# Raspberry Pi IO Hat v1.0

# Assembly Manual


Designed by: Benjamin E. Smith

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Source files: https://github.com/Llamero/RPi_IO_Hat_v1

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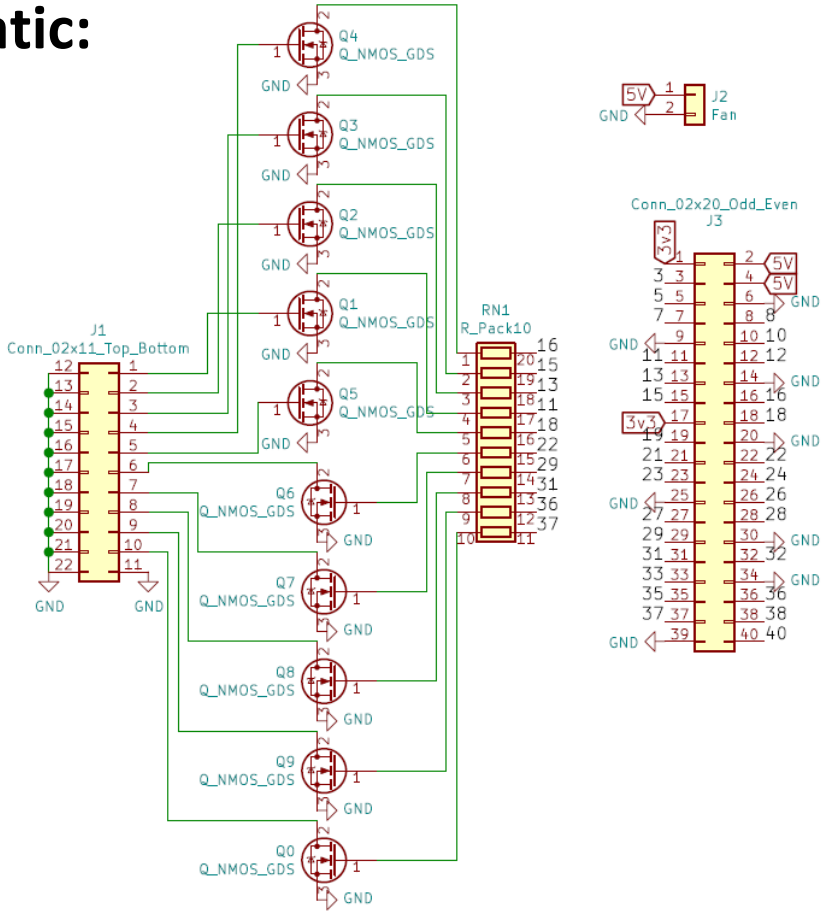
# Specifications: (air temp = 25°C)

I/O MOSFET datasheet: https://www.diodes.com/assets/Datasheets/ZVN4525Z.pdf

| Characteristic | Minimum | Maximum |
|---|---|---|
| Input voltage | -40 V | +40 V |
| Input closed voltage | +2 V | +40 V |
| Input open voltage | -40 V | +0 V |
| Output voltage | 0 V | 100 V |
| Output wattage | ----- | 1 W |

# Schematic:




## Design notes:

Input pins: 11, 13, 15, 16, 18

Output pins: 22, 29, 31, 36, 37

A 1.0 kΩ resistor has been placed in series between each of the GPIO pins and the MOSFETs to limit the pin current to 3.3 mA.

# Ordering components:

## Parts List:

A detailed bill of materials can be downloaded at:
https://github.com/Llamero/RPi_IO_Hat_v1/blob/master/Parts%20List%20(Bill%20of%20Materials).ods

| **Pi Hat Assembly:** | | | |
|---|---|---|---|
| **Digikey** | | | |
| **X** | **Part #** | **Mount** | **Quantity** |
| J1 | 277-12233-ND | Clip | 1 |
| J3 | SAM11959-ND | TH | 1 |
| Q0-Q9 | ZVN4525ZCT-ND | SMD | 10 |
| RN1 | 4820P-1-102LFCT-ND | SMD | 1 |
| | | | |
| **Optional cooling for over-clocking:** | | | |
| J2 | 259-1561-ND | Glue | 1 |
| J4 | 345-1149-ND | Glue | 1 |
| J5 | AE11388-ND | Glue | 1 |
| | | | |
| | | | |
| **Raspberry Pi 3b+ kit:** | | | |
| **Amazon** | | | |
| Raspberry Pi 3b+ kit | B07BCC8PK7 | | 1 |
| | | | |
| | | | |
| **Miscellaneous (tools, consumables, etc.):** | | | |
| **Digikey** | | | |
| Solder paste for reflow soldering | SMD291AX50T3-ND | | 1 |
| Solder wire for header through hole soldering | SMD2SW.031.7OZ-ND | | 1 |
| Thermal adhesive for mounting heatsinks | 473-1220-ND | | 1 |
| Soldering iron for through hole soldering | 1528-1684-ND | | 1 |
| IR thermometer for tracking reflow temperatures | 614-1481-ND | | 1 |
| | | | |
| **OnlineMetals.com** | | | |
| Copper block as a hot plate heat spreader | 1920 | | 1 |

