight bends and joints.

Provides extra strength for hanging light fixtures.

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Crimp Connectors

Used to join wires or add terminal lugs to ends of wires

- Insulated butt splice
  Join two wire ends
- Insulated parallel splice
- Insulated spade lug
  fit under terminal screw

More Crimp Connectors

- Ring Lug (Insulated)
- Female disconnect lug (Insulated)
- Male disconnect lug (Insulated)

Crimp connectors require proper crimping tool

Typical combination wire stripping and crimping tool
Wire Nuts

Solderless connection using a conical threaded connector

Different color denotes number and size of conductors that can be terminated using the wire nut

Yellow: up to 2 number 12 AWG or 3 number 14 AWG wires
Tan: up to 3 number 12 AWG or 4 number 14 AWG wires
Red: up to 5 number 12 AWG or 3 number 10 AWG wires
Grey: up to 4 number 10 AWG, 3 number 10 AWG or 2 number 8 AWG wires
Blue: (big ones) up to 3 number 8 AWG or 2 number 6 AWG wires

AWG – American Wire Gage

Printed Circuit Boards

Modern electronic circuit designs use printed circuit boards (PCBs) to interconnect components.

PCB Design Process

Draw schematic in Computer-aided Design (CAD) package
Use routing software to convert schematic to physical layout.
Print routed design to resist paper
Transfer design to copper-clad blank PCB
  • Areas coated with resist will remain
Printed Circuit Boards

**PCB Design Process**

Immerse blank board into chemical bath
- Unwanted material removed by chemicals

Drill holes for components
- Use small drill press and very small bits

Clean board surface and prepare for soldering

Solder Components onto PCB.

Completed PCB

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Electrical Connections

**ET 150**

Coming Next: Theory of Operation: Soldering Kit Circuit