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Introduction

Having some Raspberry PI's at your disposal is already fun. Turning them into a cluster is really fun. Well.. I think it's fun. A few years back a friend and I came to the elusive idea of building a 10 node cluster. We had our reasons to do so. The first and most obvious reason is of course to have fun. The other reasons were about learning something about clusters, software deployment on a cluster.

At that time this friend got a 3D printer, so he started to design and print a frame which could hold 10 Pi's. And one day he stopped by dropping of the PI's. The idea was to link those 2 set's of PI's together over a VPN, and we would have access to a 20 node cluster, in two separate geographic locations. How cool is that ?

We played around with it for a while, starting to configure the infrastructure needed to manage the cluster, and started to deploy software on the cluster. There was however one thing we needed to address. And that was the cooling of the cluster. Long story short: we find ourselves in busy day jobs, no time to spend on the cluster, and slowly the cluster, and the idea disappeared on a shelf. As it so often happens.

Till recently. Due to some new challenges I needed an environment of a couple of physical hosts. Something that would scale.. I needed a cluster. And yes I got one, but for the tasks I had in mind, I needed to fix the cooling issue. So after I tried to alter the current frame I soon discovered that I needed or to alter the original design, or started from scratch.

Starting from scratch was not something I wanted to simply do. For good reasons: I needed a cluster quickly. Second, designing from scratch means a lot of work, and I already got a lot of projects on my hands. There was one thing however, and that's this idea I have for a really long time. And now I have the opportunity to realise this idea. This idea is to design some kind of backplane I could plug the PI's into. I have for some reason (and don't ask my why) a fascination for backplanes.

Long story short I started on the 5th of june 2020 to design a cluster frame that would:

- Makes it possible to easy swap PI's
- Easy to maintain
- Simple to build
- Hold 10 PI's in a 19" rack

I had a lot of more requirements, but these were the essential ones. During the development of this cluster frame I learned a lot. One of the things I needed to guard myself against was the phenomenon I like to call "feature creeps". Once I start designing it's oh so tempting to put in every possible thing that makes the project more feature rich, and of course all those features are "must haves". So right from the start I created a "requirements document". It's a few pages long, but in essence I could rewrite the whole document into one sentence:

"Don't allow for any feature / aspect to slow the project down, or prevent it from coming up with a working proof of concept (PoC".

And even with this document, it's hard to put great ideas aside, or even to improve the design into prefection.

But eventually I managed to just move forward, and even when somethings aren't perfect, or even won't work as intended I build a PoC in less then 3 months. Spending most of my evening and weekend to design and build.

NOTE	This document describes the first development version. It's far from complete, and may not even be useful to anyone. :includesdir: include

Design goals

The cluster frame is designed with the idea of being as modulair as possible. This means that the minimal frame size is just for 2 nodes. This frame can then easily be extended into 4,6,8 or 10 pi's max if the frame needs to be 19" mountable. It's easy to stack 10 rows on Pi's in a rack. When extending the frame to more then 10 Pi's I'm not sure if the frame is strong enough to do this.

That brings me to the second design goal: The whole design needs to be free to everyone who wants to build it, and it must be possible for everyone to adjust it to one needs.

So this frame is ideal if you want to stack some PI's together. However if you need access to the GPIO pins, this frame might not be for you. The GPIO pins are covered by a HAT which enables the PI cluster node to have proper cooling, and allows for three RGB leds. This frame intended use is for housing a PI cluster. And normally in a cluster setup the GPIO pins are not used. (in this case some of them are, for controlling RGB status LED's and a FAN for cooling). :imagesdir: assets/images :includesdir: include :fullWidth: 245 :fullHeight: 150 :development_version_beta: 2.0 Hades Edition :current_version: 2.0 Hades Edition

Current issues

The current PI Cluster version is still in the development phase. This means there are some issues. So before building the PI Cluster Frame, you may take a look at the current known issues.

NOTE	Currently the PI Cluster frame (version: 2.0 Hades Edition) is at a point that it is useful. There are however some issues that needs to be addressed:

1. The back-plane connectors doesn't align properly with the Raspberry PI

2. The PI Cluster HAT hardware problem, causing the MOSFET to be none functional
3. Polarity markings on some PCB silkscreen are missing, or are misplaced.
4. Not easy to enable EEPROM write
5. The documentation is not fully completed yet.
6. When using a PI4 it's difficult to remove the Ethernet cable.

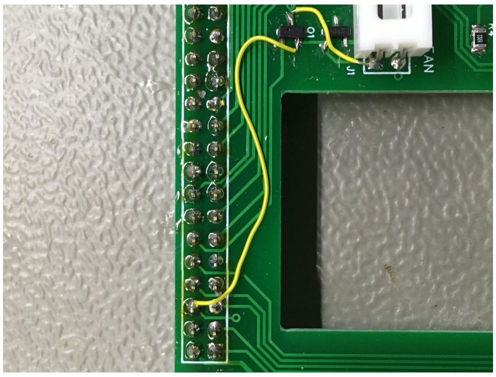
.1. Back-plane alignment issue

In the development version **2.0 Hades Edition** the back-plane connectors don't align well with the PI Tray's connectors. Currently the Power connectors work. However the connectors which can be used for I2C are not tested, or operational. This misalignment makes placing the back-plane onto one PI Cluster Frame quite difficult, however it can be done. Once the back-plane is correctly aligned, both connectors should mate perfectly with the connectors on the PI Tray. However this is not tested with multiple PI Cluster frames stacked together.

Severity: **HIGH** : Currently it is not advised to manufacture the PI Cluster back-plane PCB's until this issue is fixed or completely tested.

.2. The PI Cluster HAT hardware problem, causing the MOSFET to be none functional

In the version: **2.0 Hades Edition** of the PI Cluster HAT the MOSFET is wired wrong. Causing the cooling FAN always to spin at full speed. The fix is already applied, and push to the repository. However when using the **2.0 Hades Edition** there is any fix, by cutting two traces on the PCB, and solder two bodge wires:



Severity: **Medium** Issue is already solved, and is fixable in the 2.0 Hades Edition

.3. Polarity markings on some PCB silkscreen are missing or are misplace

Overall there is a lot of work to be done to get the silkscreens of the PCB to have prober markings. In the next versions this issue is going to be addressed.

Severity: **LOW** This is just an inconvenience, care should be taken when soldering wires /

connectors for example.