## PCB Board:

To order the PCB board and optional stencil, download the Gerber files and send the files to your preferred PCB fabricator. If you are ordering a stainless steel stencil, be sure to have the fabricator electropolish it, or else the solder paste will stick to the stencil. The board and stencil can also be directly ordered from the following link:
https://www.pcbway.com/project/shareproject/Raspberry_Pi_GPIO_Hat_with_Aperture_for_Overclock_Cooling.html

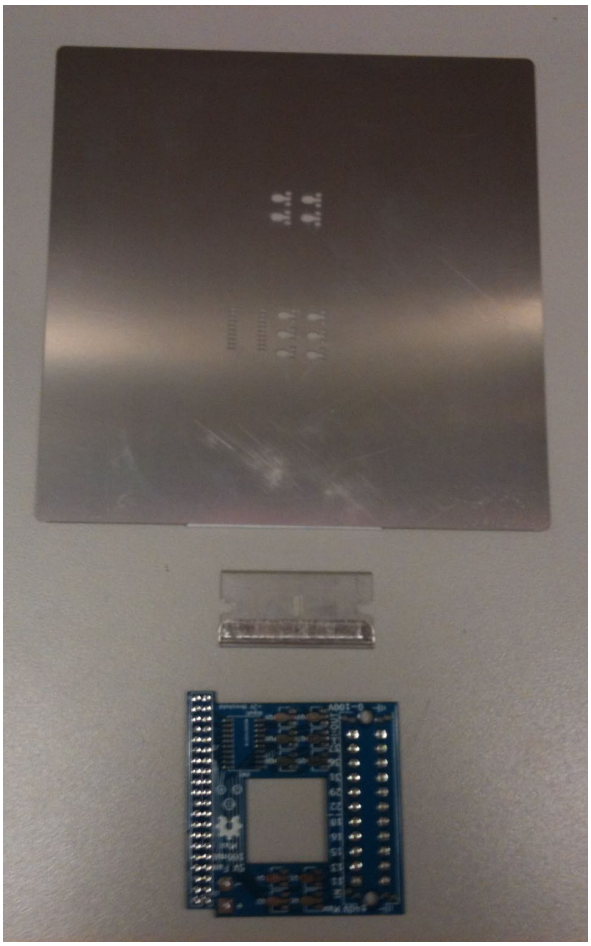
# Stenciling solder paste:

Stenciling is by far the fastest and easiest way to solder on the surface mount components (10x MOSFETs and 1x resistor array). The components can also be hand soldered, but stenciling is highly recommended. Here is one among many online tutorial on applying solder paste with a stencil: https://www.youtube.com/watch?v=WDIqtGMROjM

**NOTE:** Take care to not get the solder paste on your skin, as it cannot readily be washed off.

## Parts needed:

PCB board
Solder paste
Box cutter blade
Tape
Applicator (pipette tips work very well)
Gloves



1. Lay the stencil on the edge of a counter or table so that it hangs of the edge slightly, then tape the other side of the stencil to the table or counter.
   **NOTE:** This both helps to keep the stencil in place when applying the solder paste, but also create a hinge that allows the stencil to be lifted vertically, so that the solder paste is not smeared when the stencil is removed.
2. Line up the PCB board with the stencil so that the pads are all clearly visible through the stencil.
3. Put on gloves to protect your hands from the solder paste. Also keep the box nearby, as you will likely be changing gloves regularly as you get solder paste on them.
4. Use the applicator to thoroughly mix the solder paste.
5. Apply some solder paste to the edge of the box cutter blade, and then while pressing on the stencil to hold the board in place, liberally apply solder paste over the pads (holes in the stencil).
6. Once all the holes are filled with solder paste, use the box cutter blade to scrape off all of the excess solder paste.
7. Carefully lift the stencil off the board.
8. When finished with the stencil, clean it with 70% ethanol to remove any remaining traces of solder paste.

**NOTE:** Once the solder paste is applied, you have to reflow the board within 2 hours. Otherwise, the flux can evaporate leading to the solder failing to reflow correctly.

