4.3 Proposed Design

4.3.1 Overview

Provide a high-level description of your current design. This description should be understandable to non-engineers (i.e., the general public). Describe key components or sub-systems and how they contribute to the overall design. You may wish to include a basic block diagram, infographic, or other visual to help communicate the overall design.

Our Automated Testing Station is composed of a few subsystems. Our device includes the LED PCBs, the gas regulation system, the DUT(device under testing) probe system, and the software interface that interprets the data and controls certain components. The LED PCBs are composed of two identical PCBs mounted to servos. The PCBs have three different LEDs of different wavelengths that can be pulsed and a photosensor. The servo allows the PCBs to be rotated by the servos to allow the different LEDs to be used for testing. The gas regulation system controls the gas flow rate into the testing environment and also allows for a vacuum within the testing environment. This system contributes to the ability to test different devices in the presence of different gasses. The DUT probe system allows for collecting raw data from the DUT, which the software interface can then interpret. Lastly, the software interface communicates with each component, allowing for control of certain features. It also collects data from the DUT and interprets and graphs that data.

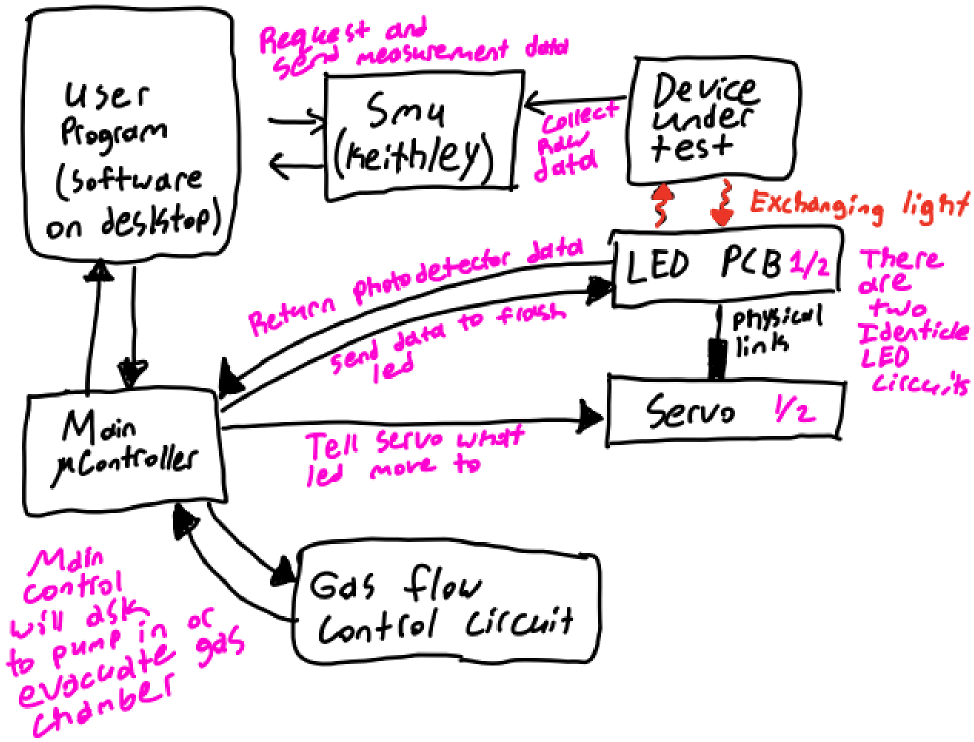
4.3.2 Detailed Design and Visual(s)

Provide a detailed, technical description of your design, aided by visualizations. This description should be understandable to peer engineers. In other words, it should be clearly written and sufficiently detailed such that another senior design team can look through it and implement it.

The description should include a high-level overview written for peer engineers. This should list all sub-systems or components, their role in the whole system, and how they will be integrated or interconnected. A visual should accompany this description. Typically, a detailed block diagram will suffice, but other visual forms can be acceptable.

The description should also include more specific descriptions of subsystems and components (e.g., their internal operations). Once again, a good rule of thumb is: could another engineer with similar expertise build the component/sub-system based on your description? Use visualizations to support your descriptions. Different visual types may be relevant to different types of projects, components, or subsystems. You may include, but are not limited to: block diagrams, circuit diagrams, sketches/pictures of physical components and their operation, wireframes, etc.

