OrcaProbe

Reconfigurable Electrical Probing System for Thin Film Devices

Team Policy & Management

ELEC 491 Capstone Project
University of British Columbia

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1. Team Policies

1.1. Team Goals and Values

As a team, we value:

1. **Innovation**: We strive to ensure our solutions are not only cutting-edge but also practical and impactful.
2. **Efficiency**: We are committed to optimizing processes to streamline the workflow of thin film testing processes.
3. **Automation**: Automation is at the core of this project. By embedding automation into the testing process, we aim to increase throughput and reduce human error.
4. **Cost-effectiveness**: We aim to deliver solutions that not only meet the technical requirements but also adhere to budget constraints.

As a team, our goals are:

1. **Build a Functioning Device**: Our primary goal is to develop a complete device that fully meets the client's expectations. This will help the client advance their business and give our team the satisfaction of completing a project.
2. **Foster Collaboration and Initiative**: We aim to create a collaborative and supportive environment where team members actively help each other. This ensures adaptability when challenges arise and promotes team cohesion.
3. **Promote Personal and Professional Growth**: Each team member will have the opportunity to grow with technical and interpersonal challenges. The goal is not only to complete the project but also to enhance the skills and confidence of our team.
4. **Ensure Clear and Open Communication**: Both internally and externally, our goal is to maintain transparent communication. Team members are encouraged to share their ideas and feedback openly, ensuring all perspectives are heard.

5. **Complete Tasks Professionally and On Time**: We strive to maintain a professional standard for all deliverables, and to complete tasks before deadlines to allow time for feedback and refinement.

1.2. Team Commitment and Participation

While many behaviours have been identified as important to ensure team commitment and participation, the most common ones that ensure commitment and success are proactive communication and active engagement during team meetings and work sessions.

The most important factor ensuring commitment and participation throughout most team scenarios is having a team member who actively communicates to the team on their progress updates and roadblocks. This is important as a lack of communication makes it extremely difficult for any progress to be made as a team. By having members who actively communicate with the team, we can identify issues early before they develop into catastrophic problems and can determine how best to support them with the issues they are facing.

Another significant behaviour that impacts commitment and participation is being fully engaged during team meetings and discussions. Having everyone's undivided attention during these times is important as it not only affects contributions made by members but also impacts the overall morale of the team. Even one member who is busy working on other coursework or on their phone creates a demoralizing atmosphere that discourages more active individuals from contributing. By maintaining the undivided attention of all members during team gatherings, we can foster a committed and productive environment.

Overall, while there are many different factors that we found to have an impact on commitment and participation, proactive communication and engagement during meetings will ensure a supportive and highly engaged team environment.

1.3. Criteria for Major / Minor Project Contributions

In order to achieve clear expectations on the work and effort each team member is expected to put into the project, certain criteria are established for defining major and minor contributions. These criteria, from a team structure perspective, will ensure each team member makes the necessary contributions individually and provides support to other members when required. Also, from a project planning perspective, they will ensure the ownership of tasks is well-defined, with a balanced workload distribution, and members receive the credit they deserve for their work.

Major project contributions are defined as any form of work that significantly and meaningfully affects an aspect of the project. This includes but is not limited to the design, physical prototype and testing of the product, as well as all documents produced throughout the duration. The following work is defined as a major contribution:

- **Sub-system design and development:** Each team member is assigned a sub-system of the high-level architecture. They are to be under the ownership of the designated team member, and the work members lead for the design of the sub-system is considered a major contribution.
- **Problem-solving:** Team members who offer innovative and effective ideas to help solve problems related to an aspect of a project will be considered for a major contribution.
- **Testing:** Team members who create test plans to verify or validate any requirement, and execute the plan will be making a major contribution.
- **Documentation and deliverables:** Team members who write more than half of a section of any document or deliverable (both for the course and client) will be considered to have made a major contribution.

Minor contributions are defined as any form of work that is still valuable for the progress of the project but is limited in its scope. These are, by nature, intended to help out another team member. This includes but is not limited to implementation, debugging and supporting tasks.

- **Implementation:** Each team member can help out another team member to implement a small part of their sub-system prototype. This can range from a small part of the design to testing setups. These are considered a minor contribution.
- **Debugging aid:** Team members might be required to assist with debugging efforts on critical parts or assigned to debug lower-priority parts individually. This will be considered a minor contribution.
- **Support work:** Each team member can help out other members when necessary. Any work defined by the owner of the task as support work to complete the major task will be defined as a minor contribution.

