Battle of the Daleks: Game of Signal Detection and Control Design Journal

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Aim

The goal of this project is to construct a signal detector which rotates itself towards an emitting source. The circuitry is contained in the shell of a Dalek. Sub-group B's aim is to implement the signal detection feature for the Dalek. Specifically, the goal is to create a detector which registers what direction the emitting source is in. As such, the detection system must take advantage of the incoming infra-red signatures and auditory signals emitted from the target to direction-find. The detection system should be precise, indicate the direction of the incoming signals, and seamlessly integrate into the larger design.

Week 2

Overview
I am taking a leadership position within the group. I am yet to decide which subgroup, but predict that it will be on the signals team. Both halves of this project are interesting, and I have initial considerations about both.

Rotating Platform

The best designs are often taken from nature or the everyday because they're intuitive and simple. Initial thoughts involving the Dalek's movement centre around the idea of a lazy-susan with a motor underneath. I predict that the components that we get will be low-end, and we will have a tight budget (if any.) From experience, the motor should have as little weight on it as possible or else it will move slowly. I think that immediate design approaches would be to separate the dead-weight from the essentials - and to decide on a material for the shell and rotating platform. Figure 1 shows a rough draft of this idea, where A is dead weight, B is the head (which is dead-weight and finding a way to not have it connect to the rotating disk (C) with the motor would be ideal.

The material of the shell should be light and be easy to mold to the shape of a Dalek. 3D printing comes to mind immediately, as we can make it thin, precise, and hollow out irrelevant spaces. PLA will likely be the filament because it is light and cheap, however this will be an area to develop further with the mechanical engineers in our group.

In preparation for when we have all required components, the majority of our team has undertaken the soldering proficiency badge through the electrical maker space, and we are interested in the Kirby space for design. However, one of our teammates has his own 3D printer, which is a massive positive.

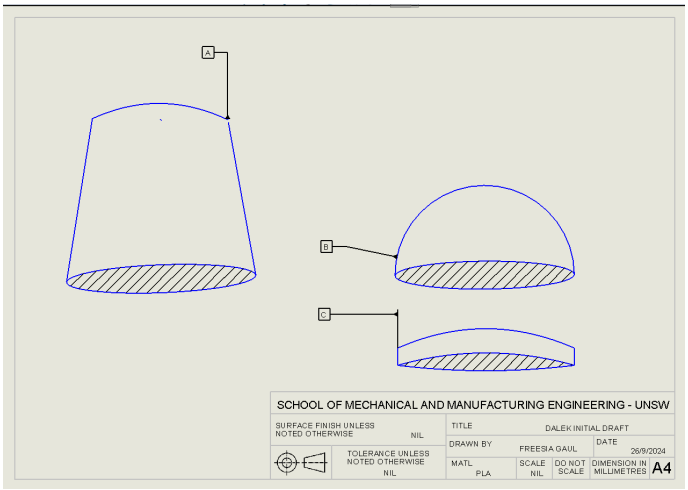

Figure 1: A High-Level Decomposition of the Dalek

Signal Detection

Signal detection is going to be harder than motor work. I have stuck my teeth deeper into this problem out of the fear of how long it will take to create accurate angle of arrival (AoA) measurements. I've taken a high-level research approach to this as well. Rhode and Schwarz have detailed lectures and documentation which has helped me.[1]

I aim to make a schematic for the AoA part of the project as soon as possible. I will likely make it in KiCad, Altium, or LTSPice. From experience, I am assuming that the AoA system will use operational amplifiers (Op-amp's) and comparators. Though, I still have an open mind for other areas to approach this from. I am currently improving my proficiency in MATLAB and Ansys Electronics with the short-term goal of modelling our electronics, and the long term goal of models and simulations for the final report.

Reflection

Considering the lack of information and materials thus far, the team and I have done a significant amount of brainstorming, planning, and research. I look forward to deciding on subgroups and developing a plan for the rest of the term.

[1] The lecture "An Introduction to Direction Finding", Rhode Schwarz, Youtube. has helped significantly.

Week 3

Sub-Group Choices

I am the manager for the signals group (subgroup B.) I have flirted with the idea of create a GitHub repository for easy file sharing as well as organisation, as the people on my team seem interested. Beyond this, I have developed a Gantt chart for the design life-cycle of our project as seen in Figure 2.

