EE/CprE/SE 491 WEEKLY REPORT 2

9/19/2024 – 9/26/2024

Group: ***sdmay25-17***

Project title: ***Microbial Pill Sensor***

Client &/Advisor: ***Dr. Meng Lu***

Team Members/Role:
Roles still subject to change as we transition from research to design phase.
Wes Ryley: Data Transmission Design Lead
Rakesh Penmetsa: Bacteria Housing Design Lead
Alex Upah: Biosensor Design Lead
Cade Kuennen: PCB Design Lead

Weekly Summary

To start the week, group members continued to perform research via readings of various similar devices published in peer-reviewed journals as well as doing research on various general components identified as necessary to the function of the device.

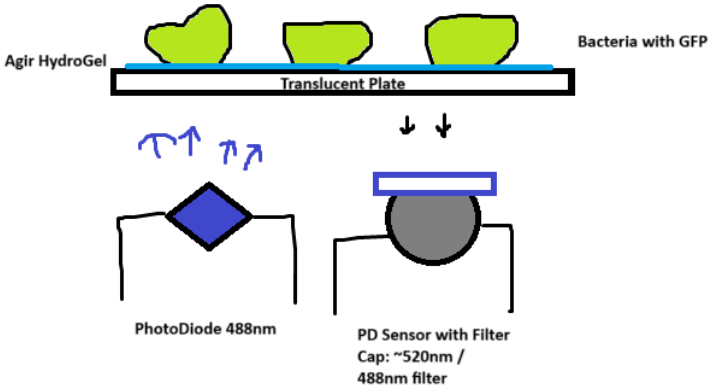
Using previous discussions from week 1, Cade developed a high-level system sketch depicting required components and modules for overall design. As a team we reviewed this high-level design with faculty advisor Dr. Lu. In this meeting, we clearly established an intellectual understanding of requirements and function of each required component identified in high-level system sketch via team and faculty advisor meetings. We also developed a complete understanding of fundamental biosensing mechanisms and optical detection via photodetectors. During this meeting, we also discussed various difficulties regarding each module and decided that initial testing will be done on breadboard using microflourescent beads and photodetectors and LED available through ETG or lab.

We established the future need to identify components used in design, specifically the need to identify MCU that we will use. During the meeting, we established that temperature sensing and control is currently the lowest priority portion of the design, and we will initially focus on other mechanisms.

Past week accomplishments

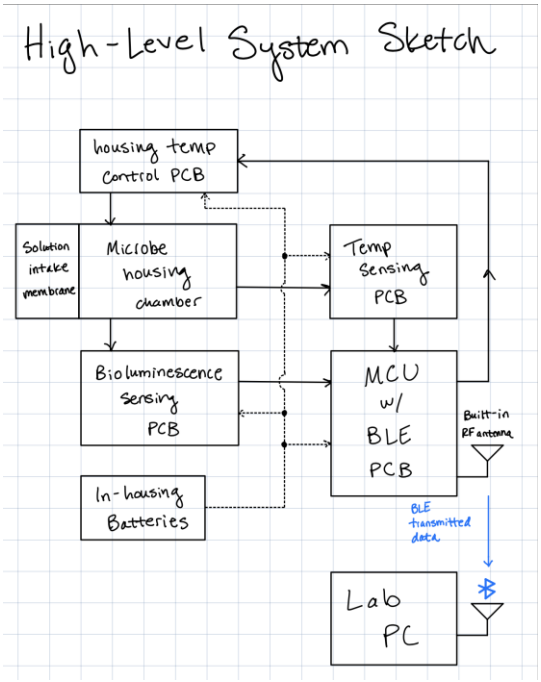
Team:

- Established clear understanding of biosensing mechanism via green fluorescence protein
    - Our LED will emit a specific wavelength. GFP in yeast cells will absorb this wavelength, promoting electrons to higher energy levels, upon which a specific different wavelength will be emitted by the GFP when electrons return to ground state. We will filter incoming light to photodetector to only this desired wavelength, of which then our photodetector will produce a current. The magnitude of this current will be proportional to the intensity of light which will be proportional to concentration of analyte in solution.