It is expected that some work may not fit into the definitions and examples provided above. For those, the team will collectively decide on the level of contribution by evaluating the time and effort the member put into the task, the initiatives taken by them and the risk they took by getting the extra responsibility.

1.4. Decision-making Process

Successful project decisions are made continuously throughout the entire process, and our team's plan is designed to address both minor and major decisions to avoid potential pitfalls. As defined by our team, major decisions will require the collective attention of the whole team as they significantly impact interactions with other subsystems. In contrast, minor decisions can often be made individually, though they will still need to be communicated to the team to ensure alignment and transparency.

At the outset of any decision-making process, we will gather as much relevant information as possible as a first step. Then we will assess the trade-offs, pros, and cons of each option while linking the options to the project requirements, giving us a chance to analyze how each choice might influence the overall outcome. Wherever feasible, we will employ quantifiable methods to rank the available options and minimize the influence of biases or personal preferences. One example of this could be a weighted decision matrix to assign scores to the pros and cons of each choice, aligning them with the project’s objectives.

For major decisions, the team will vote to reach a consensus on the available options. When a decision cannot be quantified, we will rely on a majority vote, ensuring that all viewpoints are considered. In cases of disagreement, we will communicate and strive to find a compromise that meets the project's requirements. Ultimately, our team will finalize decisions when we are collectively confident that we have selected the best possible solution to drive the project's success. To reiterate, our decision-making process is effective because, wherever possible, we will eliminate bias and preference by utilizing quantitative methods and reaching a consensus once the benefits and drawbacks are analyzed. Figure 1 highlights our team’s decision-making process.

