UNIVERSITY OF CAPE TOWN

EEE3088F

DESIGN PROPOSAL

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GROUP 18

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1. Power Subsystem

1.1 Specification

This submodule must be able to receive 3-3.6V, and deliver 5 volts. It will contain the following components/circuits:

- A 18650 connector (DNP)
- A Li-Ion battery charger
- Input voltage polarity protection
- Battery polarity protection
- Battery Under-voltage cutout protection
- This module will provide an output of 5V, The current and power required havent yet been decided on, but these can easily be altered by using cheap analog components

In terms of the charger for the battery, we are still undecided as to how we wish to power it, but one of our ideas is to not power from the discovery board but from an external source, and then use this part/circuit.

https://datasheet.lcsc.com/lcsc/1809261820_TOPPOWER-Nanjing-Extension-Microelectronics-TP4056-42-ESOP8_C16581.pdf

These are some of the components we are looking to use for this part of the circuit. In the next section there isn't a parts list as we haven't fully decided on the power rating, and how much current the other modules need at this point. The only point of looking at parts was to get an idea of prices.

PMOSFET:

https://datasheet.lcsc.com/lcsc/1810171817_Alpha---Omega-Semicon-AO3401A_C15127.pdf

Voltage Regulator:

https://datasheet.lcsc.com/lcsc/1810231832_Advanced-Monolithic-Systems-AMS1117-5-0_C6187.pdf

LED:

https://datasheet.lcsc.com/lcsc/2006301912_TOGIALED-TJ-L3FYTGCGMCGLFLC2G-A5_C331056.pdf

https://datasheet.lcsc.com/lcsc/2006301911_TOGIALED-TJ-L3FYTGCTCGSFLC2G-A5_C330751.pdf

Resistors:

https://datasheet.lcsc.com/lcsc/2007151113_YAGEO-RC0402FR-0710R5L_C477603.pdf

https://datasheet.lcsc.com/lcsc/1810231425_YAGEO-RC0603FR-07100RL_C105588.pdf

https://datasheet.lcsc.com/lcsc/2110252130_UNI-ROYAL-Uniroyal-Elec-0603WAF332JT5E_C23004.pdf

https://datasheet.lcsc.com/lcsc/1810161313_HKR-Hong-Kong-Resistors-RCT0330R1FLF_C177931.pdf

https://datasheet.lcsc.com/lcsc/1810241340_YAGEO-AC0402JR-0750RL_C227387.pdf

https://datasheet.lcsc.com/lcsc/1810241325_YAGEO-AC0402FR-0760R4L_C144744.pdf

NOT Gate:

https://datasheet.lcsc.com/lcsc/1809172025_Texas-Instruments-SN74HC14PWR_C6821.pdf