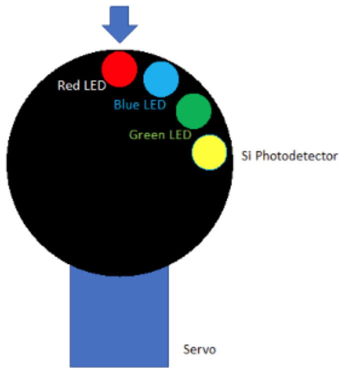
Systems level design

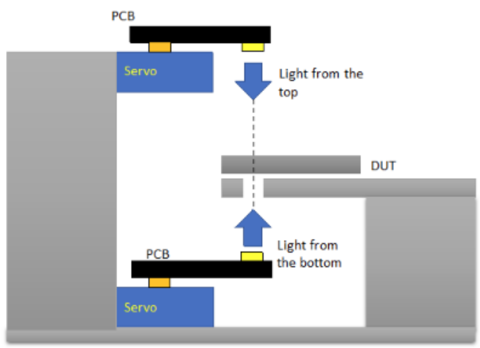


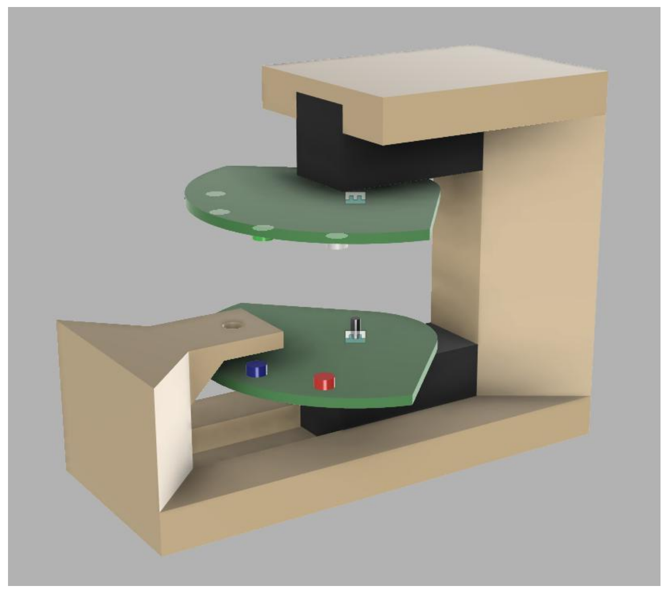
Above is a systems level diagram of our proposed solution. The user will load the device under test (DUT) into the machine and seal it up. From there they will begin interacting with the user interface software running on a desktop computer. The program will be a lab view interface that allows the user to graph and analyze data as well as control the machine to take measurements. When instructed to make a measurement by the user, the desktop software will communicate with a main microcontroller that will send directions to subcomponents to begin making measurements. To make a measurement the gas control circuit will be instructed to either vacuum out the testing chamber or fill the chamber with air or another provided gas (note the machine will sit inside an airtight chamber). From there it will instruct one of the two servos (top or bottom) to move the proper LED or Photodetector into position under/over the DUT. It will then instruct the LED PCB to flash the LED to stimulate the DUT with light. At this point the user interface will also need to talk to a source measurement unit (SMU) that will periodically take electrical current vs voltage measurements of the DUT, which will be solar cells for most types of test. For a specific type of test the DUT will be an LED or some other device that will generate light itself, the intensity of which can be measured by a photodetector on one of the PCB boards. The main controller will then send data from the photodetector back to the program.

Finally the program will automatically perform analysis and graph relevant information for the user.

Physical design







Above are initial design concepts for the physical assembly of the core of the machine. As you can see the two PCBs will be mounted above and below the DUT which will be sitting on a stage in the middle of the device. The main structure will be 3-d printed, and will include mounting holes to secure the servomotors. The LED flasher PCB will sit on top of these servos. (Not Pictured) This core assembly will be placed inside of an airtight, blacked out chamber that will also house PCB's for the the gas control circuitry and main servo controller. Additionally there will be many wires connecting for power and communication between the various components. As well as wires leading through airtight junctions of the chamber for connecting the SMU multimeter leads to the DUT, and connecting the main microcontroller back to the desktop running the user interface.

4.3.3 Functionality

Describe how your design is intended to operate in its user and/or real-world context. What would a user do? How would the device/system/etc. respond? This description can be supplemented by a visual, such as a timeline, storyboard, or sketch.