.4. Not easy to enable EEPROM write

To be able to program the EEPROM, the test points TP1 needs to be shorted together. This now requires a 0 ohm 0805 SMD resistor, ar a small piece of wire. This needs to be fixed, so a jumper can be placed.

Severity: **LOW** This is just an inconvenience.

.5. The documentation is not fully completed yet

The documentation is becoming more and more complete, however it still needs a lot of work.

Severity: **HIGH** Documentation is required to be able to build the PI Cluster Frame.

.6. When using a PI4 it’s difficult to remove the Ethernet cable

When a Pi4 is used in a Pi Tray the Ethernet port is on the right side instead of the left side. On the left side there is a small cut-out, so it’s easier to remove a ethernet cable. However this cut-out is not available on the right side. Making it difficult to detach a ethernet cable.

Severity: **LOW** This is just an inconvenience, and the front bezel needs a redesign anyway.

Roadmap

Currently the focus of the project is to get a minimal full working PI Cluster Frame. This means a few features are postponed, or new ideas are being put on a wishlist. To keep track of these postponed features and wishes, they are listed here. Implementing these features means that components of the PI Cluster Frame are going to be changed. And there is no intention to try to keep things backward compatible. This will slow the project down, and is almost not doable.

Features postponed

- Be able to power down nodes, and keep the power status, even when the whole cluster is powered down. Implementing means possible change to back-plane.

Wish list

- Be able to connect a serial terminal to each cluster node. Implementing this causes the back-plane PCB to change, and the front bezel of PI Tray == Preparing the PI Tray :imagesdir: assets/images :includesdir: include :fullWidth: 245 :fullHeight: 150 :development_version_beta: 2.0 Hades Edition :current_version: 2.0 Hades Edition The PI Tray is responsible for holding several components:

- The Raspberry PI itself
- The PI Cluster HAT + cooling FAN
- The Power board
- The LED board
- The front plate
- The front bezel

To coop with all of this, the PI tray needs the be prepared by inserting some brass press inserts. There are several options:

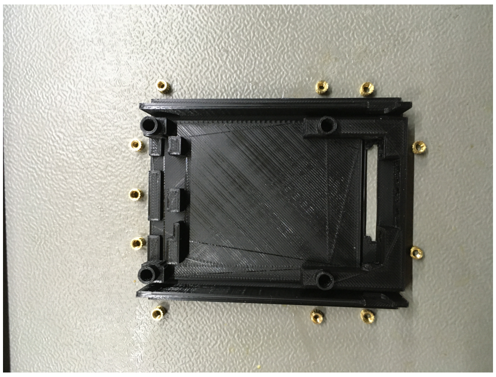
- Use 4x M2.5 brass press inserts to mount the Raspberry PI
- Use 7x M3 brass press inserts to mount the rest of the components

or:

- Use M2.5 brass inserts for every thing.

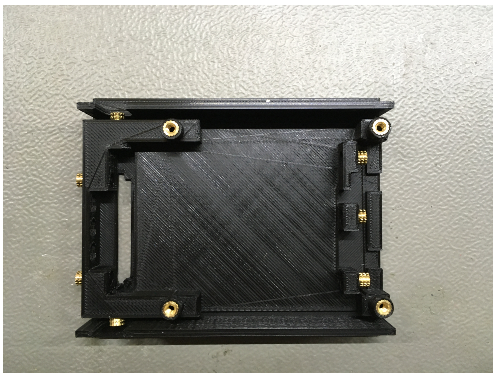
Both options will work, as long the brass press inserts require a hole of +/- 4mm (And they should)

In this document the puristic path is chosen, just because this is how the design was intended.

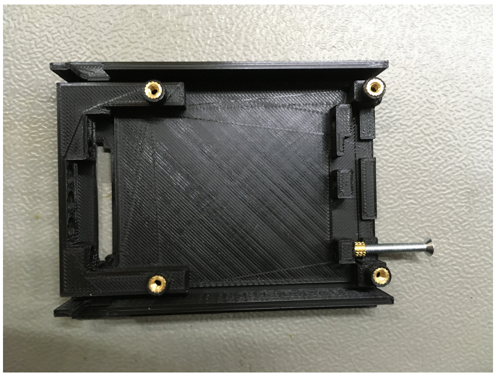


The easiest way of prepare the PI Tray is to start with the M2.5 brass inserts, by inserting them into the 4 holes and press them in the four holes by using a hot soldering iron.

Next the M3 brass inserts can be inserted. Make sure not to melt the PLA when inserting the brass press inserts for the power board. And alo keep in mind, the brass press inserts for the LED board are inserted from the front. Trying to this the other way around, will for sure damage the PI Tray beyond any repair.

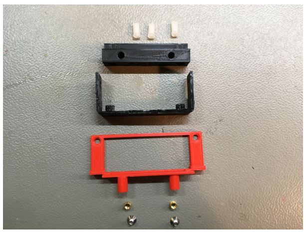


TIP Use a long screw (for example a M3x20mm) to position the brass press inserts. Just insert the screw one thread, so the screw can be easily removed.



Assemble the front panel and bezel

To assemble the front panel and bezel with 3 light pipes, the following is needed:



To assemble the front panel and bezel, the following parts are needed:

- 3D printed front panel
- 3D printed light-pipe holder
- 3D printed bezel
- 3x printed light-pipe (Need transparent PLA)
- 2x brass M3 press insert
- 2x M3x5 bolt

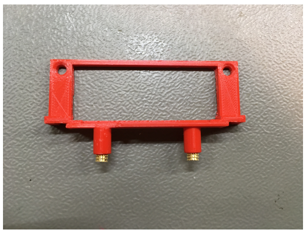
Inserting the light-pipes

Start by inserting the light-pipes into the light-pipe holder:

The light-pipes are pressed in gently from the side with the round holes. After inserting the light-pipes, the light-pipes will stick out a few millimeters.

Pressing in the brass inserts

The brass press inserts needs to be inserted into the front panel. Make sure to align the brass press inserts as straight as possible.



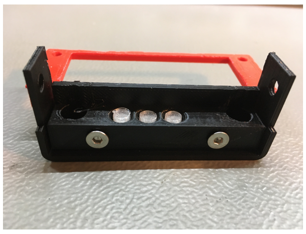
Insert the light pipe holder into the bezel

Press the light-pipe holder gently into the front bezel. The light-pipes should align with the square holes in the front bezel. Look at the image below for the right orientation. The overhanging part of the light-pipe holder is on top. This overhang part, will prevent light from escaping ones it is mounted on the PI Tray.

