4 Design

4.1 Design Context

4.1.1 Broader Context

Describe the broader context in which your design problem is situated. What communities are you designing for? What communities are affected by your design? What societal needs does your project address?

List relevant considerations related to your project in each of the following areas:

Area	Description	Examples
Public health, safety, and welfare	Our project could affect companies that sell products with solar cells and the customers of those companies, since our project can be used to test solar cells.	Our product may help producers test and create more efficient solar cell devices, which would be beneficial for public health by potentially reducing the use of other, less clean sources of power.
Global, cultural, and social	The communities that our project relates to the most are middle or upper class communities in developed nations, since these are the communities that have access to solar cell technologies. These communities may be looking for ways to use power more efficiently, which is reflected very well in our project since our project could be used to test the efficiency of solar cells.	A middle class family in Iowa may be looking for a way to use cleaner energy in their home. They decide to install solar panels, which have solar cells that were tested by our project. In this example, our project was beneficial for this community and reflected their value for clean energy use.
Environmental	Our project could have effects on the energy usage in communities that implement solar energy. This may change how environmental resources used for creating energy in that community are consumed.	Decreased use of nonrenewable energy sources as a result of increased use of solar energy.
Economic	Our product could affect the solar energy market. Our project could potentially provide a cheaper way for testing solar cells, which could have several cascading effects on the solar market and its consumers.	Cheaper solar cell testing could lead to cheaper manufacturing of solar energy cells. This could lead to decreased cost of solar energy cells, increased demand for solar energy cells, and increased job opportunities in the solar market.

4.1.2 Prior Work/Solutions

Include relevant background/literature review for the project

– If similar products exist in the market, describe what has already been done

– If you are following previous work, cite that and discuss the **advantages/shortcomings**

– Note that while you are not expected to "compete" with other existing products / research groups, you should be able to differentiate your project from what is available. Thus, provide a list of pros and cons of your target solution compared to all other related products/systems.

Detail any similar products or research done on this topic previously. Please cite your sources and include them in your references. All figures must be captioned and referenced in your text.

Our Project's goal tackles similar objectives to some other products. An example would be this Solar Cell I-V Test System by Ossila
https://www.ossila.com/products/solar-cell-iv-test-system?_pos=1&_sid=1ad613d9c&_ss=r

Which accomplishes most of the goals of our project, but is lacking in a few key areas, the system provided by Ossila doesn't allow for gas/vacuum to be used, it is very expensive, and has non-configurable data interpretation.

We hope to improve in this design by allowing more configuration of the test environment, different LED wavelengths, bottom-up / top-down lighting options, gas-flow / vacuum options, and a more configurable interface for the interpretation of data. Also since we are designing our own PCBs and testing environment, the price should be much less than the Ossila listed price.

4.1.3 Technical Complexity

Provide evidence that your project is of sufficient technical complexity. Use the following metric or argue for one of your own. Justify your statements (e.g., list the components/subsystems and describe the applicable scientific, mathematical, or engineering principles)

1. The design consists of multiple components/subsystems that each utilize distinct scientific, mathematical, or engineering principles –AND–
2. The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards.

1. Our project contains several distinct components each that utilize distinct engineering principles. Examples include the development of specialized PCBs to control LEDs for our light emitting component, the development of a gas regulation device in order to control gas flow or vacuum, and a specialized interface that connects components and extrapolates data, that implements software development principles.
2. Our project requires the development and implementation of newly designed PCBs and hardware specific software. With the goal of creating a much more cost effective device that combines the functionality of what would otherwise be thousands of dollars in components.

4.2 Design Exploration

4.2.1 Design Decisions

List key design decisions (at least three) that you have made or will need to make in relation to your proposed solution. These can include, but are not limited to, materials, subsystems, physical components, sensors/chips/devices, physical layout, features, etc. Describe why these decisions are important to project success.