# Placing surface mount components:

When placing the surface mount components, be sure to handle them carefully, as they can shoot out from forceps. Also, be sure to ground yourself and the bag containing the MOSFETs (any plumbing or electrical conduit will work) as MOSFETs are easily damaged by static charge.

## Parts needed:

PCB board with applied paste
Forceps or dedicated part handing tool
Aluminum foil
10x MOSFET chips
1x resistor array chip
Stereo microscope (optional)

1. Place the stenciled board on a piece of aluminum foil. This will allow you to move and rotate the board while placing parts, without having to handle the board directly and risk smearing the solder paste.
2. Ground yourself and the bag containing the MOSFETs to discharge any static electricity before assembling. If you are in an especially dry environment, it may be helpful to use a grounding wrist strap.
3. Remove the MOSFETs and the resistor array from their packaging and lay them out in the correct orientation on the aluminum foil (you can use the pads or the CAD file as a reference).
4. Carefully pick up each component and place them onto the PCB board. It can help to keep the parts near the board to reduce the risk of dropping any components. Once the part is placed, gently press it onto the solder paste.
   **NOTE:** You do not need to be absolutely perfect with your placements, as the reflow process will automatically center the parts (this is always fun to watch). Being closer than half a pad width is more than good enough.

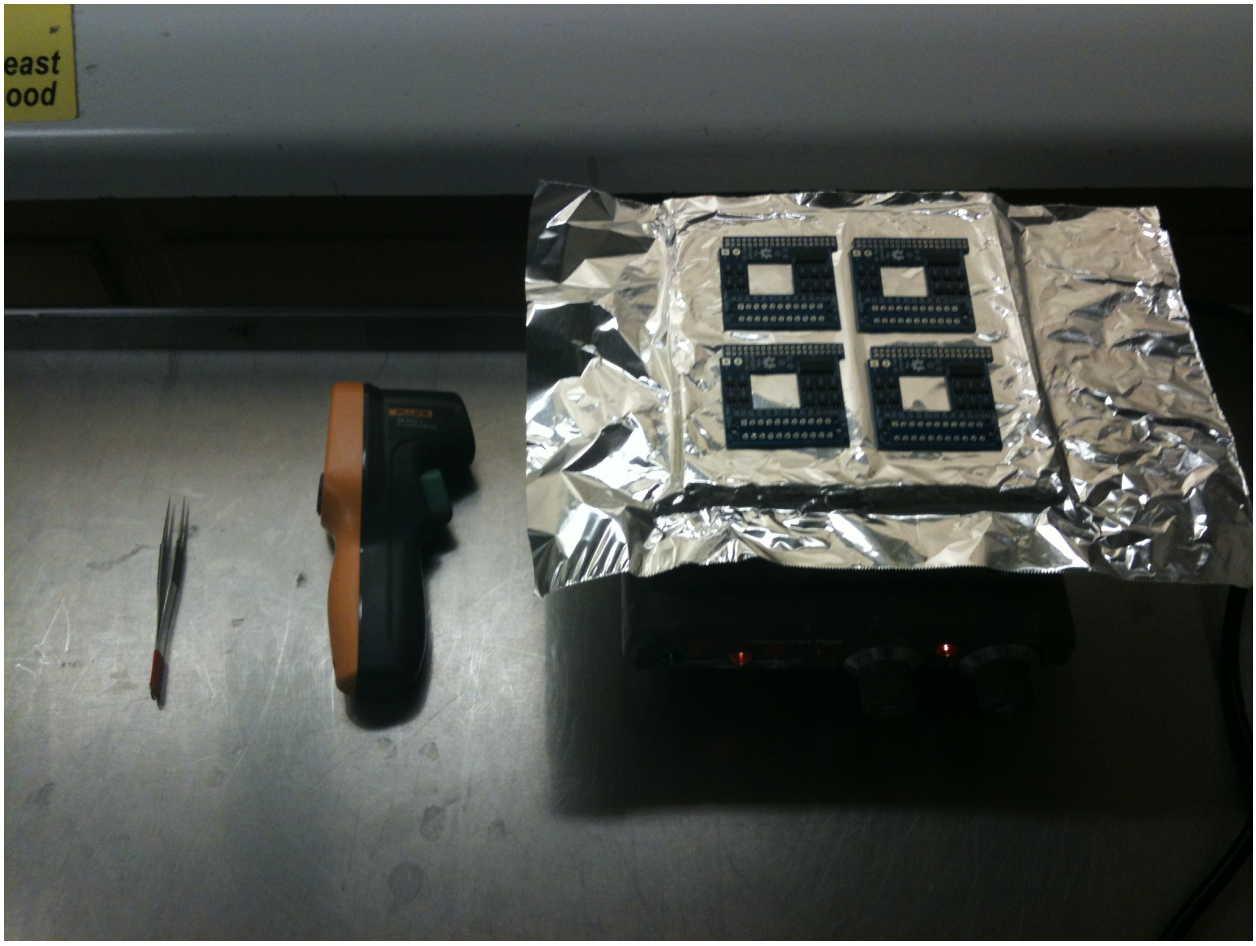
# Reflow the PCB board:

Depending on the hotplate, the reflow process will happen rapidly, so be sure to stay and monitor the boards throughout the reflow process. Here is a good video showing what the reflow process looks like (notice how the wetting force of the solder automatically centers all of the parts): https://www.youtube.com/watch?v=LCmia0Wsmqg

**NOTE:** When reflowing the boards, be sure to do so either near or inside a fume hood. The flux will burn off during the reflow process, releasing toxic fumes into the air.

## Parts needed:

PCB board with applied paste
Metal forceps
IR thermometer
Hot plate
Aluminum foil
Copper block (optional)



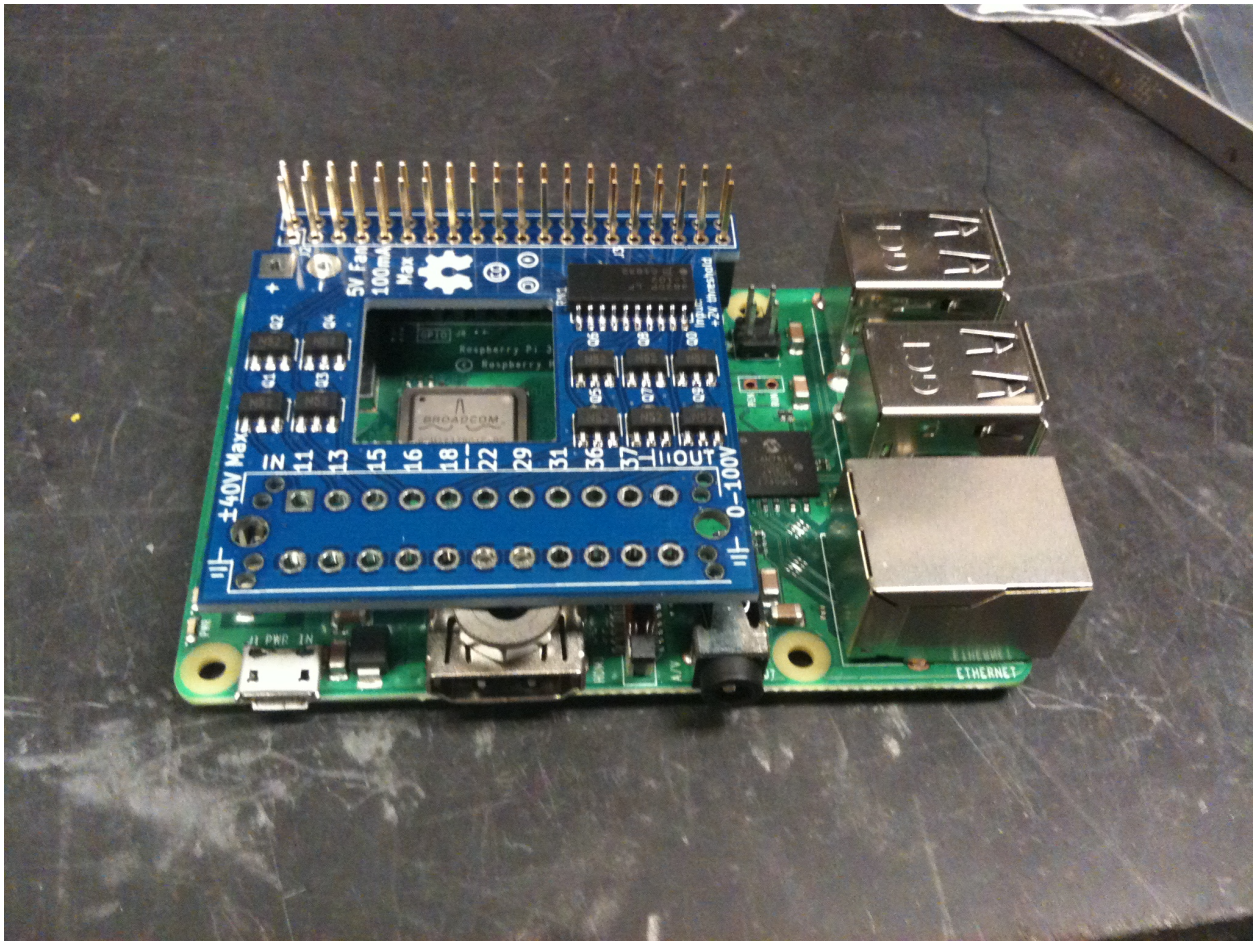
1. If you are using a copper block has a heat spreader, wrap the copper block with aluminum foil and place the block on top of the hot plate.
2. Transfer the assembled PCB boards onto the hot plate which should be in or near a fume hood, and turn the hot plate on to its highest setting.
3. Monitor the temperature of the PCB boards with the IR thermometer. The blue solder mask on the board has the highest emissivity, so pass the thermometer over the blue section of the board, and use the highest recorded temperature as the actual temperature.
4. At 160°C the flux should start to noticeably burn off, and at 183°C the solder should begin to melt. The melting step tends to happen rapidly.
5. Once all of the solder appears to have melted, confirm that all of the solder has reflowed by gently tapping each component with the forceps. If the component snaps back into place, the solder has reflowed, but if the component moves slowly or not at all, the solder is not fully melted, so wait a few seconds and test again until the part snaps back into place.
6. Continue heating the board to around 210°C and then carefully lift the aluminum foil the boards are resting on off of the hot plate, and place them on a nearby surface to cool. **NOTE:** Do not let the boards get much hotter than 210°C, as this risks damaging the components and/or the PCB board itself. After reflow, the board tends to climb in temperature rapidly.