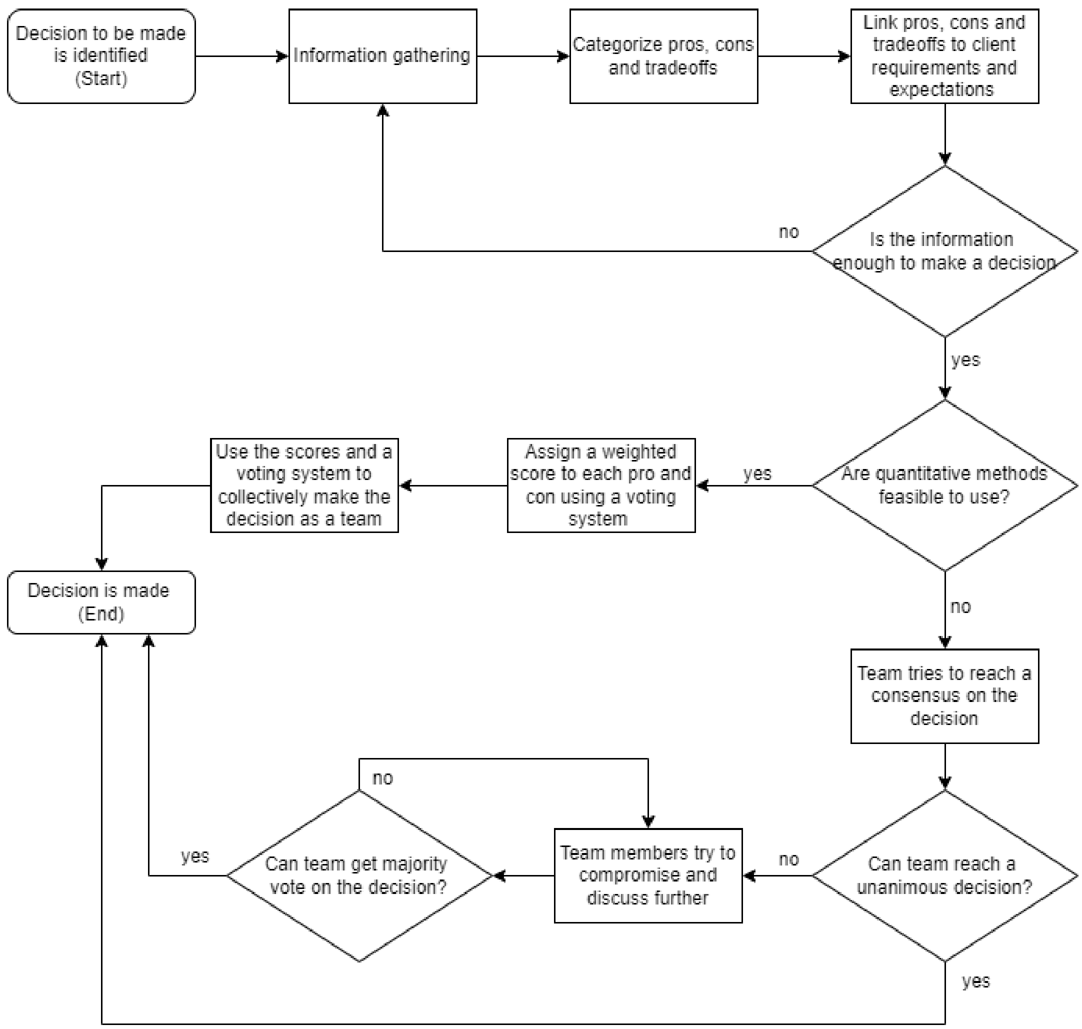


Figure 1: Decision-making process flowchart

1.5. Conflict Negotiation Process

Our team's conflict negotiation process is structured to handle disputes efficiently while ensuring open communication and fairness. The process begins at the lowest level of conflict, involving two team members. In this case, all communications between the two parties, whether verbal or written, are shared openly among the involved members and the mediator. The members have two days to attempt to resolve the issue with a mediator from the team to assist. The mediator's role is to ensure that either an agreement is made between the two team members or the conflict is escalated to involve the rest of the team. Communications during this stage typically happen via Discord, and if the conversation occurs over instant messaging, those text messages will serve as documentation for the conflict.

In the second stage, the entire team becomes involved if the conflict needs to be escalated further. Both parties must agree to share all communications with the team, including any verbal or written communication on any media, and the issue will be discussed during a scheduled team meeting. This step involves holding an in-person meeting in a reserved Capstone room in the MacLeod building, with meeting notes taken to document the discussions.

In the final escalation stage, if the conflict persists, the team will bring the issue to the instructor. All communications that the team agrees to release to the instructor will be shared. The matter will then be discussed during the weekly Thursday instructor meeting, and notes from the session will be taken for future reference.

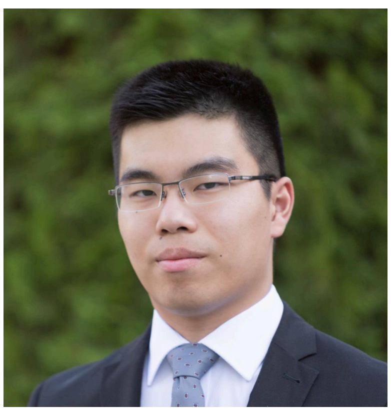
This structured process, shown in Figure 2, ensures that all conflicts are addressed properly and progressively, with clear criteria for escalation and proper documentation at each step. Our team is committed to revisiting and updating the conflict negotiation process throughout the project as needed to ensure effective conflict resolution.

	Involves two team members	Escalation Criteria	Involves the team	Escalation Criteria	Involves the instructor
Shared Info	All communications between the two parties, this can involve verbal or written communication on any media	Issue is not solved after 2 days, mediator needs to ensure either an agreement is reached or notify team members about the escalation	All communications that both parties agree to release to the team, this can involve verbal or written communication on any media	Issue is not solved after team meeting and majority of the team agrees for escalation	All communications that the team agrees to release to the instructors, this can involve verbal or written communication on any media
Who is involved?	Two team members and a mediator from the team		The whole team		All members of the team and the instructor
At what time?	Over the next 2 days after conflict arises		Over a special meeting scheduled during the next week after escalation		Thursday during instructor meetings
For how long?	1 hour		30 min		30 min
At what location?	Discord - internal team chatting channel		In a Capstone room in MCLD		SWNG 108
Acceptable communication?	Online call or chatting		In person		In person
Documented? If so, how?	If it happened over instant messaging, text messages would be documentation for the conflict		Meeting notes would be taken during the discussion		Notes would be taken after the meeting

Figure 2: Conflict negotiation process table

1.6. Team Member Profiles

Aaron Loh



As someone deeply interested in electronics and hardware design, I am excited to be working on this project and believe that my background in electronic automation and project management will be highly applicable. While the technical aspects of my previous experience differ, I am confident that the skills gained in system integration and software/hardware debugging will transfer effectively. In addition, my previous project management experience has developed my time management, multitasking, and organizational skills, which can be leveraged to support the team with a structured and efficient workflow that meets target deadlines, ultimately ensuring our success.