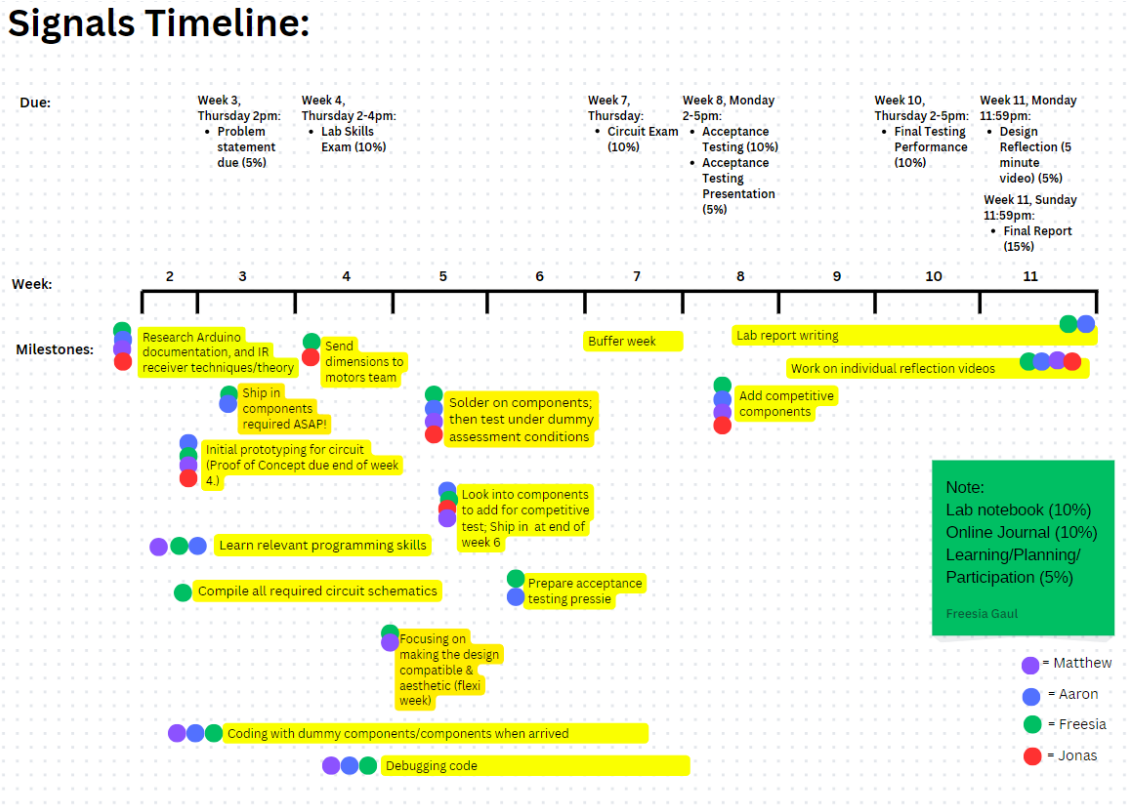

Figure 2: A Gantt chart for sub-group B

Week 7 is a buffer because I expect there is going to be time lost on procurement and prototyping. With the buffer in mind, I believe that this schedule is fair and will give us enough time to interface with the motors team, and develop an aesthetic model for the Dalek alongside the Motors team. By following the Gantt chart and reducing each goal into weekly tasks for each team member, the timeline is far less overwhelming. Week 3's tasks are compiled below.