1.2 Bill Of Materials (BOM)

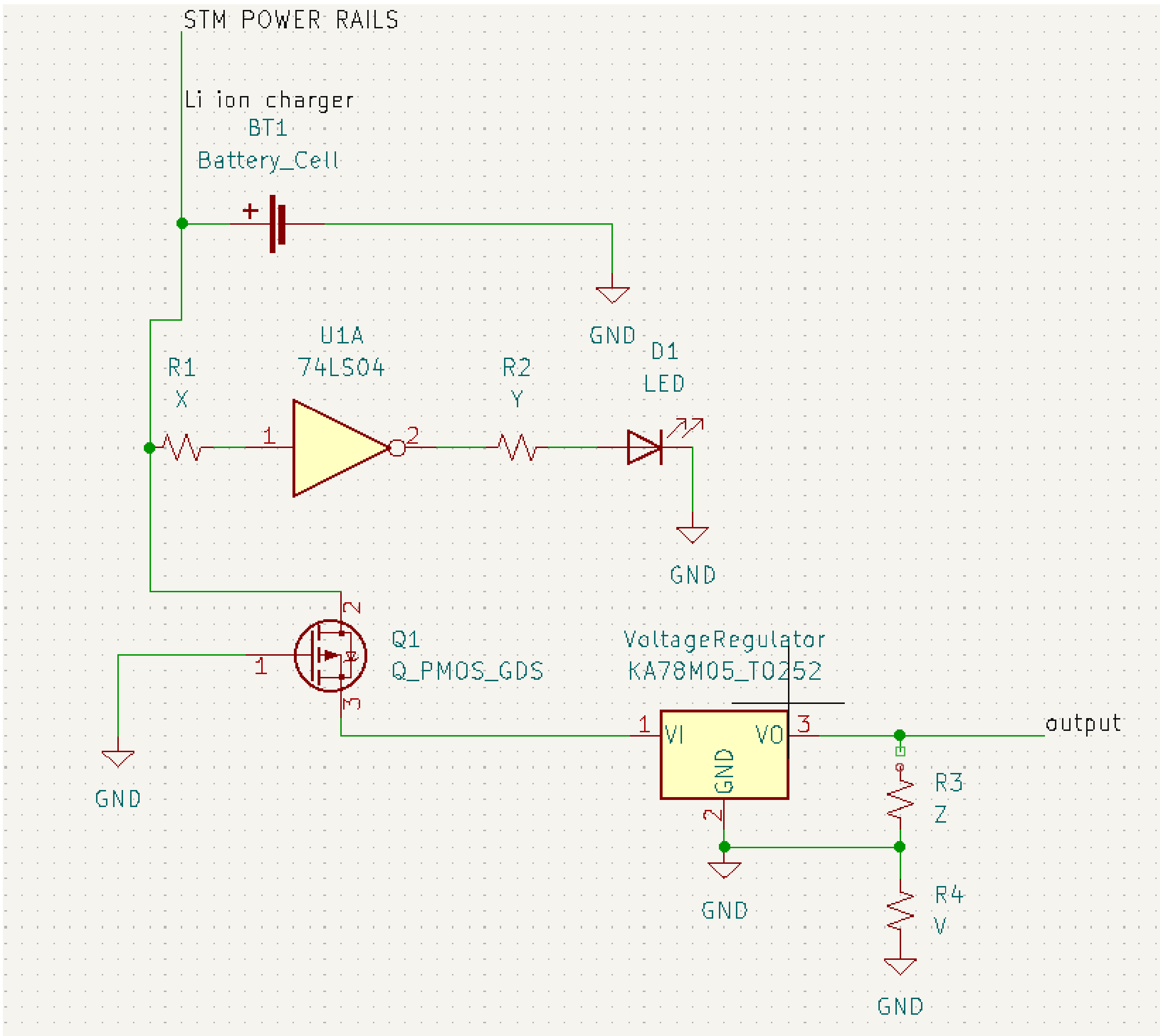

Figure 1: Power Module Schematic

The estimated cost of this circuit excluding the battery is 1.2$. The reason that parts weren't chosen from JLCPCB yet is that the availability of the parts will change as time passes, so an approximate cost for each part was taken from JLCPCB just to give us an idea of the cost. The battery that we are using (18650 LIPO battery) did not appear on JLCPCBs library so we excluded it from the approximate cost for now.

https://gitlab.com/g5168/eee3088f-group-project/-/blob/main/Design%20Proposal%20Assignment/Bill_Of_Materials_Power_Submodule.xlsx

Q1.3 Define this submodule’s interface(s) [10]

The power module is responsible for powering the microcontroller. It ensures that the correct voltage is sent to the microcontroller. The power module is protected against reverse polarity via the PMOSFET, it ensures that if the user puts the battery in the wrong way or something that current won't flow to the microcontroller, and an LED will be switched on to notify the user. The voltage regulator is the part of the power module that ensures that the required voltage is sent to the microcontroller. The power module also indirectly powers the HAT via the microcontroller.