Mount the front panel

The last step is to mount the front panel onto the bezel assembly. Align the two mounting posts of the front panel with the hole large holes in the light-pipe holder, while the overhang on the light-pipe holder is on top. In other words, the little cut-out in the front bezel is upwards. This is a tight fit, and may need some force to push the front panel into place. Don't push to hard, since this may break something. If it doesn't fit, check if the front-panel is inserted correctly, and that the holes in the light-pipe holder don't hold any supporting material that needs to be removed.

In the last step is to screw the frontpanel onto the light-pipe holder, keeping it secure:



Features of the Power Board

The power board PCB provides the following features on a small footprint:

- Efficient power distribution
- Separated 5V and 3V connections
- I2C to backplane connection
- Low voltage drop
- Rated for 2 Ampere

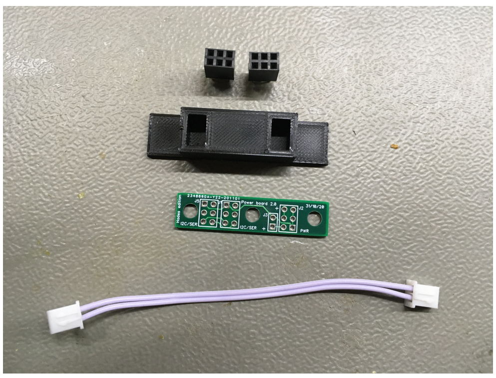
Theory of operation

The power board contains 2x female 2x3 headers which allows 5V distribution to the back-plane on one 2x3 connector, and the 2x3 connector allows for I2C connection and 3V power distribution. The Power board doesn’t contain any active or passive components, other then tw 2x3 female connectors.

Both the connectors must be aligned to the mating back-plane connectors to allow a low voltage drop connection. == Assemble the PowerBoard :imagesdir: assets/images :includesdir: include :fullWidth: 245 :fullHeight: 150 :development_version_beta: 2.0 Hades Edition :current_version: 2.0 Hades Edition

Materials needed:

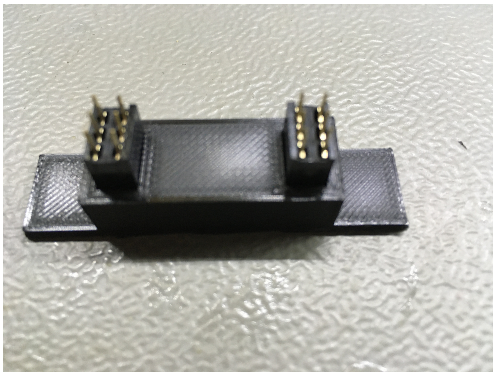
- 1x Power Board PCB
- 2x 2x3 female 2.54 pitch connectors
- 1x JST XH 254 connector
- 1x JST pre-crimped connectors
- 1x 3D printed Connector alignment tool



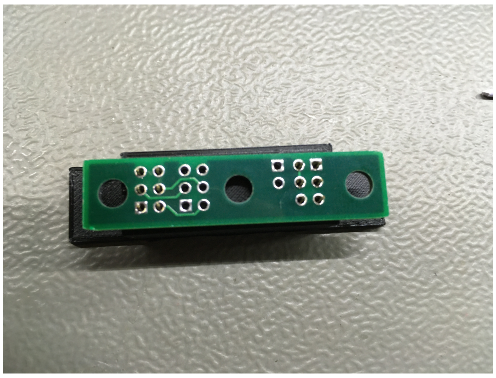
NOTE	The JST XT 2.54 connectors can be bought pre-crimped. However the copper pairs, or most likely to be very thin, causing a severe power drop.

TIP	Before assembly make sure to print the alignment tool from the extra folder. This tools helps aligning the connectors, and makes soldering more easily.

Start by inserting the 2x 2x3 2.54 female headers in the alignment tool like this:

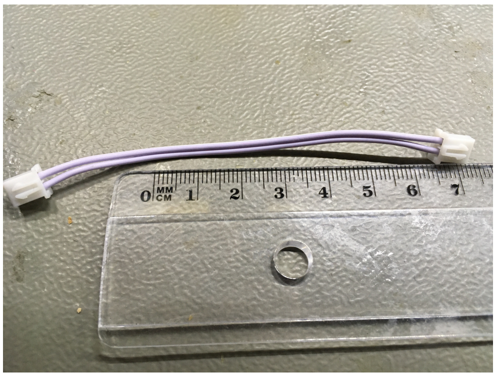


Next place the Power Board PCB with the silkscreen facing down. Make sure to align the PCB and the connectors with the most outer holes, so the PCB should be roughly in the center of the alignment tool. Press the PCB down, so it sits flat with the surface of the alignment tool:

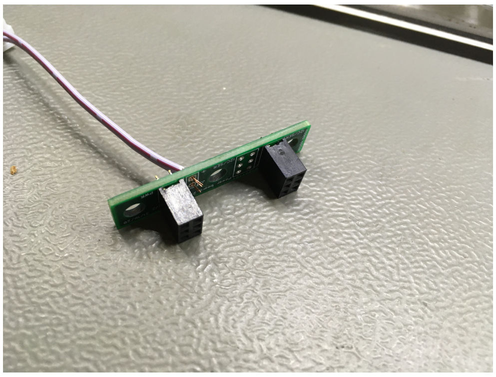


Solder the connectors onto the PCB, and once the connectors are soldered remove the PCB gently from the alignment tool.

Next, cut the pre-crimped JST cable, using a 6.5CM length, and make sure that the guiding profile of the connector is facing upwards:



The last step is to solder the wire onto the PCB. Make sure to solder the wire on the back of the PCB, and also make sure to get the polarity right: solder the RED () onto the plus () on the PCB:



The finished Power Board should look like this:

Featues of the PI Cluster HAT

The PI Cluster HAT provides the following features:

- 1x GPIO PWM Controllable FAN
- 3x GPIO PWM Controllable RGB LED’s
- 5V Power Distribution
- 3V Power Distribution
- 1x Programmable I2C EPROM
- 1x I2C Breakout

PI Cluster HAT Theory of Operation

This section explains the features of the PI Cluser HAT in more detail.