# Adding through-hole components:

The 2x20 stackable header now needs to be soldered in place, while the block terminal simply snaps onto the board.

## Parts needed:

Reflowed PCB board
Solder wire with flux core
Soldering iron
Wet sponge
Raspberry Pi
Spacer (8-32 setscrew or any other part that will hold the PCB board level on the Raspberry Pi).
1x 2x20 stackable header
1x 2x11 terminal block header



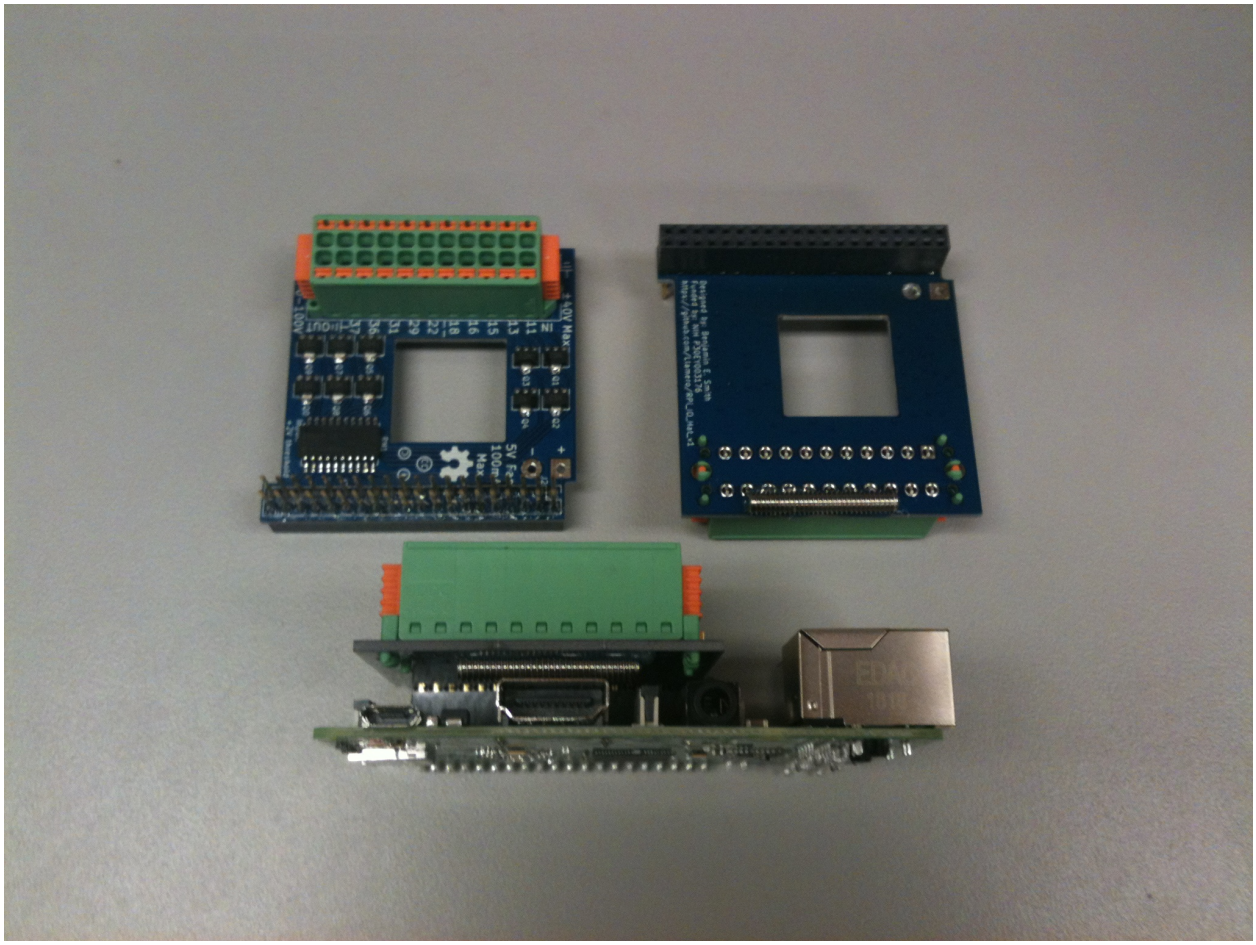
1. Place the 2x20 stackable header onto the GPIO pins of the Raspberry Pi.
2. Place the reflowed PCB board onto the header.
3. Use the spacers to level the PCB board (see bolt and washer on top of the HDMI jack in the above picture).
4. Position the PCB board so that it is roughly centered, and solder a pin on each end of the header to the PCB board to hold the board in place while the remaining pins are soldered.
5. To solder the remaining pins, heat the iron to about 400°C, and hold the tip to one side of the pin and the solder wire on the other side of the pin. Tap the solder wire against the iron tip to get the solder melting, and then keep feeding in solder wire until the through hole is filled. If there is excess solder on the iron tip, wipe the solder off onto the wet sponge.
6. Lift the orange tabs on the 11x2 terminal block and press the block into place (the block has only 1 orientation where it will go into the board). Once the block is fully pressed down, press down the orange tabs to lock it in place. The terminal block does NOT need to be soldered.

