LED Heartboard Assembly Instructions

In the contents of your kit you should find

<table>
<thead>
<tr>
<th>Name</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart shaped Circuit board</td>
<td>1</td>
</tr>
<tr>
<td>10 KΩ Resistors in Blue (R1, R2)</td>
<td>2</td>
</tr>
<tr>
<td>4.7 KΩ Resistors in Green (ROSC)</td>
<td>1</td>
</tr>
<tr>
<td>0.1uF Capacitor in Black (C1)</td>
<td>1</td>
</tr>
<tr>
<td>100pF Capacitor in Orange (COSC)</td>
<td>1</td>
</tr>
<tr>
<td>4.7uF Capacitor in Red (C3)</td>
<td>1</td>
</tr>
<tr>
<td>30Ω Resistor (R3, R5-R21)</td>
<td>18</td>
</tr>
<tr>
<td>Red Light Emitting Diodes (LED)</td>
<td>18</td>
</tr>
<tr>
<td>Diode (D1)</td>
<td>1</td>
</tr>
<tr>
<td>Pushbutton (S1)</td>
<td>1</td>
</tr>
<tr>
<td>Power Switch</td>
<td>1</td>
</tr>
<tr>
<td>PIC Microcontroller (SOIC1)</td>
<td>1</td>
</tr>
<tr>
<td>Battery Holder (SMD1)</td>
<td>1</td>
</tr>
<tr>
<td>Coin cell Batteries</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 1 The contents of your kit
The tools you will require are the following.

<table>
<thead>
<tr>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soldering Iron</td>
</tr>
<tr>
<td>Solder</td>
</tr>
<tr>
<td>Side Cutters, or Small wire cutters</td>
</tr>
<tr>
<td>Tweezers</td>
</tr>
<tr>
<td>Masking Tape</td>
</tr>
<tr>
<td>De-soldering Pump</td>
</tr>
</tbody>
</table>

Figure 2 The tools you will need

Before you get started
If you have never done it before surface mount soldering can seem complicated and very difficult. Let me assure you with practice you may even come to find it easier and faster to solder surface mount components then to solder through-hole components. It’s like everything, it just takes some practice!

Some general tips:

- Surface mount components are small and easy to lose.
- Use a sheet of white paper under your work area so components are easier to spot.
- When using tweezers if you squeeze too hard components can fly across the room.
- Surface mount soldering is basically the same for every type of component: get the part on the board and then solder on the other pins.
- Take your time; work slowly at first, speed will come later.
How to Surface Mount Solder:

1. Add solder to one of the pads for the component so that it forms a small ball on top of the pad, this is called tinning.

2. To add the component use a pair of tweezers to hold it. Then apply heat to the previously tinned pad to re-melt the solder. Finally move the component into place.

3. Hold the component in its place with the tweezers while you remove the soldering iron. The solder will solidify holding the component to the pad.

4. After the solder has become hard you can remove the tweezers leaving the component attached.

5. Now solder the other side of the component to the board.

6. The component is now attached to the board.
Step 1: PIC Microcontroller

The first step is to solder the PIC microcontroller (PIC) onto the circuit board. Soldering the PIC is the same process as soldering any surface mount component. The first step is to solder a single pin of the PIC to the Circuit board. After the part is attached to the board, solder the rest of the pins.

1. Add solder to a single corner pin on the circuit board.
2. Heat up the previously placed solder. Using tweezers to hold the PIC align and place it onto the circuit board. Then remove the soldering iron letting the solder cool, followed by the tweezers. Remember to check the orientation! The white dot on the circuit board corresponds to the plastic dot on the PIC Microcontroller.
3. Solder the rest of the pins to the circuit board, don’t worry if you accidently get solder attached to multiple pins (called bridging) this will be fixed next.
4. If you managed to get all of the pins soldered without bridging anything, good job! If you’re like the rest of us you will need to un-bridge the pins. This is a simple process; place the nozzle of the solder sucker against the bridged pins. Apply heat until the solder melts and then press the button on the sucker so that it sucks up the excess solder. You may need to repeat this process a couple of times. Try not to heat the components for too long or they may eventually become damaged.
Figure 4 Adding solder to the first pin (tinning)

Figure 5 The first pin tinned
Figure 6 Aligning the Microcontroller to the pads

Figure 7 Soldering the first pin
Figure 8 The PIC Microchip with one pin soldered

Figure 9 Soldering the opposite pin of the PIC Microcontroller
Figure 10 Soldering the other pins of the PIC Microcontroller

Figure 11 Soldering the other pins of the PIC Microcontroller Cont
Figure 12 All of the pins soldered, the far right two pins are bridged with solder
Figure 13 Removing the Bridge with a solder pump

Figure 14 The PIC Microcontroller fully soldered and ready to move to the next step
**Step 2 Capacitor C1**

The second component installed is capacitor C1, it has a black mark on the case. Following the standard procedure for attaching a surface mount component:

1. Tin one of the pads on the circuit board.
2. Using tweezers to hold the capacitor heat the solder and then move the capacitor into place
3. Remove the heat and then the tweezers, so the capacitor is halfway attached to the board.
4. Solder the other side of the capacitor to the board.
5. You can now go back and touch up the first side of the capacitor.