The PI Cluster HAT is designed with the PI HAT regulations and requirements in mind. However, some requirements are not met. In this section, this is addressed as well.

The PI CLuster HAT main purpose is to provide a PWM Controlled cooling FAN which is placed just above the Raspberry PI CPU, so the CPU is cooled in a very efficient way.

Cooling FAN

The FAN is connected by a N-CHANNEL MOSFET to BCM pin 18. Which makes it possible to control the cooling FAN easily by software. By using PWM the FAN speed can be controlled. This allows efficient cooling, reduces power consumption, and hopefully less FAN noise.

To protect the MOSFET a fly-back diode can be added. However during testing, this seems not required.

5V Power

The second most important task of the PI Cluster HAT is to distribute power to the PowerBoard, making it possible to connected a Raspberry PI to a back-plane.

The PI HAT design rules, require a polarity protection diode. This diode is not implemented for the following reasons:

- The PI CLuster HAT is mounted on a PI Tray, which is placed inside a Cluster frame, the power pins are not accessible.
- A Diode will cause a voltage drop, even when using a Schottky diode, which is problematic when distributing 5V across a back-plane

The only risk of damage the Raspberry PI by reversing the 5V polarity, is when:

- Testing the PI node outside the cluster frame.
- When the power board or power wires are assembled incorrectly.

However a power drop of more then 0.2V, can cause instability problems, rendering each cluster node useless. To provide some protection, the + 5V power line is protected by a 63V 2A fuse.

GPIO Features

Futhermore the PI Cluster HAT provides a means of using some of the GPIO pins/features, which normally won't be accessible once the Raspberry PI is inside the cluster frame.

3x software PWM controllable RGB LED's

By providing 3 RGB LED's which are PWN software driven, it's easy to control these RGB LED's from software as status LED's. The RGB LED's can for instance be used as a power on LED, Temperature status, or any other status.

The PI Cluster HAT Provides current limiting resistors, to protect the GPIO PIN's and the RGB LED's as well.

I2C feature

The Cluster PI HAT also provides a one breakout I2C connector, so the for each node the I2C bus can be used, since the I2C bus interconnects on the back-plane.

I2C EEPROM

The Raspberry PI provides separate I2C GPIO pins to control a I2C EEPROM, The PI CLuster HAT includes this EEPROM is as well. The EEPROM is programmed to provision the GPIO initial status, and controls the Power On LED. The contents of the EEPROM can be overwritten, by reprogramming the EEPROM, and writing an own overlay.

NOTE	The EEPROM is not necessarily for the operation of the PI Cluster HAT. The Power on LED is controlled by the EEPROM at boot time. However this can be done by an external script as well.

The EEPROM has the required pull down resistors, as well as test points to control the Read and Write (R/W) signals.

NOTE	To be able to write to the EEPROM, the test-points TP1 must be shorted. == Assemble the PI Cluster HAT :imagesdir: assets/images :includesdir: include :fullWidth: 245 :fullHeight: 150 :development_version_beta: 2.0 Hades Edition :current_version: 2.0 Hades Edition The PI Cluster HAT PCB contains SMD parts and also Through Hole parts. It may require some skills to solder these SMD parts, but it shouldn't be too hard to do, since the SMD package size is rather large (SOT-23-3 and 0805).

Per PCB you need:

- 9x SDM 0805 330 Ohm resistor
- 2x SMD 0805 3.9K Ohm resistor
- 1x SMD 0805 1K Ohm resistor
- 1x 2 Amp SMD 1206 fuse 63V 2A Slow blow
- 1x CAT 24c32 EEProm
- 1x NDS351N MOSFET (SMD sot-23-3)
- 2x 10 pins JST XH cable connectors (these are available already crimped to a cable)

Depending on how you connect everything to the PI Cluster HAT:

- Solder the wires directly onto the PCB
- Use connectors

When using connectors you need the following:

- 1x 40 pins GPIO header
- 1x 10 pins JST XH 90 degree angle PCB connector
- 2x 2 pins JST XH 90 degree angle PCB connector
- 1x 6 pins box header

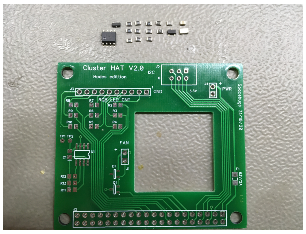
The pro of soldering the wires directly to the PCB is the low profile. The downside is of course that when removing or when needing to replace a part, the wires needs to be de-soldered.

When using connectors, all the connections can easily be disconnected. Which makes maintenance much easier. However, it costs more.

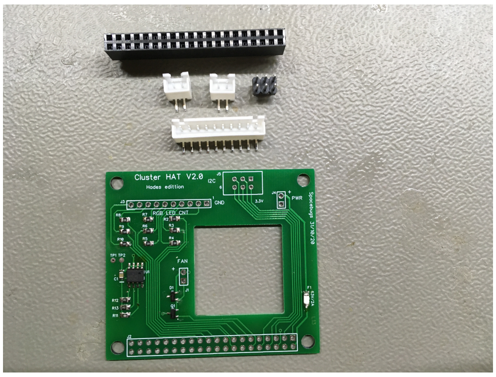
Whichever solution you choose, it doesn’t matter, as long as the profile of the PCB is as low as possible.

Soldering the PCB

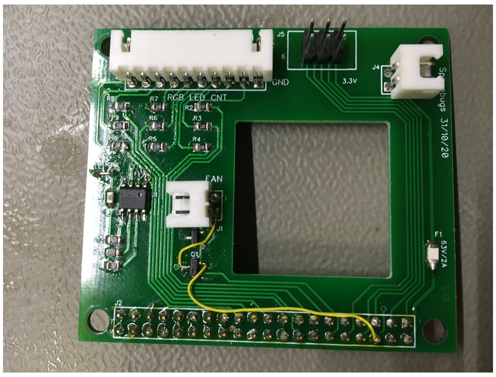
When starting to solder the PCB, first start with the SMD components:



Next solder the JST XH 2.54 haeders onto the PCB



As a last step solder the 6 pins 2.54mm header, and then the as the last component the 2x20 GPIO pin header at the other side of the PCB. The final PCB is shown below. In a last step the FLUX must be cleaned up from the PCB. But apart from that, this is how the finished PCB should look like.