Dipak Shrestha

As someone passionate about electronics and hardware systems, I am thrilled at the opportunity to collaborate with my team in designing a technology that will make a meaningful impact on the R&D industry. My background in designing and testing electrical and firmware systems has equipped me with the skills to work effectively alongside my Capstone teammates. I am a highly motivated individual, ready to tackle any challenges that come our way and committed to seeing the project through to its successful completion. I believe that my blend of technical expertise and strong interpersonal skills will make me a valuable asset to our Capstone project.

Idil Bil

As someone who developed a measurement board with an interactive graph in a past internship, a project that closely relates to aspects of this Capstone project, I'm excited about the challenge this project will bring. I am confident that my background in electronics and PCB design from various project courses, combined with my web design experience from working in an Engineering Design Team, will be highly applicable here. Additionally, my co-op in technical product management in the consumer electronics industry gave me valuable experience in managing product life cycles and improving my organizational and detail-oriented skills. I believe my diverse experience and attention to detail will be well-suited to this project.

Kerem Oktay

As someone who has a strong background in digital electronics and embedded systems and values creating efficient and meaningful products, I am eager to follow my passions with this Capstone project alongside my teammates. Over my university education and co-op terms, I worked on various embedded system projects ranging from designing System-on-Chip with FPGAs to validating functionalities of ASICs and PCBs. All these experiences equipped me with technical skills that are valuable for this Capstone project. In addition, these experiences allowed me to gain technical documentation and task management skills while teaching me the project life cycle of embedded systems. I believe by transferring all my experiences to our Capstone project and supporting my teammates with documentation and task planning, I can push our project toward the success our team is aiming for.

Peggy Yuan

As someone with hands-on experience in circuit design, prototyping, and system validation from past internships, I have gained experience in hardware design, testing, and system integration. I have been an active team member in the complete lifecycle of hardware projects, from initial concept to testing and final integration, giving me a solid understanding of the challenges of real-world system development. Additionally, my experience collaborating in diverse teams allows me to approach projects with both technical proficiency and strong teamwork. My technical experience and collaborative attitude will be a valuable asset in achieving our project goals, ensuring that we meet deadlines and deliver a high-quality final product.

2. Team Management

2.1. Project Technical and Values Alignment

Our team has identified 4 main technical areas of the project as well as the goals and values of the project. Below is Table 1 showing each member's skill set before starting the project based on how proficient or interested they are in each technical area.

Table 1: Technical Alignment

Technical Area	Proficient	Development preference	Knowledge gap
Electronic hardware Design and assembly	KO, DS, AL	PY, IB	
Firmware Design	KO, DS, AL	IB	PY
Software GUI design	IB	PY	KO, DS, AL
3D modeling	PY	KO, DS, AL, IB	

Our team has a diverse skill set and interests based on the table. There isn't an area where every member possesses the necessary skills or interests to complete the project. Our team has also identified 4 main goals and values of the client's organization to compare our alignment. They are shown below in Table 2.

Table 2: Goals and Values Alignment

Goals/Values	Members With Alignment
Innovation	KO, DS, AL, IB, PY
Efficiency/Automation	KO, DS, AL, IB, PY
Cost Efficient	KO, DS, AL, IB, PY
Sustainability	KO, DS, AL, IB, PY

All of the members support the client's goals and values, which were discussed during the SI lab modules. With aligned values and required skill sets, our team will collaborate effectively to complete the project.

2.2. Project Process Diagram

The project process diagram shows the different steps that our project intends to follow from inception to completion. This diagram was designed to be as solution-agnostic as possible to account for potential changes during the design process.

Our preliminary steps involve doing background research on probing methods and clarifying the requirements that our client has. Research is conducted to decide which methods are feasible and to confirm with the client that the proposed device meets their requirements. We then move on to the high-level design, starting with the overall architecture of the device, followed by requirements for each individual subsystem. After finalizing detailed requirements, we confirm that these requirements fully fit the client's expectations before entering the detailed design and prototyping process. These steps are shown in Figure 3 below.