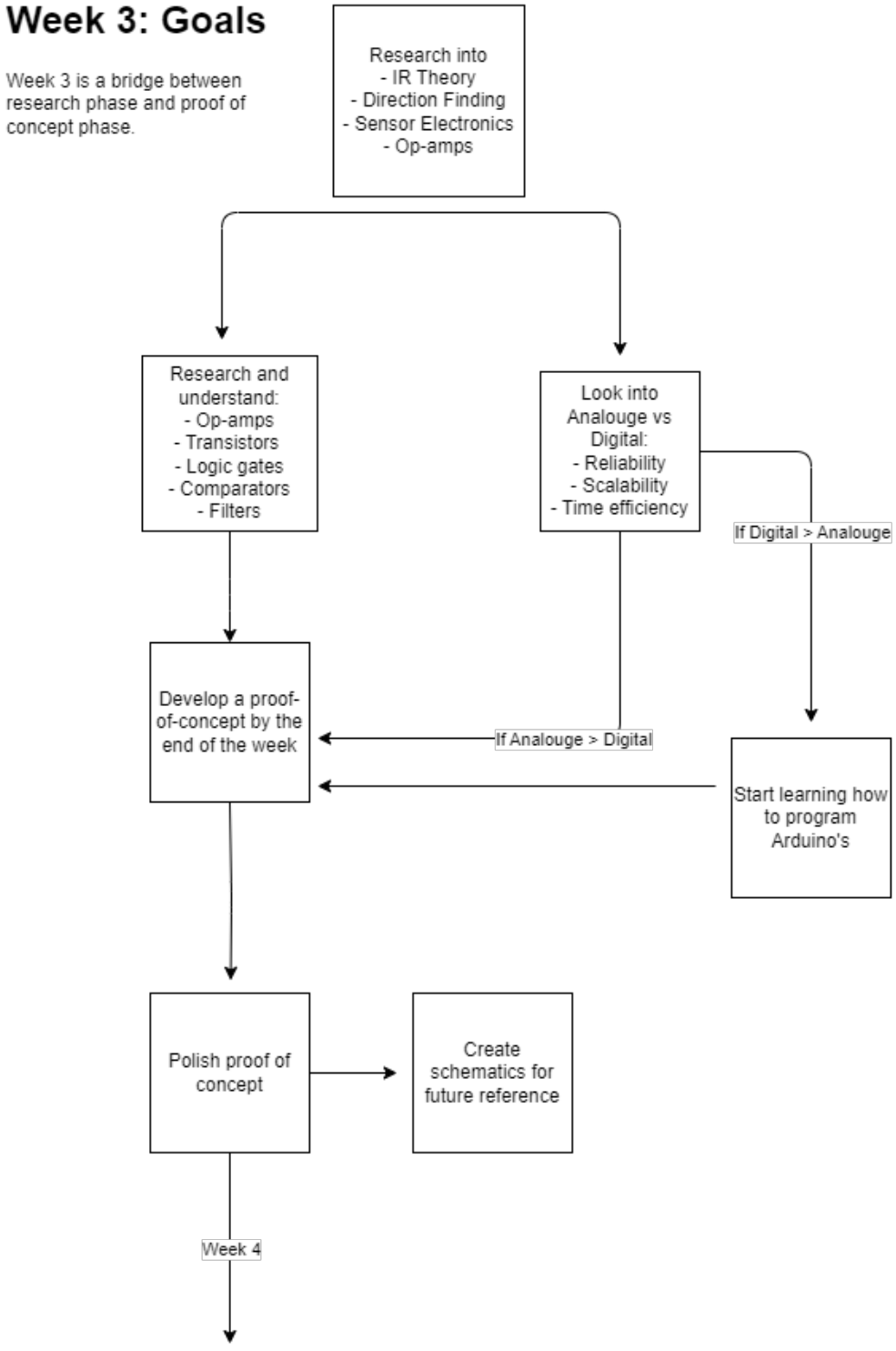

Figure 3: A flow chart of tasks for Week 3

Tasks

- Research further into IR theory and electronics
- Start prototyping the proof of concept AoA detector
- Weigh pros and cons of digital vs. analogue

- Polish the proof of concept going into Week 4, such that a bill of materials (BoM) can be made and communicated with stakeholders

Research

Beyond the lectures and lab materials, we are increasing the scope of our research. I commenced this week by participating the the Electrical Societies (ELSOC's) LTSpice workshop. This helped me gain a better foundation in circuit simulation, logic-gate analysis, and comparators. Figure 4 shows one of the messy, but very useful schematics I made in the workshop, that is assisting with our designs currently.

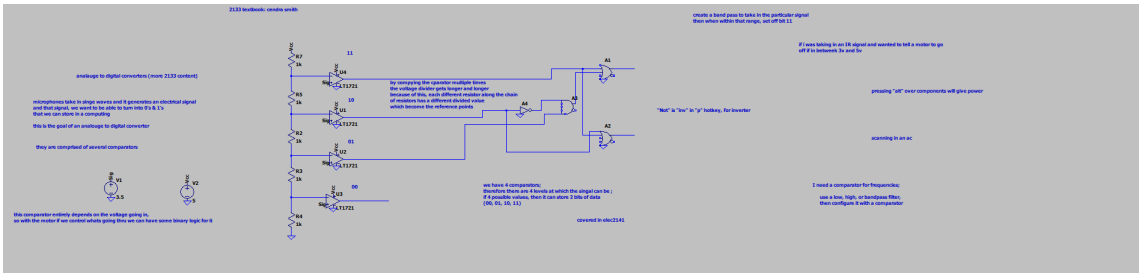

Figure 4: Notes and simulation of comparator from ELSOC workshop.