# Finishing Assembly:

The last step for assembling the PCB board is to add a shim under the terminal block to help support the board when the push-in springs are pressed down.  In this step, we will use an 8-32 setscrew and will attach it with hot glue, while any shim and adhesive should work.

## Parts needed:

Assembled PCB board
8-32 setscrew (or any other shim of ideal height)
Hot glue (other adhesives will also work)
Hot glue gun
Pliers or forceps
Bunsen burner (or hot plate, heat gun, etc.)
Thermocouple (optional)



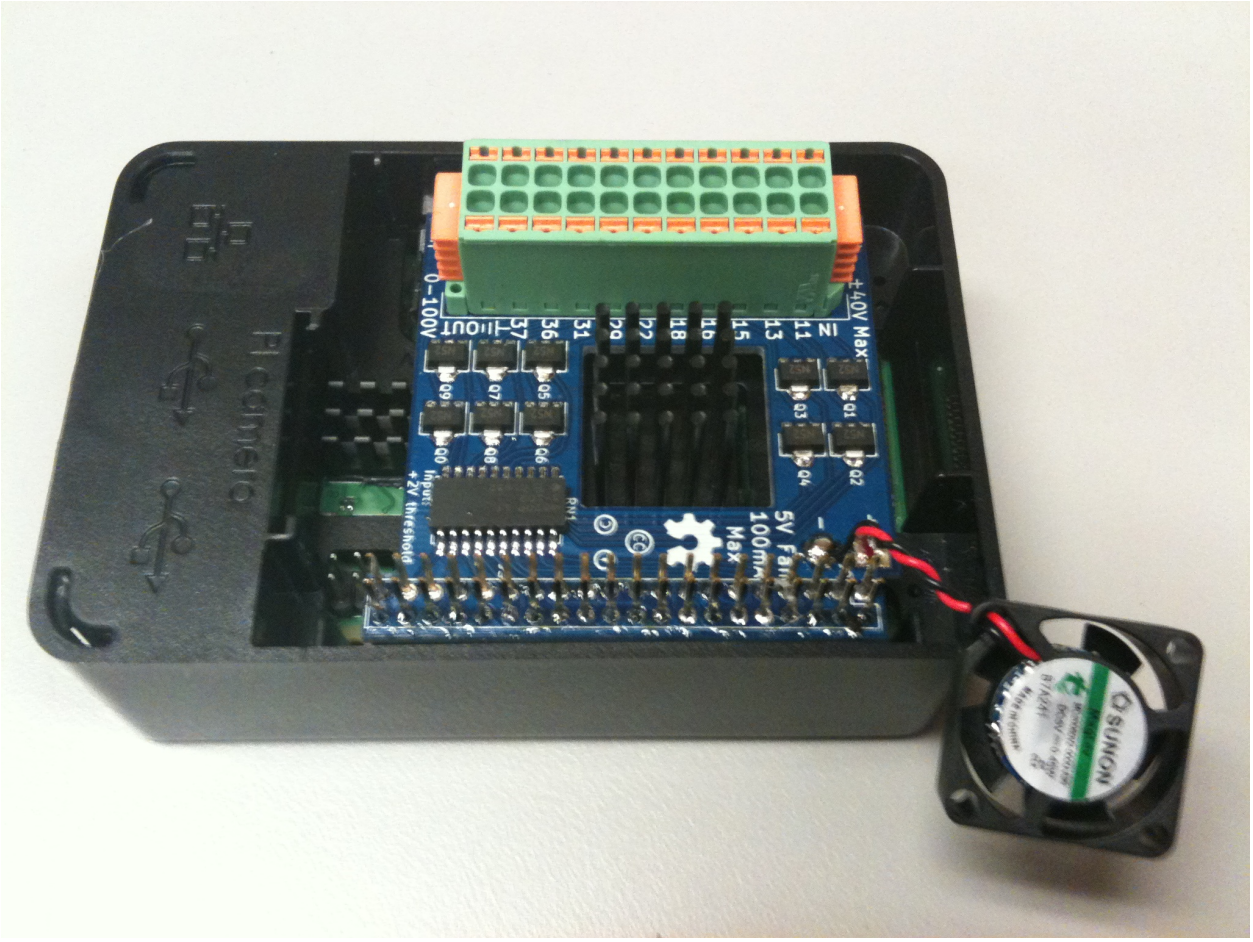
1. Allow the hot glue gun to reach full temperature
2. While holding the setscrew with a pair of pliers, use the Bunsen burner to heat the setscrew to approximately 100°C.
   **NOTE:** This is essential to ensure the glue fully wets onto the setscrew, rather than hardening on contact, resulting in a much stronger bond.
3. Apply  a line of hot glue onto the edge of the PCB board directly over the HDMI hack.
4. Press the hot setscrew into the hot glue, and slide it to under the outer edge of the board.
5. Allow the glue to fully cool and set before moving the board.

# (Optional) Add heatsinks to Raspberry Pi:

If you intend to overclock the Pi or even run it at 100% CPU power for long periods of time, it is ideal to add a high quality heatsink to the CPU and USB controller.

## Parts needed:

Thermal adhesive
20 mm x 20 mm (large) heatsink
8.5 mm x 8.5 mm (small) heatsink
Raspberry Pi
Raspberry Pi enclosure
Weigh boat (or piece of stiff plastic)
Pipette tip (or other applicator)
70% Ethanol
Kim-wipes
Incubator at 45°C to 50°C (optional)



