Laboratory 5: Smart Light - Introduction to Soldering and PCB Design

Introduction and Objective: In this laboratory, you will learn the principles, tools, processes, and tips for electronic circuit soldering. Two circuits, the Inferred switch light and the button LED flowing circuits, will be soldered in the lab. You should acquire the basic skill of soldering by practice.

1 Soldering of Electronic Components

Soldering is a vital skill in electronics, essential for creating strong connections in circuits. It involves joining metal surfaces by melting a filler metal, solder, to form mechanical and electrical bonds. In this lab, you will learn soldering tools, materials, and the process of making conductive joints. We will also cover common mistakes, avoidance strategies, and best practices for quality results. Mastering soldering enhances the functionality and lifespan of electronic devices, whether on simple breadboards or complex PCBs. You should explore soldering and equip yourself with the confidence to build and repair circuits.

1.1 Soldering Tools and Materials

Familiarize yourself with the essential tools and materials for effective soldering before starting. Here is a list of key items that you will need:

1. **Soldering iron**: Heats the solder to melt it. Available in various watts and tips; 15-30 watts with a fine tip is best for electronics.
2. **Solder**: The metal alloy, usually tin, melts at low temperatures. Solder with flux at the core is preferred for electronics.
3. **Flux**: Chemical that cleans and enhances solder adhesion. Additional flux may be needed if it is not present in the solder.
4. **Soldering Stand**: Holds soldering iron safely, often with a cleaning sponge or brass wool.
5. **Sponge or Brass Wool**: Cleans oxidation and debris from the soldering iron tip; typically with the stand.
6. **Wire Cutter**: trim wires, strip insulation, trim excess leads, and ensure precise, clean connections in circuit integration and soldering.
7. **Safety equipment**: Good ventilation and goggles protect against fumes.

1.2 Soldering Process

Soldering involves a series of steps to ensure a strong and reliable connection. Here is a general guide to the process. The video of the process can be found in https://youtu.be/gLGFd_Oxyuo.

1. **Preparation**: Clean surfaces before soldering to remove contaminants. Ensure that the soldering iron tip is clean and tinned.
2. **Heating the Joint**: Position the soldering iron on the joint to adequately heat both surfaces.
3. **Applying Solder**: Touch the solder wire **to the joint** so the heat of the joint melts it, forming a connection. Apply enough solder for a smooth and shiny fillet, avoiding excess.
4. **Cooling and Inspection**: The solder wire should be removed first and then the soldering iron. Let the joint cool naturally and inspect for a smooth, shiny finish without cracks or voids.

1.3 Best Practices and Common Mistakes

Please follow the Best Practices below:

1. For safety, wear safety goggles to protect your eyes from splashes of molten solder and always work in a well-ventilated area to avoid inhaling harmful fumes. Keep flammable materials away from your workspace.
2. Wash your hands after soldering, especially if using lead-based solder, to avoid ingestion of harmful substances.
3. Always place the soldering iron on its stand when not in use to prevent accidents. Keep your soldering iron tip clean and tinned to ensure efficient heat transfer.

And avoid the following common mistakes:

- **Cold Joints**: Result from inadequate heat or movement during cooling, making them dull and unreliable. You should sufficiently heat and avoid movement until the solder cools.
- **Solder Bridges**: Caused by excess solder creating unintended connections between pads or pins. You should use the correct amount of solder and inspect the joints carefully.
- **Overheating Components**: Excess heat can damage components or lift PCB traces. You should use the right soldering iron temperature and work quickly.
- **Insufficient Wetting**: This leads to a weak bond between the solder and the metal surfaces. You should thoroughly clean the surfaces and use flux to improve flow.

2 Circuit Integration with Soldering

With a solid grasp of soldering, it is important to understand its role in circuit design and assembly. Circuit design involves creating a schematic to connect electronic components for a specific function. Soldering transforms this design into a working device. Follow the steps to do so.