This workshop was beneficial, and the questions that I asked are helping me direct my research further into analogue electronics and op-amps.[2] Currently, sub-group B is tackling how to place and work with differential op-amps such that they can subtract incoming signals to converge on the point of nearest amplitude to the emitting signal.

I am taking an apprehensive approach to the testing phase. Out of my teammates in the sub-group, I am the furthest into my electrical courses. I want to ensure my teammates understand op-amps and the other key components such that I can rely on them, and no components will be blown during prototyping. I am promoting simulation techniques in LTSpice and TinkerCad to avoid damages. Matthew and Jonas are working on understanding the basics and working up from there. Beyond this, I have been working largely with Aaron to weigh up the pros and cons of analogue versus digital solutions.

Digital versus Analogue: Pros and Cons

On the one hand, digital solutions using the Arduino are more diverse and flexible. On the other, analogue is energy efficient, compact, and avoids the learning curve of a new programming language. The motors team agrees that analogue solutions would be lighter on the motor, and from our current tests, it looks possible to interface. We are leaning towards analogue.

Proof of Concept and BoM

We have commenced the outline for how the AoA detection system will work, but we're waiting on the target emitter to test on to be supplied. While waiting for this go-ahead, we are continuing our testing and research. I am flirting with the idea of creating printed circuit boards (PCB's) or getting veroboards for the project so that the wiring and weight of the circuitry doesn't pose a problem during acceptance testing. We could order them in cheap from PCBWay or JLCPCB. This would making developing a BoM much easier, as software such as Altium and KiCad generate it automatically and display products that are in stock. PCB's would require communication with David Taubman about the scope of our project.

The rest of week 3 is focusing on prototyping and schematics. We are on schedule with our Gantt chart. Taking a step back, the high-level abstraction on how everything will connect for the prototype is seen in Figure 5.

[2] I have completed ELEC1111, and am starting ELEC2134. Hence "Fundamentals of Electric Circuits" by Charles K. Alexander and Matthew N.O. Sadiku, as well as "Microelectronic Circuits" by Adel S. Sedra and Kenneth C. Smith have been great theoretical resources.