2. Microcontroller interfacing

Q2.1 Specification [10]

Item	Requirement	Specification	Additional Notes and Documentation Links
	Memory		
M1a	Key configuration data must be kept in a non-volatile medium and data from the temperature sensor must be time-stamped and stored alongside this throughout the operational period	EEPROM needs to be used to store configuration data and to read in and store data from the temperature sensor. The **M24128-BRMN6TP** is a 128Kb chip which is compatible and costs $0.2052. The 64Kb **M24C64-RMN6TP** and the 2Kb **M24C02-WMN6TP** chip cost $0.2029 and $0.1355 respectively per component.	Datasheets: https://datasheet.lcsc.com/lcsc/1809061818_STMicroelectronics-M24C02-WMN6TP_C7562.pdf Here it is important to note that there have been huge fluctuations of both price and stock over the week so multiple options have been listed but a final decision will be made based on availability, price and required usage once the memory required to be stored is more clear. However, the 128Kb chip is preferred as it likely has enough memory and has a small price increase compared to the 64Kb chip, it does not have large stock currently available and an alternative may be required.
M1b		Pins **PF6** and **PF7** on the discovery board are used for I2C to connect the EEPROM.	
	Clock		
C1	Measure at a minimum of 1/60 Hz which is required to be soft-configurable.	The STM32F051's internal RTC will be used.	
	USB		
U1a	On USB plug-in event	A **C404969** Surface Mount Micro-B SMD USB Connector that costs $0.048 is needed so that a Micro-B USB can be used.	Datasheet: https://datasheet.lcsc.com/lcsc/1912111437_SHOU-HAN-MicroXNJ_C404969.pdf

U1b		A USB-MicroB cable is needed to connect the microcontroller to the HAT.	These may be reused from the equipment given out for EEE2046F.
U2a	Data captured by the temperature sensor should be written to EEPROM.	Pins **PA2** and **PA3** on the microcontroller are required for the FTDI chip.	The data needs to be transferred from the sensor to a FTDI chip via USB to be “translated” into USART which is then written to the external EEPROM in the form of an array. CH340C Datasheet: https://www.mpja.com/download/35227cpdata.pdf
U2b		A **CH340C** chip can be used to interface between the sensor and memory. The chip “translates” the data from USB to USART. This chip costs $0.7311 and has a built-in clock generator so requires no external crystal source.	
	Pin Interfacing		
PI1	Analog Sensors(LDRs) should output to the microcontroller	9 GPIO pins need to be made available for the analog sensing unit. These should be configured in analog input mode.	
PI2	The microcontroller must receive power from a power module powered by a Li ion battery.	A 5V-tolerant **GPIO** pin on the STM32F051 Discovery Board must be used as a power input.	https://www.st.com/content/ccc/resource/technical/document/application_note/group0/13/c0/f6/6c/29/3b/47/b3/DM00315319/files/DM00315319.pdf/jcr:content/translations/en.DM00315319.pdf (section 5.2)
PI3	The microcontroller must output 5V to HAT.	The **5V pin** needs to be available to output 5V to the HAT to charge the battery.	

Q2.2 Draft Bill Of Materials (BOM) [10]

- Link to spreadsheet in gitlab:

https://gitlab.com/g5168/eee3088f-group-project/-/blob/main/Design%20Proposal%20Assignment/Draft_Bill_Of_Materials_Microcontroller_Submodule.xlsx

- Component cost:

A single board costs $0,9843 and hence, the total cost for the 5 boards is **$4,9215**.