NOTE	During development, the PCB version 2.0 (Hades Edition) a few bodge wires where needed, to let the MOSFET do it’s work. Also note that the test points are shorted together, allowing the EEPROM te be written. :imagesdir: assets/images :includesdir: include

Featues of the LED Board

The LED Board provides the following features:

- 3x RGB LED on a small PCB
- Easy connection to the PI Cluster HAT by using one JST XH 10 pins female connector
- One common GND PIN for easy controlling the RGB LED's and save precious space on the PI Cluster HAT
- Easy and solid attachment to PI Tray

Theory of Operation

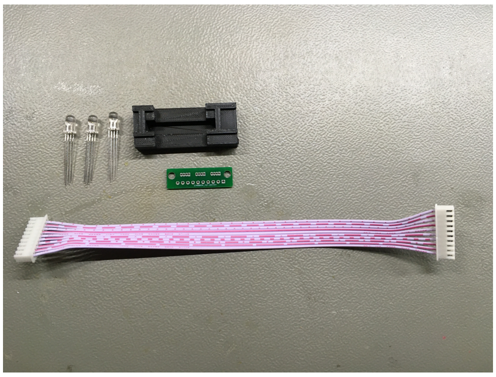
The LED Board holds 3 Common Cathode RGB LED's on a small PCB. The RGB LED's share a common GND. This reduces the number of connections needed from 12 connections to 10 connections, which save space on the PI Cluster HAT, and also save on the number of wires.

NOTE	The silkscreen on the PCB has no GND or (-) marking. This is fixed in the next version of the PCB. The pin closest to the silkscreen marking "J1" is the common GND pin. == Assemble the LED Board :imagesdir: assets/images :includesdir: include :fullWidth: 245 :fullHeight: 150 :development_version_beta: 2.0 Hades Edition :current_version: 2.0 Hades Edition

The assembly of the LED Board is perhaps the most tricky one. Since space on the LED Board is quite limited, the footprint of the RGB LED's are somewhat "spaced close together". You get this when trying to solder the RGB LED's, without trying to bridge the pins together.

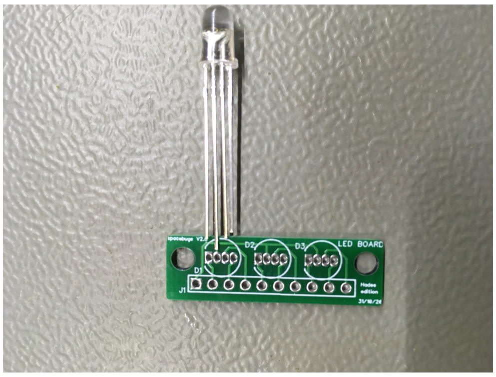
To assemble the LED Board, the following is needed:

- 1x LED board
- 3x RGB LED
- 1x Solder helper tool (Trust me, you really want to 3D print this tool and actually use it)
- 1x (pre) crimped JST XH 10 pins 2.54 female connector



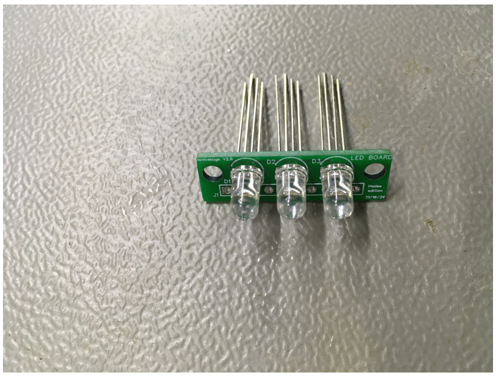
Placing the RGB LED’s

The first and most important thing is to insert the RGB LED’s in the right orientation. The next image is demonstrating this:



Another way of looking at this is: On the PCB the LED markings have an open spot, the flat side of the RGB should be at this opening:

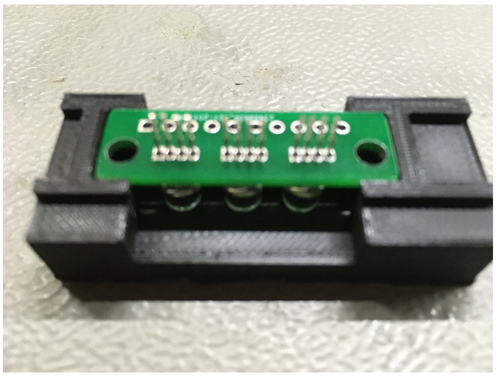
After determine the right orientation of the RGB LED’s insert them into the LED board:



Using the soldering helper tool

Add this point, you should have 3D printed the solder helper tool. Place the LED Board PCB as follows in the solder helper tool:

NOTE	To align the RGB flat with the PCB, there is only one way of inserting the PCB correctly into the solder helper tool



As you can see from the picture, it may help to cut the RGB LED’s legs short, to make soldering even easier.

Once the PCB is inserted correctly, and the RGB LED’s are flat with the PCB surface, solder all the legs of the RGB LED’s without bridging them.

TIP	To prevent bridging, use 0.5mm tin. And if pins are bridge, cut the legs short as possible and use solder wick to suck away the tin.

Soldering the wires onto the LED Board

Once all the RGB LED’s are soldered, time to cut the the wire to length, by cutting the 10 string cable at at a length of 9.5CM. Make sure the guiding pins on the connector face upwards:

Next pull apart the 10 strings for about 3CM, and cut off +/- 0.5CM of isolation, to expose the bare copper wires.

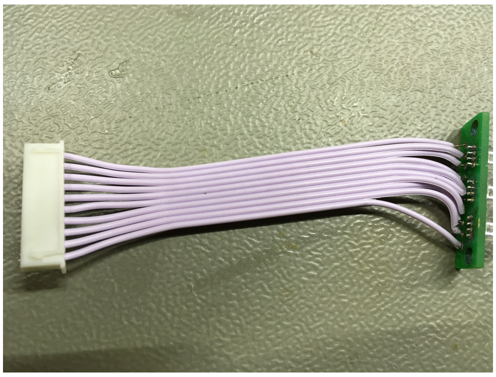
To make inserting the 10 wires into the PCB easier, tin the wires lightly. This is best done by using 0.5mm soldering tin, and clean the solder iron tip after each wire, to loosen the extra tin, preventing it going onto the next wire.

Take your time to tin the wires lightly. When to much tin is applied to the wires, they may become to thick to be inserted into the holes on the LED Board PCB.