Quasi-Logic/Circuit Diagram

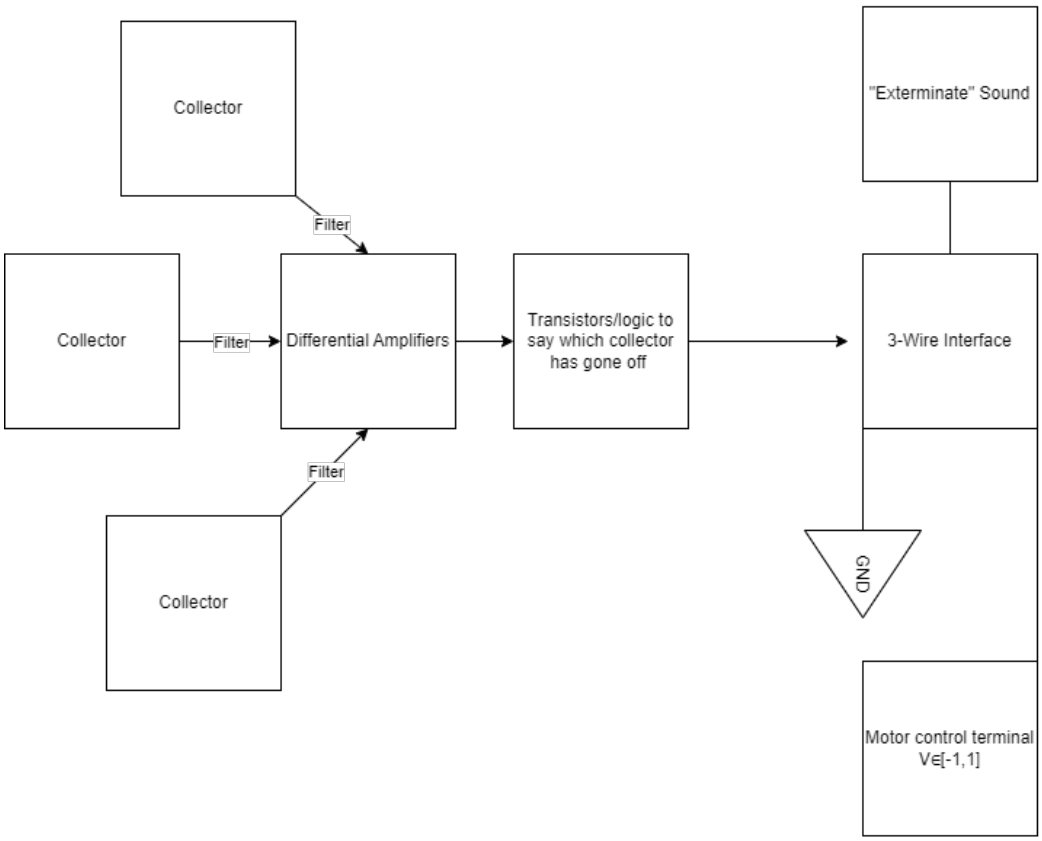

Figure 5: Abstraction of how sub-groups' circuitry will connect

Week 4

Prototyping
Currently we are in the finalisation phase of prototyping the rough signal detector. This is on schedule with the rough product being complete by the end of week 4. (See: p.3 Gannt Chart.)

Weekly Plan:

- Complete initial prototype for detector
- Send dimensions to motors team
- Compile circuit schematics
- Familiarise team-members with Arduino environment

Progress and Individual Tasks
Sub-Group A is working at a faster rate than B. This is likely due to the theory involved with signals being less intuitive. Currently, I am working on:

- Create a rough prototype using an Arduino, then synthesise this into an analouge-style detector

- Research further into comparators so that we can synthesise with sub-group A
- Compile circuit schematics in LTSpice

Currently, progress on the Arduino prototyping is going well, and I have created a working design for the left detector and LED. Presently, I am working on understanding how I am going to use the comparator to send through a voltage through to the motors team that they can understand. I adore Arduinos, so I'm having lots of fun!

Challenges and Risks

I predict there will be a time-management risk. For now, we are still on schedule. I fear that I will run into the allocated buffer time due to mid-term exams. I know after them I can do much more work, but my course load is high this term.

The predicament is that as I have more of a background in hobby projects, so the harder tasks can fall to me. This is okay, and I love being challenged; However, if I take too long in a task that is dependant on me completing something first, I could hold up the progress of the whole design.

I can do a lot of work over the flexible week - and will - but need to equally balance my study load out beyond DESN1000.

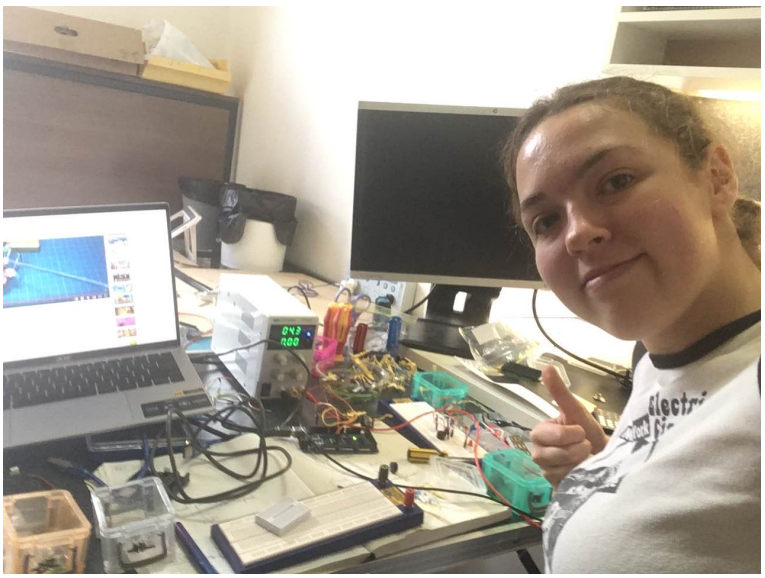

Figure 6: Freesia working with Arduino's and IR testing in her room

One more personal challenge that I face is getting work done in the labs.