Cade Kuennen

- Researched different Low-power MCU's with Bluetooth communication capabilities
    - nRF52832: Low-power MCU using BLE 5.4
    - ESP32: Low-Power Arduino with BLE comms ability
    - BGM220P: Low-Power MCU using BLE 5.2
- Designed a High-Level System Sketch
    - Brought to weekly advisory meeting to discuss with team



- Practiced PCB Design using KiCad
  - Created a schematic for a clap on / clap off light switching circuit for practice
  - Created a PCB layout for that same clap on / clap off light switching circuit for practice

Alex Upah:

- Performed research on various similar designs and necessary components
  - Reviewed peer review documents provided by Dr. Lu intended to serve as prototype for our design.
  - Established that our original concept for fluorescence detection can start simpler than the proposed arrangement in the provided paper.
- Reviewed principles of photodetectors, LEDs and application in optical biosensing
  - Reviewed principle of light excitation of electrons in semiconductors as mechanism to promote conduction electrons responsible for current flow.

Wes Ryley

- Researched different MCU's on their capability of Low Power Bluetooth Transmission
  - The ESP32-UE MCU, which can be used through Arduino for testing, has a low energy Bluetooth transmitter and a built-in antenna. The concern with this MCU is the size requirements would require our project to almost double in size.
  - The nRF52832 also has a low power Bluetooth transmitter and would fit better with the needed application size. The main concerns with this MCU would be that we would have to solder an MCU to a temporary board to conduct testing, which could drive up potential prices.
  - Upon contacting Dr. Lu, we have concluded that the best MCU to be used during the initial design and testing phases would be the ESP-C2 model which meets both low power and size requirements.
- Researched different photodetectors that could be used during testing as well as in the final application.
  - Some complications that have come about during this part of researching components have been the size requirements of some VIS Photodetectors are much larger than allowed or are too costly to be used.
  - Understanding the exact application of the PD along with possible positioning in our PCBs will allow us to narrow the search.
  - During our meeting there was discussion of both a cover filter for the PD, this would have to be made after design and testing, and the possibility of a focused lens which would improve the sensors range.

Rakesh Penmetsa

- Researched on different types of MCU's and studied on the research articles provided my Dr.Lu
  - nRF52832: Low-power MCU using BLE 5.4
  - ESP32: Low-Power Arduino with BLE comms ability
  - BGM220P: Low-Power MCU using BLE 5.2

- Done research on different types of thermosensors that are available that suits the requirement of the project
- Tried to adapt to Fusion 360 by creating the team collaboration file and trying different options

Pending issues

Team:

- No member of the team is familiar with 3D modeling or printing for design of outer capsule.
- No member of the team is familiar with optical simulation to ensure emitted fluorescence is efficiently captured by photodetector.

Alex Upah:

- Unfamiliar with PCB design (seems others in team will have this portion of project covered)

Wes Ryley

- I am unfamiliar with the application of transmitting data through the ESP32-C2 MCU since it isn't through the Arduino software. Will investigate the UART and GPIO requirements for the antenna connection and transmission functions.

Rakesh Penmetsa

- Getting familiar to fusion 360 and trying to figure out the correct micro controller to be used.

Individual contributions

NAME	**Individual Contributions** *(Quick list of contributions. This should be short.)*	**Hours this week**	**HOURS cumulative**
Alex Upah	Spent time reviewing photodetectors, LEDs and optical biosensing. Researched various similar devices discussed in peer-reviewed papers. Contributed to high-level sketch review during team meeting. Contributed to course assignment documents.	5	9.5
Wes Ryley		5	9
Cade Kuennen	Spent time researching low power MCU's that could potentially be used in our design. Created a high-level system sketch for our design. Spent time learning how to use KiCad for PCB design aspect of the project. Contributed to course assignment documents.	6	10.5

Rakesh Penmetsa	Spent time on looking for thermo sensors, studied on the research articles and trying to figure out the fusion360	5.5	10.5

Plans for the upcoming week

At this point in the process, we will continue to discuss plans for upcoming week on a team basis rather than by individual.

Team:

- Identify MCU for design in team meeting
- Identify other components used in design (photodetector, LED, membrane, material for housing)
- Start 3D housing design by learning how to do 3D modeling / printing
- Learn about optical simulation and lensing (needed to ensure that the fluorescence emitted by cells is captured by photodetector).