Insert the wires with the correct orientation

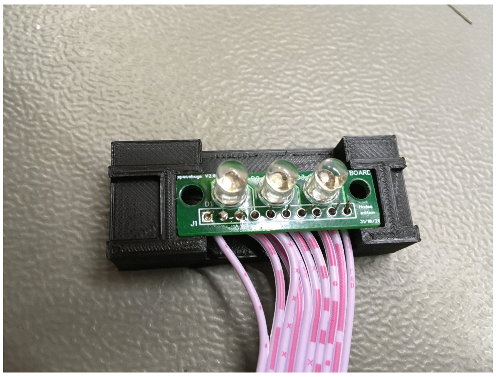
Once the wires are tinned, insert the 10 wires onto the back of the LED Board PCB. When inserting the wires make sure that the orientation is correct. The next image shows an complete assembled RGB LED Board, and notice the orientation of the connector:

The guide lines thingy on the connector is facing upward, while on the LED Board the wire connections are on the bottom.



Looking at the image above, the GND (common) pin is on the left.

Once the wires are inserted, the soldering helper tool can help by making it more easy to soldering the wires:



It may be tricky to insert the wires, and make sure they stay inserted into the PCB while placing the PCB into the helper tool.

TIP	It may help to solder the first two or three wires "by hand", and then inserting the wires into the PCB, and placing the PCB carefully into the helper tool. By soldering the first wires, it may help to keep the wires into position.

Testing the LED Board

Once the RGB LED’s and wires are soldered, the LED Board can be tested if you have a 5V power supply (for example a LAB Power supply)

When positioning the LED board as shown in the following picture, the left pin is the (common) GND pin. Insert for example a 330Ohm resistor, and supply 5V with low Amperes (around 20mA)

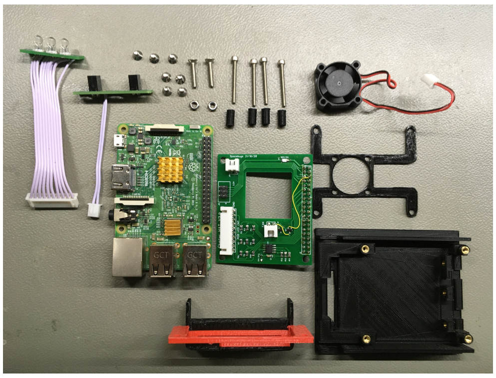
Connect the GND power lead to the resistor, and touch insert a thin wire into the second hole right next to where the resistor is inserted. You should see a RED LED, place the wire into the next hole beside it, and you should see a BLUE LED, connecting the positive wire to the next hole you should see a GREEN LED. Repeat this process for each other LED. For every RGB Led you must see the RED,BLUE,GREEN LED’s light up.

If all the three RGB LED's are working, the assembly of the LED Board is completed. :imagesdir: assets/images :includesdir: include :fullWidth: 245 :fullHeight: 150 :development_version_beta: 2.0 Hades Edition :current_version: 2.0 Hades Edition

Assemble the PI Tray

Do you remember that a long, long time ago you prepared the PI Tray at the very beginning of this Hardware manual ? Well, now is the time to blow the dust of it, and start assembling the PI Tray.

To assemble the PI Tray, the following is needed:

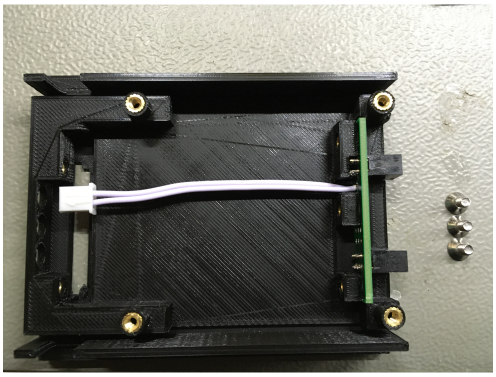


- 1x Raspberry PI3 (or PI4)
- 1x An prepared PI Tray
- 1x An assembled PI Cluster HAT
- 1x An assembled Power Board
- 1x An assembled LED board
- 1x An assemble front panel + bezel
- 1x 3D printed fan holder
- 4x 3D printed stand-off
- 1x 5V Fan + wire + JST XH 2.54 connector
- 4x M2.5x25 bolt
- 5x M3x5 bolt
- 2x M2x6 bolt
- 2x M3x16 bolt
- 2x M3 nut

TIP	The 2x M3x5 bolt can be replaced with 2xM3x6 bolt. Another thing to consider is to use metal M2.5 stand-off with M2.5 bolt/screw.

Place and attach the Power Board to the PI Tray

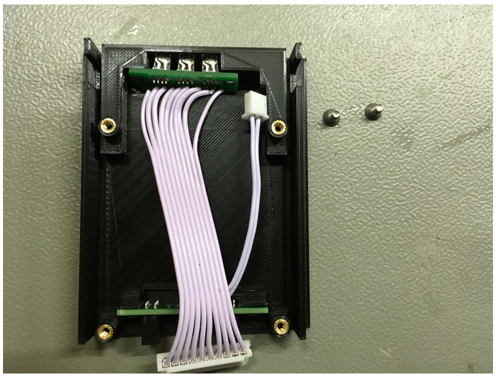
The first step is to attach the Power Board. The PowerBoard should click into place:



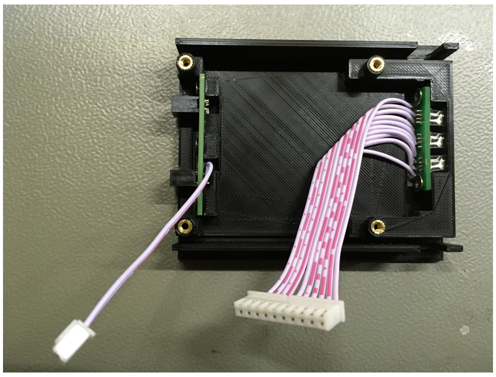
When the board is correctly fitted, use 3x M3x5 bolt to screw the board into place.

Place and attach the LED Board to the PI Tray

Next the LED Board can be placed. The easiest way of placing the LED board, is to put it in under a angle, face the LED’s down in a angle, towards the front of the PI Tray. The LED’s should line up with the 3 holes in the front of the PI Tray. Next push the underside of the PCB into the cut-out. It should click into place. This may require some force, but don’t use to much force.