Plans for Week 5

- Synthesise from digital to analouge circuit design wherever possible from the first prototype
- Create the comparator that connects with the motors' teams 3-wire interface
- Take LTSpice schematics and turn them into a more optimised design in Altium or PSpice

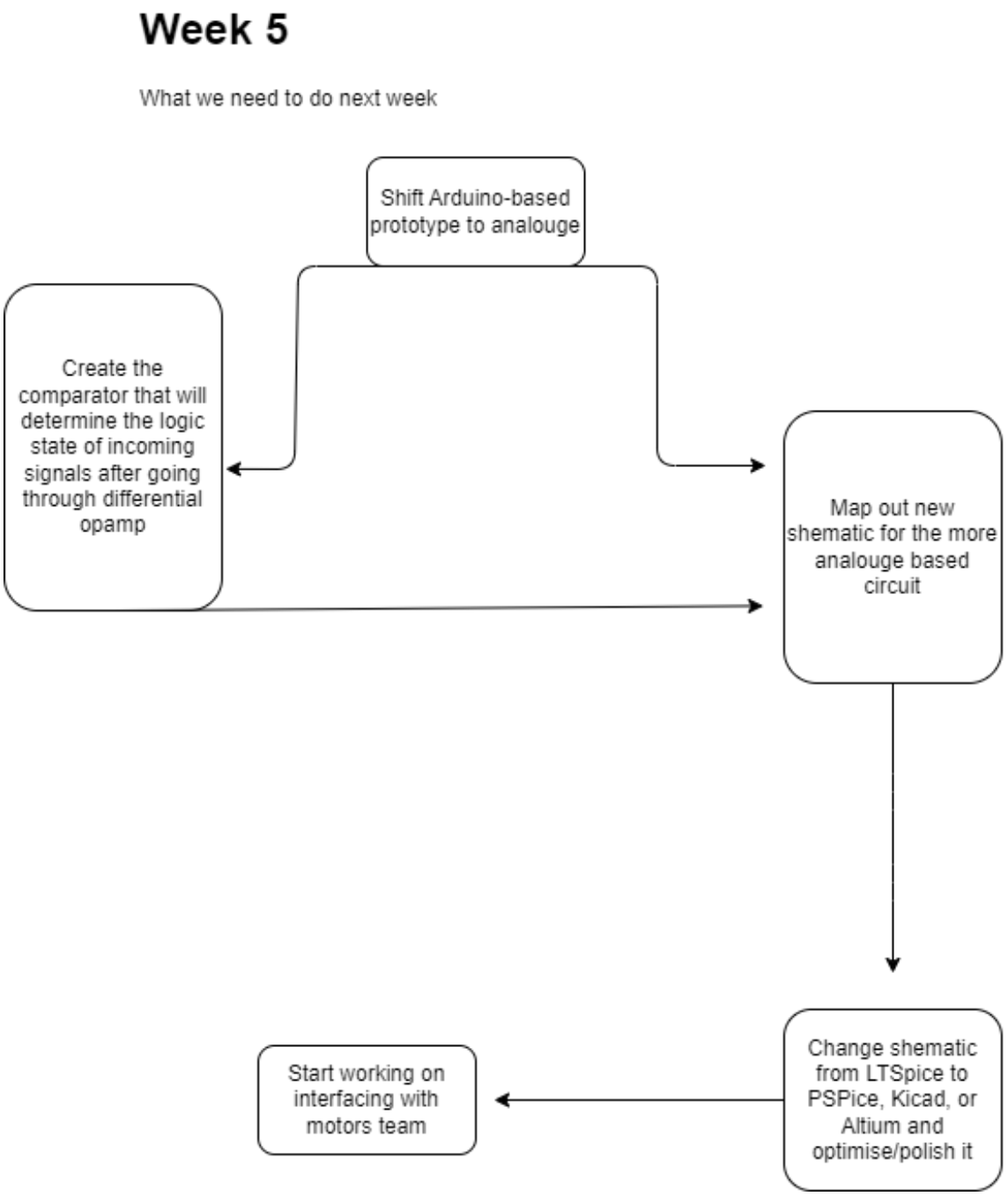

Figure 7: Flowchart of Tasks for Week 5