Cade:

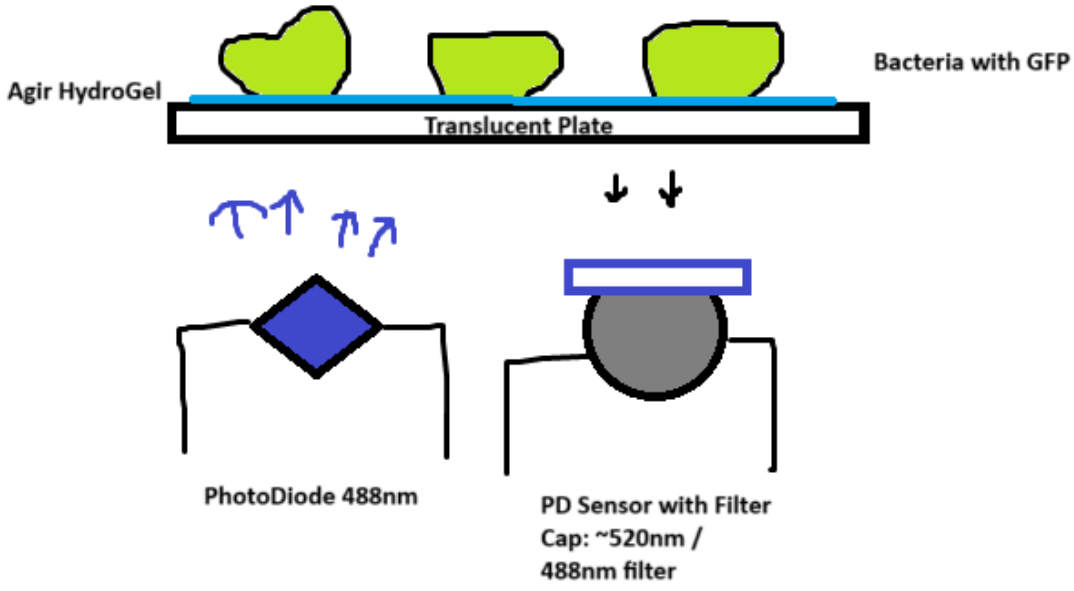
- Generate 3D high-level system design indicating system flow down

Summary of weekly advisor meeting

Meeting 9/23/2024

Housing Chamber & PD PCB:

- Photo Diode Excitation: 488n GFP
- PD Emission: 520n sensor, but need a filter to block out all other wavelengths
- Possibly add lens to enhance excitation and emissions.



MCU:

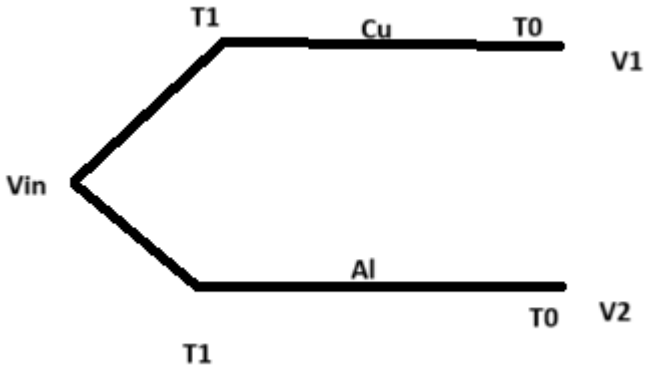
- Figure out which MCU we are using.
    - ESP32 (Arduino)
    - nRF52832 (GI Tract Project)
    - Any other Low-Power Bluetooth MCU with >4 GPIO

PCB Design:

- Will have multiple PCB's (Cade's High Level System Design)
- Use KiCAD for PCB designs.
- Use Fusion 360 for PCB testing (if needed) and 3D modeling of housing

Testing Cooling (potentially wait till semester 2 to start working on this – Dr. Lu):

- Use Passive Temperature Sensing Design. (Shown Below)
- PID circuit to process Voltages from Sensing.
- TEC to help control temperature.



Grading criteria

Each weekly report is worth 10 points. Scores will be awarded as follows:

- **8 – 10**: Progress for your project seems to be suitable. Documentation and hours reported by team members are adequate.
- **6 – 8**: There is scope of improvement both in your report and your project progress. Can consult with instructor/TA after class for further inputs.
- **< 6**: Please talk to instructors/TA after class hours about any difficulties that you/your team is facing.

Each weekly report should be unique in that they have a unique set of supporting details for your contributions. So please do not just copy your reports from the previous week. In addition, please avoid any personal pronouns (he, she, I, you). Try to keep your reports as neat as possible.