*Figure 15 Capacitor C1 in black*

*Figure 16 Tinning one side of the pad in preparation to add the capacitor to the board*
Figure 17 One pad is tinned and prepared for capacitor C1

Figure 18 Using tweezers to add Capacitor C1 to the board
Figure 19 Add heat and then move the capacitor into position

Figure 20 Remember to remove the heat first and then the tweezers after the solder has cooled
Figure 21 Capacitor C1 attached to one pad of the board

Figure 22 Soldering the second side of Capacitor C1
Figure 23 Touching up the first side of Capacitor C1
Step 3 Capacitor C3
The next component is Capacitor C3.

1. Tin one of the pads on the circuit board.
2. Using tweezers to hold the capacitor heat the solder and then move the capacitor into place
3. Remove the heat, and then the tweezers, so the capacitor is halfway attached to the board.
4. Solder the other side of the capacitor to the board.
5. You can now go back and touch up the first side of the capacitor.

Figure 24 Getting ready to attach Capacitor C3

Figure 25 Tinning the first Pad for Capacitor C3
Figure 26 Heating the pad and then adding Capacitor C3

Figure 27 Soldering the second side of Capacitor C3
**Step 4 Resistor R1, and R2**
The next two components have the same value, Resistor R1, and R2 these resistors are attached in the same manner as the other surface mount components.
Figure 30 Preparing the pad for R1

Figure 31 Resistor R1 with its first pad soldered in place
Figure 32 Resistor R1 fully soldered

Figure 33 Preparing the first pad of resistor R2
Figure 34 Soldering Resistor pad one of R2 onto the board

Figure 35 R2 Soldered to the board
Step 5 Resistor ROSC
The last resistor to be added to the board is resistor ROSC and it is attached the same way as the other surface mount components.
Figure 38 Soldering Resistor ROSC to the board

Figure 39 Soldering the second pad on Resistor ROSC
**Step 6 Capacitor COSC**
Now attach capacitor COSC to the board.
Figure 42 Tinning the first pad of Capacitor COSC

Figure 43 Adding Capacitor COSC to the board
Figure 44 Soldering the second pad of Capacitor COSC

Figure 45 The board with Capacitor COSC attached
**Step 7 Diode D1**

When attaching diode D1 make sure that the bar on the diode is on the same side as the bar on the board. If you are not sure about the orientation look at the figures that follow for a clearer understanding.

**Figure 46 Diode for the board**

**Figure 47 Close-up of the diode with the line on the left hand side**
Figure 48 Close-up of the diode, the line on the left side has to correspond to the line on the board.

Figure 49 Tinning the first pad of the diode.
Figure 50 Adding the diode, remember to match the line on the diode to the line on the board

Figure 51 Soldering the second pad of the diode to the board
Figure 52 Diode mounted on the board-
Step 8 LED Resistors
Now attach all of the outer LED resistors to the board.

Figure 53 The LED resistors in the long strip

Figure 54 LED resistors on a piece of white paper
Figure 55 Tinning all the pads for the LED resistors
Figure 56 Adding the LED resistors to the board

Figure 57 The LED resistors have all been soldered on one pad
**Figure 58** The LED resistors have all been completely soldered onto the board

**Step 9 Pushbutton**
Now that the surface-mount components on the front side of the board are attached it is time to attach the pushbutton. The pushbutton only fits into the board two ways and both of these will work; it needs to be pushed so that the plastic is flush with the board and the wire leads from the button go all the way through the circuit board. Solder all four leads to the board.

**Figure 59** The pushbutton switch
Figure 60 The switch only fits one way into the board

Figure 61 Push the button flush with the board
Figure 62 The pins should extend through the board

Figure 63 Make sure the pushbutton is flush with the board
Figure 64 Solder the connections on the backside
Figure 65 The board with everything except the LEDs mounted
Step 10 Power switch
The power switch is the second last surface mount component, there are mounting pins on the switch that lock it in place, for this component:

- Place it on the board making sure the plastic pins line up and the switch is flush to the board, if you want you can tape the switch down.
- Solder the pins one at a time.

Figure 66 The power switch for the board
Figure 67 The board with the power switch placed in its alignment wholes

Figure 68 Power switch with the right lead being soldered
Figure 69 The rest of the power switch pins being soldered on

Figure 70 The power switch mounted and soldered on
Step 11 Red LEDs

Now for the LEDs.