- Screenshot of **draft** schematic:

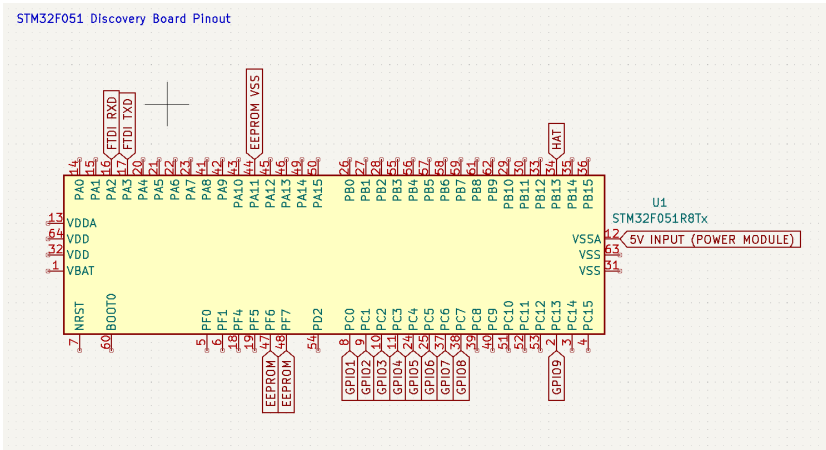

Figure 2: STM32F051 Microcontroller Module Pinouts

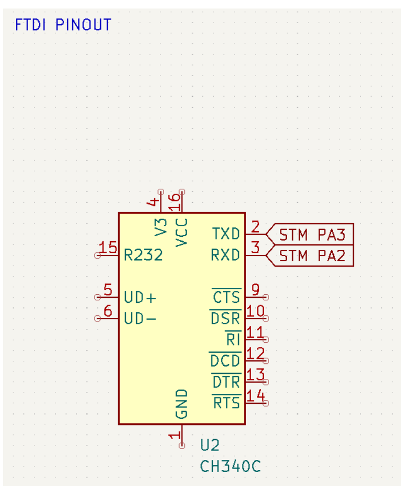

Figure 3: FTDI Microcontroller Module Pinouts

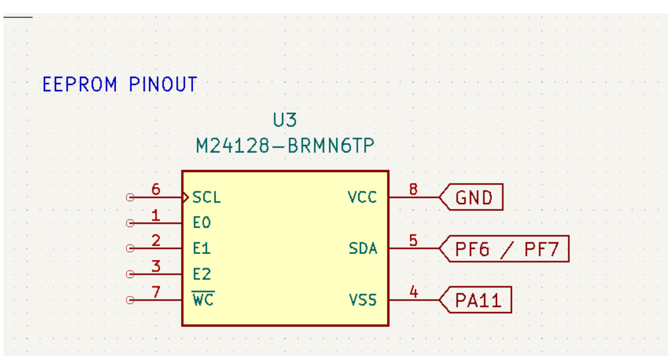

Figure 4: EEPROM Microcontroller Module Pinouts

Q2.3 Define this submodule's interface(s) [10]

Interface	Description
Power Module	The power module is responsible for powering the microcontroller. These 2 submodules are interfaced via a 5V-tolerant GPIO pin.
HAT power supply	The microcontroller is responsible for providing power to the HAT. The HAT and the microcontroller are interfaced via the 5V output pin.
Analog Sensors	The 4 LDRs on the HAT as well as the 4 LDRs on the peripheral device are interfaced with the microcontroller via GPIO pins.
Digital Sensor	The digital temperature sensor is interfaced with the microcontroller module via the USB connection to the FTDI chip.
LED on microcontroller	Red LED LD1 (PWR) and LD2 (COM) light up and green LED LD3 blinks to indicate the microcontroller is powered on.