Once the LED Board is correctly placed, use 2x M3x6 bolt to secure the board in place:

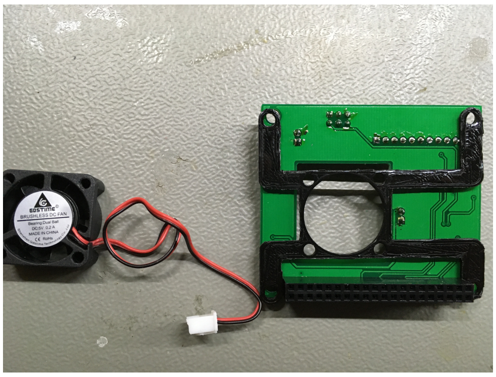


Attach the FAn to the FAN holder

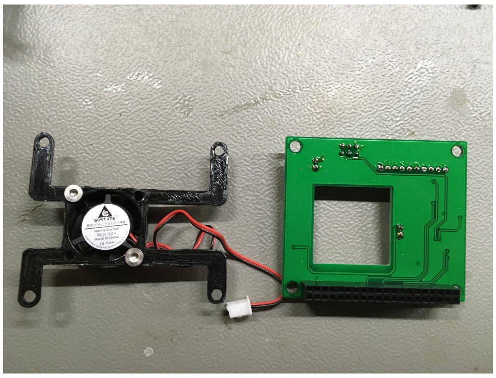
The FAN should be placed correctly on to the FAN holder. This means the FAN should suck in cool air, and blow the air against the CPU.

TIP	To determine in which way the FAN spins, connect the 5V FAN to a 5V PSU, and use a small piece of paper. Hold this small piece of paper close to the FAN, while it's spinning. If the piece of paper moves towards the FAN, the air is sucked in. If however the piece of paper is blown away from the FAN, the FAN is blowing air out.

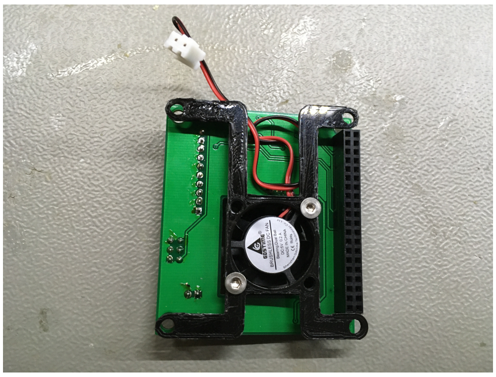
When connecting the FAN take note of the FAN holder. The FAN holder fits only in one direction:



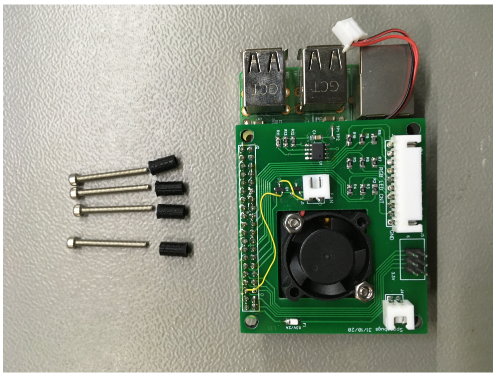
When the correct position of the FAN holder is determined, screw the FAN onto the FAN holder:



Finally attach the FAN holder onto the PI Cluster Frame. Make sure that excessive wire is out of the way of the FAN

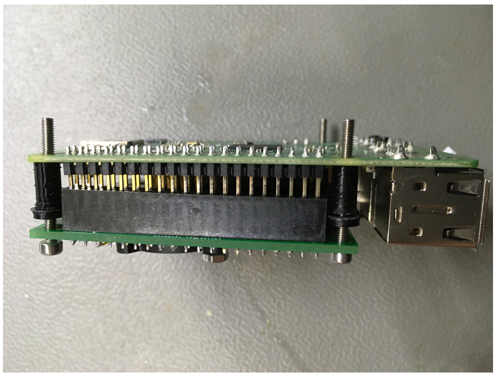


Attach the Raspberry PI and PI HAT together



To attach PI Cluster HAT onto the Raspberry PI, 4 3D printed stand-off can be used with 4x M2.5x25 bolt. However, you could also use metal stand-offs with the same height. Personally I prefer to use long screws with the 3D printed stand-offs. The funny thing is that I discovered this by accident. I didn't had enough M2.5 metal stand-offs in stock. So I quickly sketched some PLA stand-offs, and used at that time M3x25 bolts. And I discovered that by using this construction I can simply unbolt 4 bolts, and take the hole PI assembly of the PI Tray, which make swapping a PI or an other component a breeze.

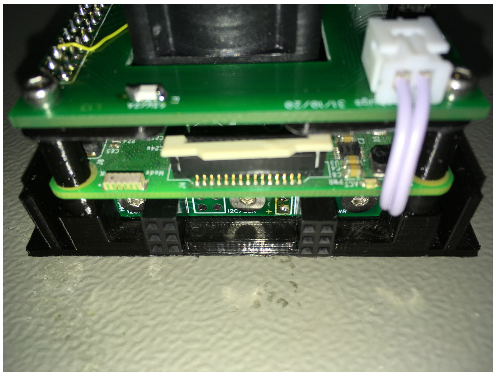
Anyway: Start by pressing the PI Cluster HAT somewhat down on the 2x20 male header on the Raspberry PI. Don't push the PI Cluster HAT all the way down. This makes inserting the 3D printed stand-offs easier:



Insert the 4x 3D printed stand-offs and 4x bolts.