The device we are building is called an Automated Testing Station, and the main purpose of this device is to get the data and information required when testing a solar panel. The operation of the device would be very simple. The user will place the device under testing (DUI) in a bracket and use a computer to control the testing environment. To control the testing environment, the user can choose the light frequency and the type of gas going into the testing device. By choosing that, the user can understand how the DUI would react in different environments. After choosing the light frequency, the motor responsible for the light frequency will rotate to the angle so that the chosen LED will be placed directly above and under the DUI. Then, after the type of gas is selected by the user, the device will input the gas into the device while the flow rate of the gas device will appear on the LED screen that will be on the device. Then, sensors placed onto the PCB will collect data and send data to the Microcontroller, which will then show complete data in the computer.

4.3.4 Areas of Concern and Development

How well does/will the current design satisfy requirements and meet user needs?

The current design met the user's needs as the device would collect and show the data required by the user.

Based on your current design, what are your primary concerns for delivering a product/system that addresses requirements and meets user and client needs?

The primary concern that we have for our device is we do not know if the device can work synchronously or not, as PCBs for light frequency and gas type are in two different PCBs.

What are your immediate plans for developing the solution to address those concerns? What questions do you have for clients, TAs, and faculty advisers?

We plan to have them connect via cables to the pin available on the Microcontroller.

4.4 Technology Considerations

Describe the distinct technologies you are using in your design. Highlight the strengths, weaknesses, and trade-offs made in technology available. Discuss possible solutions and design alternatives.

Our Design will link together several key technologies for measurement and further analysis of data.

On the hardware side we will be making the bulk of our electrical measurements using highly accurate source-measurement units (SMU) such as the Keithley 2400 that has been provided to us. The benefit of using such a device is the precision of the measurements the system is able to take compared to other measurement devices. The tradeoff being such units can cost thousands of dollars to purchase, so our design solution is predicated on the

user already having access to an SMU (although nearly every college and electrical lab likely does have this available).

Addition ally our design solution requires actuators to move certain components into or out of position for a measurement. To do this we have paired an Atmega-238PB microcontroller (the same controller used on the Arduino Uno) with common RC servo motors. The servo motors are a great choice as opposed to regular DC motors and Stepper motors as they allow precise, repeatable positioning of the disk attached to them. The negative is that controlling them is a little more challenging which is why we need a microcontroller. Thankfully though the Atmega has great support from pre-existing code libraries provided by the arduino community. Besides controlling the servos, the microcontroller will have to communicate with the user interface program hosted on a computer over an interface such as serial communication standards like UART. The final piece of our electrical system will be the gas flow controller. We need a system to ensure that we are able to control the atmosphere of our testing station, ranging from regular air, to vacuum, to CO2 and more. This will allow us to test semiconductor materials based sensors under different operation conditions, a key requirement of our design goals. Besides the electrical hardware we still need support structures to hold all the components together. We have decided on using 3-D printed parts for this part as it will allow us to rapidly prototype different parts, additionally it will allow for easy replacement should a custom part break in the future.

On the software side we will be creating an interface with LabView, this allows for the efficient development of data interpretation and graphing, along with existing libraries for easy connection to device components. The downside to LabView is that since it's a graphical language it might be lacking certain configurability options. A possible solution to this would be to develop the interface with C++ or some related language, but this would require a much more complicated coding solution as the libraries available via LabView would not be available.

4.5 Design Analysis

Discuss what you have done so far, i.e., what have you built, implemented, or tested? Did your proposed design from 4.3 work? Why or why not? Based on what has worked or not worked (e.g., what you have or haven't been able to build, what functioned as expected or not), what plans do you have for future design and implementation work? For example, are there implications for the overall feasibility of your design or have you just experienced build issues?

So far, we have created electrical schematics and a PCB design for the LED PCBs mounted on motors. We have begun designing electrical schematics for the gas control valve portion of the device. We have created a BOM for the project. We have begun CAD designs for the supporting structures of the device. We have begun working on the software for the device as well. Some aspects that we have yet to start working on include adding a silicon cell to the LED PCBs for light detection, programming the processors to flash the LEDs and

rotate the motors, programming the gas control valve portion of the device, and designing a 3D printed structure for mounting the PCBs. We will also have to add the software to the device once it is ready. One feasibility issue that we might encounter involves the LEDs and whether they will provide enough light to achieve the desired results. The LEDs will have to be as close as possible to the DUT, which may cause some build issues. Even if the LEDs are as close as possible to the DUT, we are unsure whether they will be strong enough to produce the desired results.