1. **Understanding Circuit Design**: Circuit design starts with circuit diagram, which ensures the correct connection of components. You should figure out the components, power and ground, I/O and their connections of the circuit, and of course the function of the circuit. You might use simulation tools or a breadboard to test the functions.
2. **From Schematic to Physical Circuit**: Select the right components and a platform for assembly, such as perfboard or printed circuit board (PCB). Following the circuit diagram, place the components in the correct position and orientation. Plan the layout to reduce wire lengths and prevent clutter.

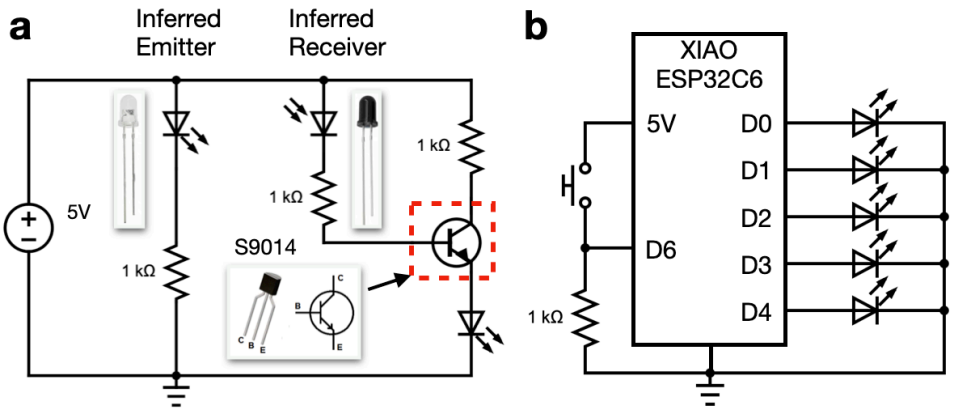

Figure 1: a, the inferred switch light and b, the Button LED flowing using the XIAO development board.

3. **Soldering in Circuit Assembly**: Solder each circuit connection using previous techniques for strength and reliability. Inspect for defects such as bridges or cold joints. Test continuity with a multimeter to avoid short circuits. Trim the excess leads after soldering.

4. **Testing the Circuit**: After finishing the soldering, power on the circuit and test the circuit functions.

To ensure a successful assembly, you should design a detailed schematic and select components that meet the needs of the circuit. Check each circuit section during assembly to identify errors early. Document your schematic, component list, and any changes made for error tracking. The following example would demonstrate the steps by assembling the Inferred-sensitive Light.

3 Inferred Switch Light

Figure 1a shows the circuit diagram of the inferred switch light. Follow the steps state above to build the circuit by soldering the perfboard and the electronic components. In addition, a video is uploaded to the Internet for reference https://youtu.be/cHaRlrCLzWU. Take photos of the front and back sides of the circuit board. Demonstrate the function of the circuit board and take video of it. Please take photos and fill in the answer sheet ever-though the soldering is not finished or the circuit is not function.

3.1 Photos of your soldered inferred switch light.

3.2 Take a video to demonstrate the inferred switch light and upload it to Moodle with the file name " lab5_v32"

4 Button LED Flowing

Figure 1b shows the circuit diagram of the button LED flowing that you have built in Lab 10 of the BE202 course using the breadboard. Follow the steps state in Sec. 2 to build the circuit by soldering the perfboard and the electronic components. In this circuit, two 7-pin sockets should be soldered for further installation of the XIAO development board. Take photos of the front and back sides of the circuit board. After finishing the soldering, check the connection of the board, install the XIAO development board and upload the program "Button_LED_Flowing" downloaded from

Moodle. Demonstrate the function of the circuit board and take video of it. Please take photos and fill in the answer sheet ever-though the soldering is not finished or the circuit is not function.

4.1 Photos of your soldered button LED flowing circuit.

4.2 Take a video to demonstrate the button LED flowing and upload it to Moodle with the file name " lab5_v42"

5 Conclusion

In this laboratory, you gained hands-on experience in electronic circuit soldering by assembling the infrared-sensitive light and button LED flowing circuits. These exercises improve your understanding of circuit construction and provide a solid foundation for future electronic projects. Keep practicing soldering to improve your skills.