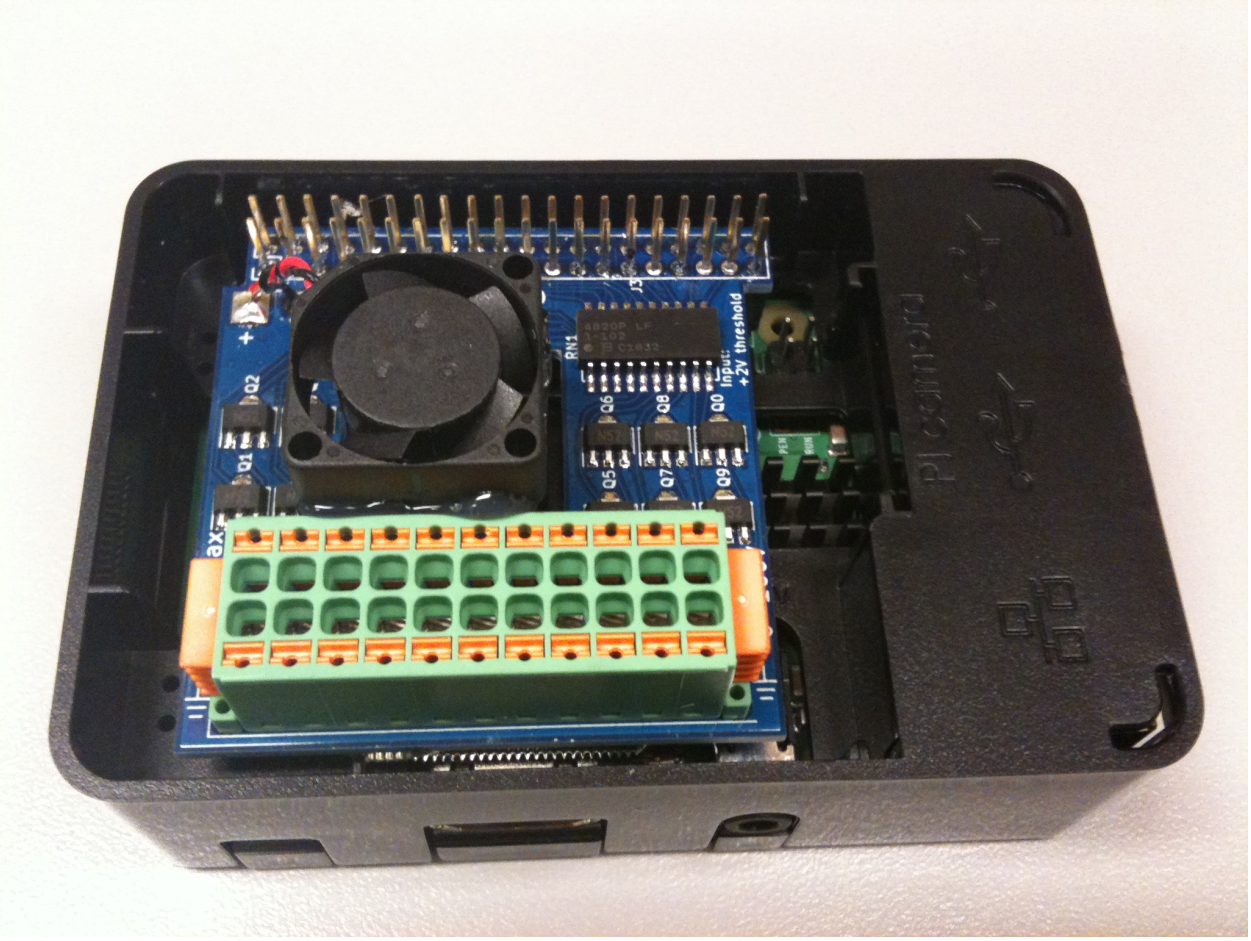
1. Clean the CPU and USB controller, as well as the base of each heatsink, with 70% ethanol.
2. Assemble the Raspberry Pi into its enclosure as this will be needed as a reference when placing the heatsinks.
3. Mix a small amount of the thermal adhesive and apply a thin layer to the bottom of both of the heatsinks making sure to cover the entire bottom.
   **NOTE:** The adhesive is not nearly as thermally conductive as heatsink itself, so you want to keep the layer of adhesive as thin as possible to ensure peak heat transfer efficiency.
4. Press the large heatsink onto the CPU, and slide it side to side to transfer the adhesive to the CPU housing.
5. Remove the heatsink and check if the top of the CPU is uniformly covered with a thin layer of adhesive. If not, apply a small amount of adhesive to the bare spot, and repeat steps 4 and 5 until the CPU and heatsink both have a uniform, think layer of adhesive.
6. Press the large heatsink onto the CPU, and slide it side to side fully couple the heatsink to the CPU housing, and then center the heatsink.
7. Repeat the above steps with the small heatsink and the USB controller.
8. (Optional): Put the Raspberry Pi into a 50°C incubator overnight, or allow the adhesive to cure at room temperature (this could take a few days).

