uHat Specifications

Considering the user acceptance criterias in the final report and looking at the operational approach for each requirement, here is how we will go about designing a HAT that is compatible with the Raspberry Pi sense HAT standards.

General Details

Our HAT board will be conform to the following add-on board requirements:

- It should have a valid ID EEPROM (including vendor info, GPIO map and valid device tree information).
- It should have a full size 40W GPIO connector.
- It should follow the HAT mechanical specification (See details in the below table 1.1).
- It should use a GPIO connector that spaces the HAT between 10mm and 12mm from the Pi (i.e. uses spacers between 10mm and 12mm).
- It should be able to supply 2.0A of current continuously to the Pi. We should consider back powering the Pi via a GPIO connector so the HAT should be able to supply a minimum of 1.3A continuously to the Pi.

Other details to consider:

- We should consider having some specific GPIO sequencing that should consist of having some pins being active by default, so they can have unexpected results in case there are no current limitations on LEDS connected to them.
- Nothing will be connected to pins 27 and 28 other than a valid EEPROM.
- We should consider back powering the Pi via the HAT, therefore it will be questionable to establish a clear need to connect the 3.3V supply from the HAT to the Pi.
- We should also consider putting in protective components to prevent 5V via USB causing conflicting power issues.

Design Specifications

- **Pins configurations**

We will put this part of the design into a spreadsheet to make it easier to parse all the options and to do some checking to see what is available and if the function assigned to a particular pin is valid. I have inserted both a screenshot and the link (read-only) to the in-progress work on the spreadsheet here:

Pin Number	Specification	LEDs GPIO pin (via current limiting resistors)	Pin Number	Specification	LEDs GPIO pin (via current limiting resistors)
1	3v3 Power		2	5v Power	
3	GPIO 2 (I2C1 SDA)		4	5v Power	
5	GPIO 3 (I2C1 SCL)		6	Ground	
7	GPIO 4 (GPCLK0)		8	GPIO 14 (UART TX)	
9	Ground		10	GPIO 15 (UART RX)	
11	GPIO 17	LED	12	GPIO 18 (PCM CLK)	
13	GPIO 27	LED	14	Ground	
15	GPIO 22	LED	16	GPIO 23	LED
17	3v3 Power		18	GPIO 24	LED
19	GPIO 10 (SPIO MOSI)		20	Ground	
21	GPIO 9 (SPIO MISO)		22	GPIO 25	LED
23	GPIO 11 (SPIO SCLK)		24	GPIO 8 (SPIO CE0)	
25	Ground		26	GPIO 7 (SPIO CE1)	
27	(EEPROM SDA)		28	GPIO 1 (EEPROM SCL)	
29	GPIO 5	LED	30	Ground	
31	GPIO 6	LED	32	GPIO 12 (PMW0)	
33	GPIO 13 (PMW1)		34	Ground	
35	GPIO 19 (PCM FS)		36	GPIO 16	LED
37	GPIO 26	LED	38	GPIO 20 (PCM DIN)	
39	Ground		40	GPIO 21 (PCM DOUT)	

Figure 1: Pins configurations showing where our 10 LEDs will be connected.

https://docs.google.com/spreadsheets/d/16PtPY0GQPKd3i4CP3gYp-tbYzPIeMka0UuIFL_dIIac/edit#gid=0

Each pin will be numbered from 1 to 40, starting from the lower-left corner. These are the physical pin numbers.

Power and Ground

Highlighted in red will be power pins labeled 3 or 5 for 3.3V or 5V. These pins will allow us to send power to the device without the need for any code. There will not be a way to turn these off either.

There will be two power rails: 3.3 volts and 5 volts. The 3.3V rail will be limited to 50mA current draw. In contrast, the 5V rail will provide whatever current capacity is left over from the power supply after the Pi has taken what it needs.

Highlighted in brown will be the ground pins (GND).

Note: 5V GPIO pins will be physical numbers 2 and 4 and 3.3V GPIO pins will be physical numbers 1 and 17. Ground GPIO pins will be physical numbers 6, 9, 14, 20, 25, 30, 34, and 39.

Input/Output Pins

The green pins will be generic input/output pins. These will be easily used as inputs or outputs without clashing with other functions such as I2C, SPI, or UART.

These pins will be sending power to LEDs and/or other components, or they can be used as an input to read sensors, switches, or other input devices.