3. Sensing Subsystem

Q3.1 Specification

3.1.1 Digital Sensor Specification

Item	Specifications	Additional Notes	Datasheet Links
1	One LM75BD Temperature sensor is required.	This operates at 2.8V - 5.5V, and as such is perfect for the HAT as a digital sensor. Further operating conditions can be found in the attached datasheet.	https://datasheet.lcsc.com/lcsc/2110111830_UMW-Youtai-Semiconductor-Co---Ltd--LM75BD_C725792.pdf
2	One red LED (BL-HUE35A-AV-TRE) to indicate that the temperature is outside optimal functioning conditions.	This will be connected to a pin which reads the LM75. The temperature data register will be polled to ensure that when the temperature exceeds a specified limit, the LED is lit up.	https://datasheet.lcsc.com/szlcsc/1809192334_BrtLed-Bright-LED-Elec-BL-HUE35A-AV-TRE_C138549.pdf
3	20mA of forward current through the LED must not be exceeded.	Put a resistor in place to ensure correct operation (see Item 4).	N/A
4	Items 2 and 3 necessitate the use of a 300Ω resistor. The RCT02300RFLF seems to be perfect for this use case.	Performing a KVL analysis on a 5V power supply in series with a 300Ω resistor (with a forward voltage drop of 3V) and a 2V LED, shows that the current through the LED will be: I = V/R = 3/300 = 10mA. This is a correct operating current for the LED.	https://datasheet.lcsc.com/lcsc/1810162030_HKR-Hong-Kong-Resistors-RCT02300RFLF_C173569.pdf
5	One CT41G-0402-2X1-16V-0.1μF-K(N) capacitor, to decouple the signal at the Vcc pin.	This adds safety from undesirable noise signals.	https://datasheet.lcsc.com/lcsc/1809291518_TORCH-CT41G-0402-2X1-16V-0-1-F-K-N_C141382.pdf
6	Three RCT0310KJLF 0.1W, 10KΩ resistors are required. No more than 0.1W can be dissipated by each resistor.	These act as pull-ups for the temperature sensors. Pull-up resistors are necessary for this temperature circuit configuration at the bus output and the interrupt line.	https://datasheet.lcsc.com/lcsc/1810161330_HKR-Hong-Kong-Resistors-RCT0310KJLF_C177337.pdf

3.1.2 Analog Sensor Specification

Item	Specifications	Additional Notes	Datasheet Links
1	The HAT requires four GL48516 photoresistors (LDRs).	These assume values of 5-10 KΩ at 10 LUX, and approximately 0.2 MΩ in the dark.	https://datasheet.lcsc.com/lcsc/2009121137_JCHL-Shenzhen-Jing-Chuang-He-Li-Tech-GL48516_C779572.pdf
2	Four RCT0310KJLF 0.1W, 10KΩ resistors are required. No more than 0.1W can be dissipated by each resistor.	These will be placed in series with the LDRs in 4 separate voltage divider configurations.	https://datasheet.lcsc.com/lcsc/1810161330_HKR-Hong-Kong-Resistors-RCT0310KJLF_C177337.pdf
3	One C13828 push-button is required. It operates at ≤ 12VDC and ≤ 50mA.	This will be used to toggle the control of the rotation of the peripheral device from the photoresistors on the HAT to those on the peripheral unit.	https://datasheet.lcsc.com/szlcsc/1912111437_Dongguan-Guangzhu-Industrial-C13828_C13828.pdf
4	The photoresistors cannot be placed very closely together on the final HAT pcb.	The four photoresistors on the HAT and on the peripheral unit need to be separated using plastic slats, to separate the LUX reading on each. They thus cannot be placed too closely together.	N/A
5	The outputs from the voltage divider configurations must operate between 2.4V and 3.6V.	GPIO pins in analog mode operate between 2.4V and 3.6V. ADC pins will likely be needed when the software is implemented.	N/A
6	Item 5 implies that the input voltage should lie at around 5V. Thus the input voltage to the photoresistor voltage divider configuration should be connected to the STM32F0's 5V pin.	This is very important for the pcb's dimensions and tracks.	N/A
7	There need to be connectors on the HAT to interface with the photoresistors/resistors on the peripheral module. Connectors should include +5V pins, and 4 GPIO pins with uninterrupted ADC capabilities.	The peripheral module is not part of the HAT system directly, but it should be allowed to operate via the pins on the HAT that can be connected to.	N/A

3.2 Draft Bill Of Materials (BOM)

- Link to spreadsheet in gitlab:

https://gitlab.com/g5168/eee3088f-group-project/-/blob/main/Design%20Proposal%20Assignment/Draft_Bill_of_Materials__Sensing_Submodule.xlsx

- Component cost:

A single board costs $0.8632 and hence, the total cost for the 5 boards is **$4.316**.