Place the whole assembly of the Raspberry PI and the Pi Cluster HAT onto the PI Tray, align the holes with the four bolts. Press the PI CLuster HAT down onto the Raspberry PI (if you not had done this already)

Screw the assembly into place. Make sure the power cable on the back is not between the Raspberry PI and the SD card holder, by making sure the power cable is guided along the corner:



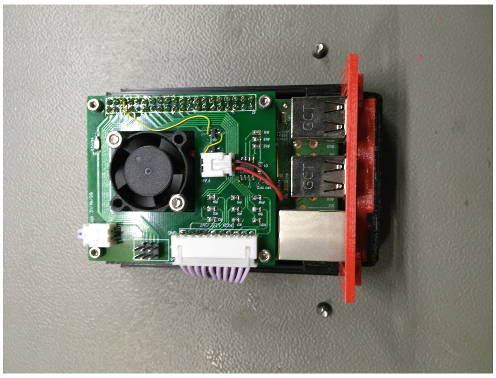
Connect all the wires:

- Connect FAN wire
- Connect Power wire
- Connect the RG wire

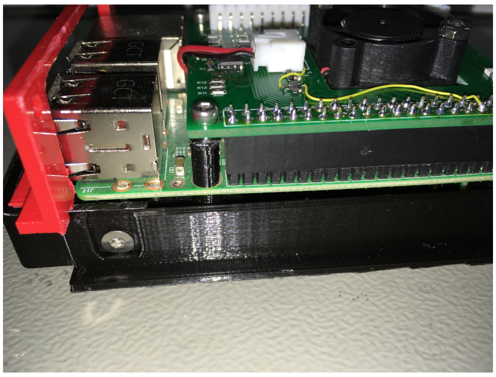
Attach the front panel

The last step is to attach the front panel to the PI Tray using 2x M3x5 bolt:

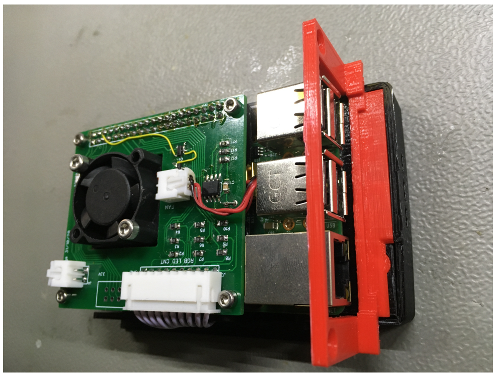
Slide the front panel onto the PI tray:



Secure the front panel into place with two screws:



The finished PI Tray should look like this:



Building the frame

To build 1 cluster frame, the following is needed:

- 1x backplate
- 1x front-plate
- 1x connecting rod left
- 1x connecting rod right
- 1x back-plane shim (more on that later on)
- 1x back-plane PCB
- 6x Brass press insert M3
- 2x M3x10
- 2x M3x25

The first step is to 3D print all the parts. When building a frame for 10 nodes this is a process that can take several days to complete. It’s also possible to print the parts for 2 nodes (so one frame at the time). And extend the frame in the course of a few days.

The 3D printed parts needed are shown in the picture below:

The attribute fullWidth is set to 245

NOTE	During development a back-plane shim is used. This will no longer be needed in production.

Before starting the assembly, make sure to deburr all the edges. Next place the brass press inserts into both sides of the connecting rods and use a hot conical tip from a soldering iron the gently press the inserts into the hole. Make sure that the insert is level with the surface. So that the insert isn’t sticking out, and make sure don’t press the insert to deep.

Also make sure that the press insert is inserted straight. Inserting the press insert on a slightly angle will cause the frame to be out of alignment.

Once the insert are pressed in, press the two remaining inserts into the top holes of the front plate. == Parts List introduction The complete parts lists contains per main components the parts needed. The main components of the PI Cluster frame are:

- PI Cluster Frame
- PI Tray

Per main components the list is divided into

- Hardware
- PCB
- Electronic parts needed.

The lists contains all the parts which are needed to build the intended design. However, the design is modular and flexible. Which means there are more then one way to build the PI cluster frame.

For example:

- Not using any connectors, and solder the wires directly to the PCB's.
- Instead of using M2.5 screws, M3 screws can be used, by filing out the Raspberry PI mounting holes.
- Instead of using M2.5x25mm bolts, M2.5 stand-offs with screws can be used to mounbt the PI Cluster HAT onto the Raspberry PI

The complete parts list however doesn't take these variants into account. == Complete Parts List NOTE: List is provided AS IS. List may contain errors.

PI Tray

Parts needed to build 2 Pay tray's and 1 PI Cluster frame (which holds 2 PI's)

Hardware

- 8x M2.5 THREADED SOLID BRASS BARBED INSERTS FOR PLASTIC,PRESSFIT
- 18x M3 THREADED SOLID BRASS BARBED INSERTS FOR PLASTIC,PRESSFIT
- 8x M2.5x25
- 14x M3x5
- 8x M3x10
- 8x M3x14
- 8x M3 nut

PCBs

- 2x Fully assembled PI Cluster HAT
- 2x Fully assembled PowerBoard
- 2x Fully assembled LEDBoard

PI Cluster HAT

Parts needed to assemble 2x PI Cluster HAT

Electronic Components

- 18x SMD 0805 330 Ohm resistor
- 2x SMD 0805 1K Ohm resistor
- 4x SMD 0805 3.9K Ohm resistor
- 2x SMD SOIC-8 CAT24C32 EEPROM
- 2x SMD SOT-23 NDS351N Logic Level Mosfet
- 2x Litle Fuse SMD 1206
- 2x 1x 25x25 5V FAN with 2 pins JST XH 2.54 connector
- 2x JST XH 2.54 10 PINS connector
- 4x JST XH 2.54 2 PINS connector
- 2x JST XH 2.54 90 degree angel JST XH 2.54 10 pins connector + 10CM cable (pre crimped)
- 2x JST XH 2.54 straight JST XH 2.54 2 pins connector + 10CM cable (pre crimped)
- 2x SparkFun GPIO 2x20 Female header

NOTE	Recently the NDS331N became obsolete. Replacement: SSM3K344R, package is different (SOT-23F-3). Same footprint as SOT23

PCB

- 2x PI Cluster HAT PCB

Power Board

Parts needed to build 2 Power Boards

- 4x 2x3 rows 2.54 pitch female header
- 2x Pre-crimped JST XHT 2.54mm connector

PCB

- 2x Power Board PCB

LED Board

Parts needed to build 2 LED Boards:

- 6x RGB LED 5MM
- 2x JST XHT 2.54 10 pins connector pre-crimped.

PCB

2x LED Board PCB

1x PI Cluster Frame

One PI cluster Frame holds 2 PI trays

Hardware

- 12x M3 THREADED SOLID BRASS BARBED INSERTS FOR PLASTIC,PRESSFIT
- 4x M3x10
- 4x M3x25
- 4x M3 threaded rod

NOTE	rod length based on the number of PI frames. Max 19" for 5 PI frames (10 nodes) For 1 PI frame (which holds 2 PI nodes) rod length is +/- 90mm

PCBs

- 1x Backplane

Electronic Components

- 2x 2x3 male header
- Enough thick isolated copper wire to connect the backplane + 5V power supply