The output power of these pins is 3.3V. Each pin shouldn't exceed 16mA of current, either sinking or sourcing. The entire set of GPIO pins shouldn't exceed more than 50mA at any one time. This can be restrictive, so I may have to get creative during the course of the project.

Note: Generic GPIO pins are physical numbers 7, 11, 12, 13, 15, 16, 18, 22, 29, 31, 32, 33, 35, 36, 37, 38, and 40.
In the figure, we have also shown to which pins our LEDs will be connected via current limitations resistors.

I2C Pins

The I2C pins will be in yellow. I2C is a communication protocol that will allow devices to communicate with the Pi HAT. These pins can also be used as generic GPIO pins.

UART (Serial) Pins

The UART pins are shown in grey. These pins will be another communication protocol that offers serial connections and can be used as generic GPIO inputs/outputs.

One use for UART will be to enable a serial connection from a Pi to a laptop over USB. This should be achieved using add-on boards or simple cables. It will remove the need for a screen or internet connection to access our Pi.

Note: UART GPIO pins are physical pin numbers 8 and 10.

SPI Pins

The SPI pins will be in pink. SPI should be described as an interface bus that sends data between the Pi and other hardware and peripherals. It can commonly be used for chaining devices such as an LED matrix or display.

Note: SPI GPIO pins are physical pin numbers 19, 21, 23, 24, and 26.

DNC Pins

Last are two pins in blue that are currently labeled as **DNC**, which stands for Do Not Connect. As mentioned in our general details section, nothing will be connected to these pins other than a possible valid EEPROM.

Note: DNC GPIO pins are physical pin numbers 27 and 28.

Mechanical Specifications

Requirement	Specification(s)	Acceptance Test Criteria
Minimum Hat Requirements	• Pi HAT Board must be 65x56mm or 65x56.5mm • Pi HAT Board must have a 3mm Radius corner • Pi HAT Board much have 4 mounting holes in corners • Pi HAT Board much follow mounting holes specifications • Pi HAT Board have full 40W GPIO Connectors	• Given the general dimensioning requirements of the Pi HAT • When being manufactured • Then ensure the Pi HAT Board dimensioning meet the listed specifications
Mounting Holes Specification	• Mounting Holes should ideally be • non-plated. If plated, hole and land must be electrically isolated (Not to be connected to ground). • Mounting hole land should be min 6.2mm and either isolated copper or bare board (open solder mask) • Mounting holes should be drilled to 2.75mm +/- 0.05mm	• Given the holes requirements of the Pi HAT • When being manufactured • Then ensure the Pi HAT Board holes requirements meet the listed specifications

Table.1.1: Mechanical specifications

Electrical Specification

Requirement	Specification(s)	Acceptance Test Criteria
Power Source	Pin Name: +5V, +3.3V, GND and Vin Description: ● +5V -power output ● +3.3V -power output ● GND – GROUND pin	● Given the power source ● When our designed Pi Hat has to be powered ● Then we should ensure output, input and ground meet the specification
Processor Operating Voltage	3.3V	● Given the Processor Operating Voltage ● When powered ● Then we should ensure Processor Operating Voltage meets the specification
Raw Voltage input	5V, 2A power source	● We should ensure Raw Voltage input meets the specification
Maximum current through each I/O pin	16mA	● We should ensure Maximum current through each I/O pin meets the specification
Maximum total current drawn from all I/O pins	54mA	● We should ensure Maximum total current drawn from all I/O pins meets the specification

Table1.2: Electrical specifications

Functional Specifications

Requirement	Specification(s)	Acceptance Test Criteria
System Processing Size	• **With 1.2 GHZ clock speed and 1GB RAM**	• Given the system processing size • When the Pi HAT is designed • Then, its system processing size should meet the required specifications to perform our described use case
Wireless Functionality	• Wireless LAN and Bluetooth facility	• Given the wireless functionality • When wireless connectivity is needed • Then our designed Pi HAT should be implemented with wireless LAN and bluetooth facility by which WIFI HOTSPOT for internet connectivity can be setup
LCD display	• LCD display port	• Specification should be met by allowing the Pi HAT to have a dedicated port for connecting LCD display
Camera	• Camera port	• Specification should be met by allowing the Pi HAT to have a dedicated camera port so one can connect the camera without

		any hassle to the PI board.
PMW	● PMW Outputs	● Specification should be met by allowing the Pi HAT to have PMW outputs for application use.

Table 1.3: Functional specifications