- Screenshot of **draft** schematic:

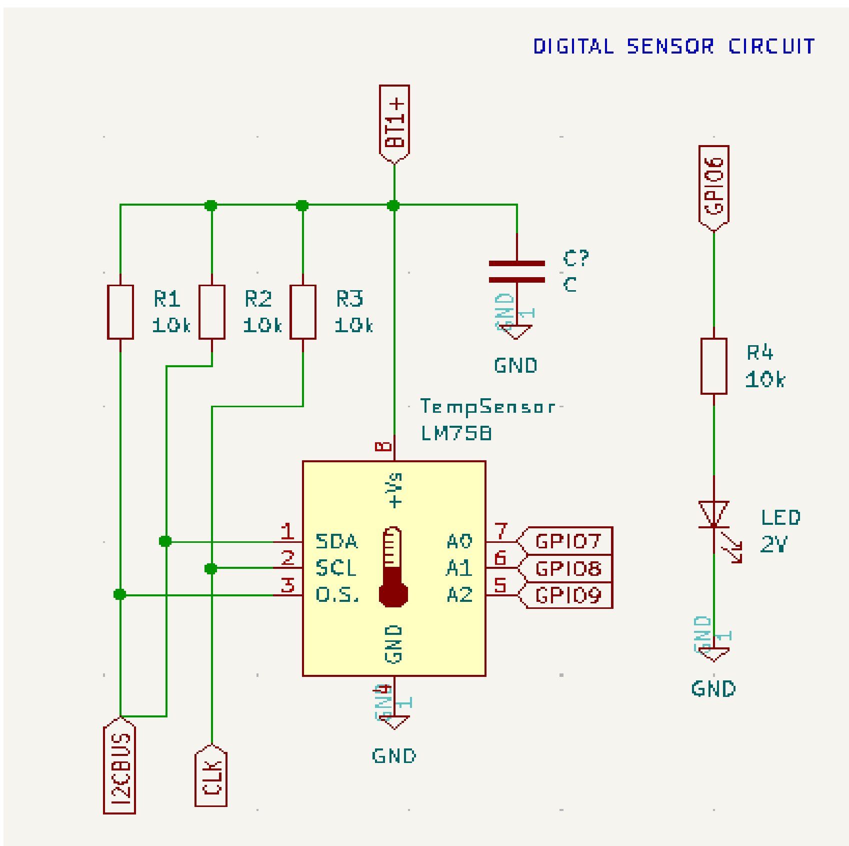

Figure 5: Digital Sensor Schematic

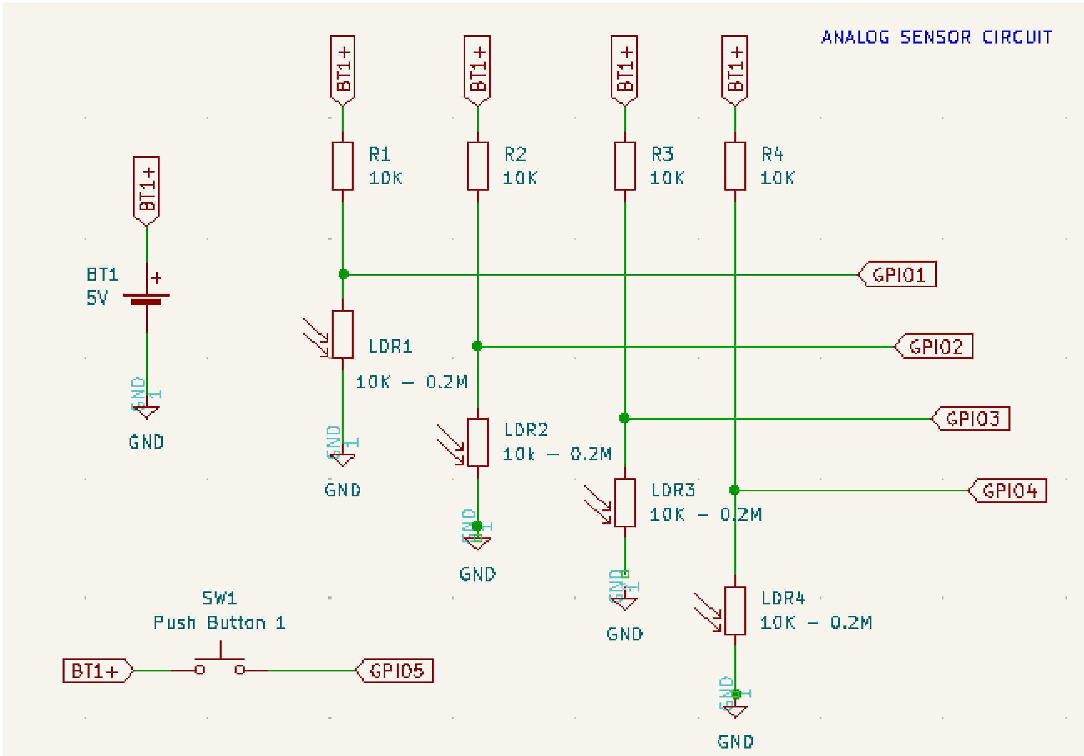

Figure 6: Analog Sensor Schematic

3.3. Sensor Submodule Interfaces

3.3.1 Digital Sensor Interface

<u>Microcontroller Interface:</u>

The temperature sensor will need to closely interact with the microcontroller, since the sensor runs off an external CLK signal. The sensor also sends data via an I^2*C BUS. The BUS will transmit data to the HAT's memory module, which will then send the data via the HAT's USB module to the STM32 microcontroller. The temperature sensor will thus interact with the memory on board the hat, as well as the input and output pins (GPIO) on the STM32.

<u>Power Interface:</u>

The sensors will also interface with the power module, via the discovery board. The batteries will power the discovery board which will provide GPIO pins and microcontroller interface abilities to the HAT. The power module is thus crucial in the operation of the HAT.

3.3.2 Analog Sensor Interface

The analog sensors - the photoresistors - will interface with the following submodules:

Microcontroller Interface:

The photoresistors will be connected to the GPIO pins of the STM32, and to its 5V pin, as shown in the schematic (Figure 6) above. The pushbutton will also interface with the microcontroller on board the STM32 as its state will control whether the photoresistors are reading data from the peripheral device or from the HAT. This requires interfacing with 9 GPIO pins on the microcontroller and 1 power pin.