1. LEDs only work in one orientation. There are two ways to find the required orientation of a LED. The first is to look for the flat spot on the LED (corresponding to cathode), when you insert it into the board it corresponds to the flat spot in the silkscreen. The second is to look for the longer lead on an LED, it is the anode or curved side of the LED on the silkscreen.
2. Push the LED all the way so that it is flush with the board and tape it in place.
3. Solder one lead to the board so that the LED is attached.
4. If the LED is not flush to the board, now is the time to fix it.
5. Being very careful, re-melt the solder and push the LED all the way flush to the board.
6. Solder the second lead to the board.
7. Clip the leads as short as possible, using side cutters.
8. Repeat for the remaining LEDs.

Figure 71 The LEDs
Figure 72 A single LED, the longer lead is the anode or positive lead, there is also a flat spot on the led corresponding to the cathode or negative side.

Figure 73 The board has a flat side in the silk screen for each LED that needs to be matched with the flat side on the LEDs.
Figure 74 The LED pushed through and taped to hold it in place while soldering

Figure 75 the LED’s leads being soldered, make sure that the led remains flush while the leads are soldered
Figure 76 the second lead being soldered on

Figure 77 The leads being clipped after they are soldered
Figure 78 Continuing to solder LED's

Figure 79 All of the remaining LED's Soldered
Figure 80 All of the LED's Clipped

Figure 81 The LED's mounted from the front
**Step 12 Battery Holder**
The last component is the Battery Holder.

1. Start by adding solder to the center pad on the back of the board. This is so when a battery is inserted the center pad makes contact.
2. Now add solder to one of the outer pads.
3. Place the battery holder with the opening facing the bottom of the board.
4. Using tweezers to hold it, because IT WILL GET HOT melt the solder on the first pad and attach the holder
5. Solder the other pad on to the board.

![Figure 82 The battery holder](image-url)
Figure 83 Tinning the base pad of the battery holder

Figure 84 The center pin tinned so that the batteries negative terminal can make contact
Figure 85 The right pad prepared to attach the holder

Figure 86 Soldering the first pad of the battery holder in place
Figure 87 Soldering the second pad of the battery holder
**Step 13 Battery**
The assembly is complete. If you have the option available I suggest you check the board for short circuits. All that remains is to insert the battery flick the switch and the board should turn on!

Press the pushbutton to change the pattern.

*Figure 88 The battery*
Figure 89 Insert the battery from the bottom

Figure 90 Slide the switch to the on position
Figure 91 The board should be flashing its first pattern
Figure 92 Press the pushbutton to cycle through the patterns
How does it work? What everything is for!

The Resistor Capacitor $R_{osc}$ and $C_{osc}$ provide an oscillator for the PIC Microcontroller. The Capacitor $C_{osc}$ is charge up through Resistor $R_{osc}$ the voltage is measured with the PIC Microcontroller when it reaches a threshold value the PIC Microchip shorts the capacitors positive terminal to ground discharging its potential quickly. It then begins the process of charging again you can see this in the graph. The PIC Microcontroller then uses these rising and falling cycles to run the instructions that are stored on it.
The resistors $R_1$ and $R_2$ both provide the same basic function. Both resistors are called pull-up resistors, they ensure that the voltage at the PIC Microcontrollers input pin is at a known voltage. To explain this look at the diagram that has just the PIC Microcontroller input pin and the Pushbutton switch. The input pin just reads the voltage it does not actively control the voltage. When the pushbutton is closed the Input pin is shorted to ground, but when the pushbutton is released and unknown voltage is sent to the PIC Microcontroller this can trigger phantom switching (THIS IS BAD!). To get around this problem a large Resistor (10K) is added between the positive supply and sensing input. When the pushbutton is closed the Input pin is still shorted to ground, but when it is released the voltage will rise so that the Input pin and positive supply are the same. The pull-up resistor that is not connected to the pushbutton is connected to the master reset of the PIC Microcontroller this will restart the program on the chip so it is always held at the positive supply voltage.

The Diode D1 protects the circuit from having current flow backwards, it only allows it to pass in the direction we want. This stops the PIC Microcontroller from being fried if the battery was inserted backwards. There is a tradeoff though, the diode we are using drops the supply of the battery by 0.4V so from the 3V coin cell we get 2.6V going to the PIC Microcontroller.

The PIC Microcontroller Controls the LEDs on the board. Code programmed into it turns the LEDs on or off. It also monitors the pin attached to the pushbutton switch to change the code.
The Resistors that lead to the LEDs limit the current that flows through them. To calculate the current that flows through a resistor, we need to know its forward voltage, this is the voltage drop that appears over the LED when it is on given by the manufacturer. We can use this and our supply voltage to find the current.

\[ \text{current}(LED) = \frac{\text{Voltage(supply)} - \text{LED Forward Voltage}}{\text{Resistance } R} \]

in our case the data sheet says the typical forward voltage is 1.85\(V\) and our supply is from the battery at approximately 3\(V\) minus the 0.4\(V\) from the diode D1. With the LED resistors having a resistance around 30\(\Omega\) we get

\[ \text{current}(LED) = \frac{2.6V - 1.85V}{30\Omega} = 25mA \]