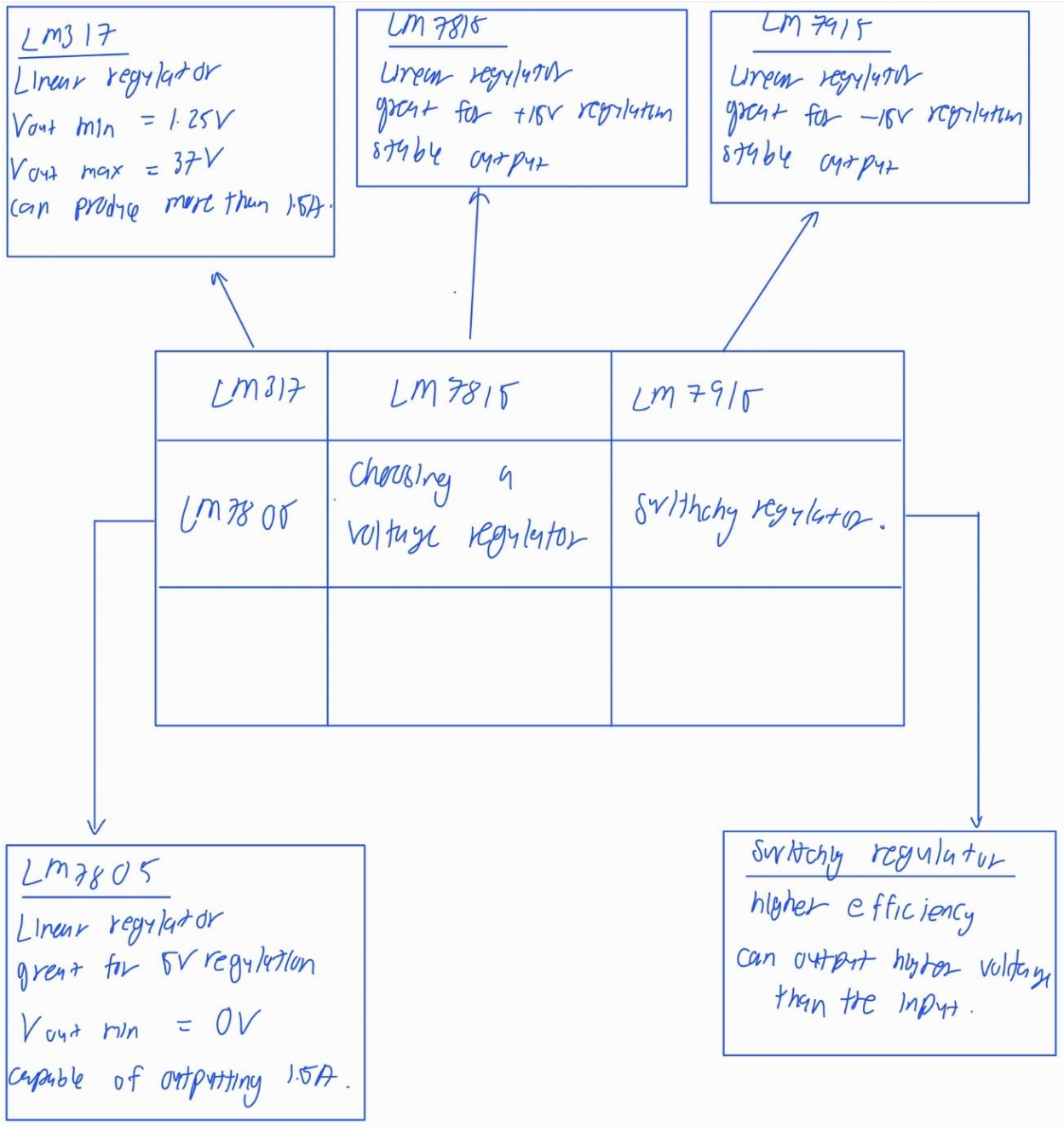
1. For this project, we required a motor that could rotate between 0 to 40 degrees so that the LEDs or the photosensor could be placed right under the device under testing (DUI). We decided to get a motor from Digikey, an electronic component supplier. We choose to get our servo motor from them because they have a lower price and sample code for programming our Microcontroller to control the servo motor.

2. Next, we must decide how to mount our PCB onto the servo. There are a few ways we could mount our PCB onto the servo, and the first way is to use the mount that comes with the servo motor. The manufacturer provided some mounting parts with the servo motor, and we can use them. However, this requires drilling holes in the PCB and screwing the PCB onto the mount. This would give us a risk of making a mistake and breaking the PCB board. On the other hand, we could use glue to stick the PCB onto the servo, which can greatly reduce the chance of breaking our PCB.

3. Then, in our project, a gas regulator could input gas into the device to regulate the testing environment. Three voltage regulators are required in this part of the project, which are +15V, -15V, and adjustable 0 to 5V regulators. After going through the components of the following regulators, our project's advisor suggested that we use LM7915 rather than LM7815 voltage regulator for the -15V regulator. We initially thought we could use four diodes to invert the voltage to negative. However, this could lead to power loss, requiring more components to use LM7815 for a -15V regulator.

4.2.2 Ideation

For at least one design decision, describe how you ideated or identified potential options (e.g., lotus blossom technique). Describe at least five options that you considered.



4.2.3 Decision-Making and Trade-Off

Demonstrate the process you used to identify the pros and cons or trade-offs between each of your ideated options. You may wish to include a weighted decision matrix or other relevant tool. Describe the option you chose and why you chose it.

	Cost	Usability	Availability	Total score
Weight	3	5	4	
Digikey Servo	4	4	3	44
ANNIMOS Servo (Amazon)	2	3	4	37

From the table above, there are two different potential servo motors we are going to use for your project. However, after using a weighted decision matrix, we have decided to use Digikey servo as the total score is higher. The first thing we would consider is the cost of the servo motor. Using a suitable servo motor with low cost could save some of the cost to produce this project. The servo we found on Amazon has a higher price than Digikey as the cost for a servo in Amazon is 15 dollars, and the servo in Digikey has servo motors ranging from 5 to 10 dollars. Then, the most important thing we considered was the usability of the servo motor. Both are very similar in usability, but Digikey, provided code for us to program the servo. Lastly, the availability of the servo. From what we can see from the website of Digikey, the quantity of servo is limited, and there might be a small risk of selling out by the time we decide to order one.