Power Interface:

The photoresistors and the push-button will operate from the discovery board which will be powered by the batteries on board the HAT (in the usual case). The power module will not directly interface with the sensors, but it will enable the functioning of this module.

Peripheral Unit Interface:

The exact schematic in Figure 6 will be replicated for the peripheral device. The operation of this unit will rely on the microcontroller and power submodules in precisely the same way as the on board photoresistors do. The photoresistors and circuitry connected to the peripheral device will only be activated if the pushbutton is in the correct state (every push of the pushbutton will change the mode of operation from HAT-controlled to Peripheral-controlled, and vice versa). Both the sensors on the HAT and the peripheral device will control the rotating frame (this is part of the peripheral device), one at a time of course (depending on the users preference).

ASSEMBLY COSTS/TOTAL COST

24 SMT components x 0.0017= $0.0408
4 hand soldered components= 3.5x4 =$14
4 extended parts [once off fee] = $12

Therefore the total cost of manufacturing one board: $29.0883
Therefore the total cost of manufacturing 5 boards: $97.4415
[This is excluding the actual cost of the pcb, we didn't include this cost because we have not decided on a size or colour yet]

https://gitlab.com/g5168/eee3088f-group-project/-/blob/main/Design%20Proposal%20Assignment/Draft_ASSEMBLY_COSTS.xlsx