# (Optional) Add CPU fan to Raspberry Pi:

If you intend to overclock the Pi or even run it at 100% CPU power for long periods of time, it is ideal to add a small fan to the CPU heatsink.  Even a small amount of airflow can dramatically improve the cooling efficiency over passive convection.

## Parts needed:

Solder wire with flux core
Soldering iron
Wet sponge
Wire stripper
Wire cutters (or scissors)
Raspberry Pi with attached heatsinks
Fully assembled PCB board
Heat gun
Hot glue gun
20 mm x 20 mm 5V DC fan



1. Plug in the hot glue gun, and allow it to get to full temperature.
2. Cut the wire leads on the fan to the desired length (see above picture for reference)
3. Strip the insulating material off of the end of each wire on the fan.
4. Apply a small amount of solder to the bare end of each wire.
5. Place the wire tips into the corresponding through holes in the PCB board (red wire into the “+” hole, and the black wire into the “-“ hole).
6. Fill the holes with solder.
7. Use a heat gun to gently warm the heatsink to about 50°C (hot to the touch).
   **NOTE:** This is essential to ensure the glue fully wets onto the heatsink pins, rather than hardening on contact, resulting in a much stronger bond. Be careful to not overheat the heatsink as this can damage the CPU.
8. Apply a small bead of hot glue along the bottom of the fan opposite the terminal block and to where the fan contact the terminal block.
9. Press the fan onto the CPU and against the terminal block (see above picture) until the glue fully cools.