In the detailed design and prototyping process, each subsystem will be worked on by a different team member depending on their area of expertise. While the design process for each system is different, the process would generally consist of coming up with potential options, determining whether the proposed design meets the requirements, and then building a physical prototype as a proof of concept. Once all subsystem prototypes have been tested and verified to work on their own individually, we can then move on to the integration phase of our project. The design steps of each subsystem are shown in Figures 4 and 5 below.

In the integration phase of our project, we aim to integrate the different subsystems to create the final product. Our plan is to integrate systems in pairs to isolate issues between subsystems and minimize complications in the completed system. During this phase, we will also complete other tasks that are dependent on subsystem design, such as the PCB design based on the subsystem circuit prototypes and physical casing for the entire device. Once the integration step is complete, we can then test the fully integrated system to validate and verify the design. Our final step will then be to create the workflow document on device operation and a technical report detailing the design, testing, and potential applications of the device. The integration process and final steps of the project are shown in Figure 6.

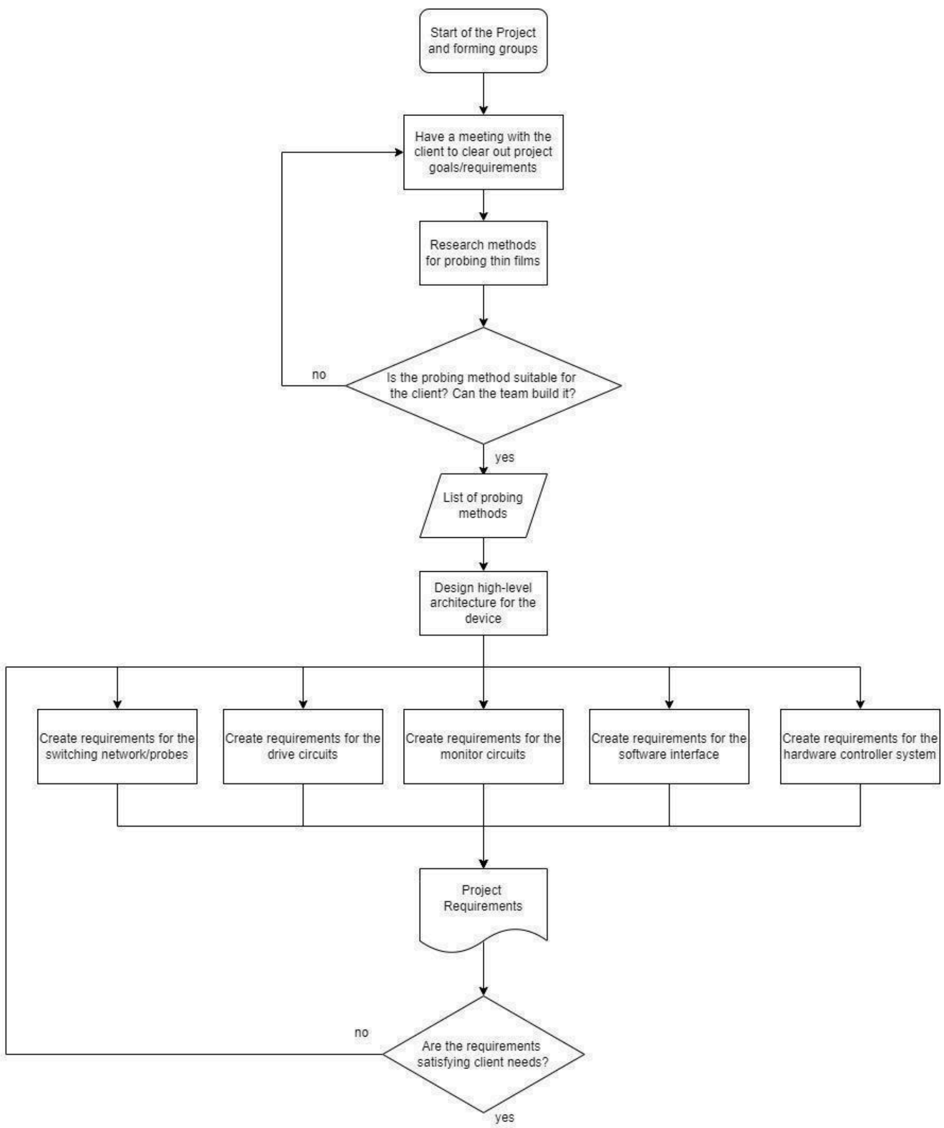


Figure 3: Problem Definition and Research Steps

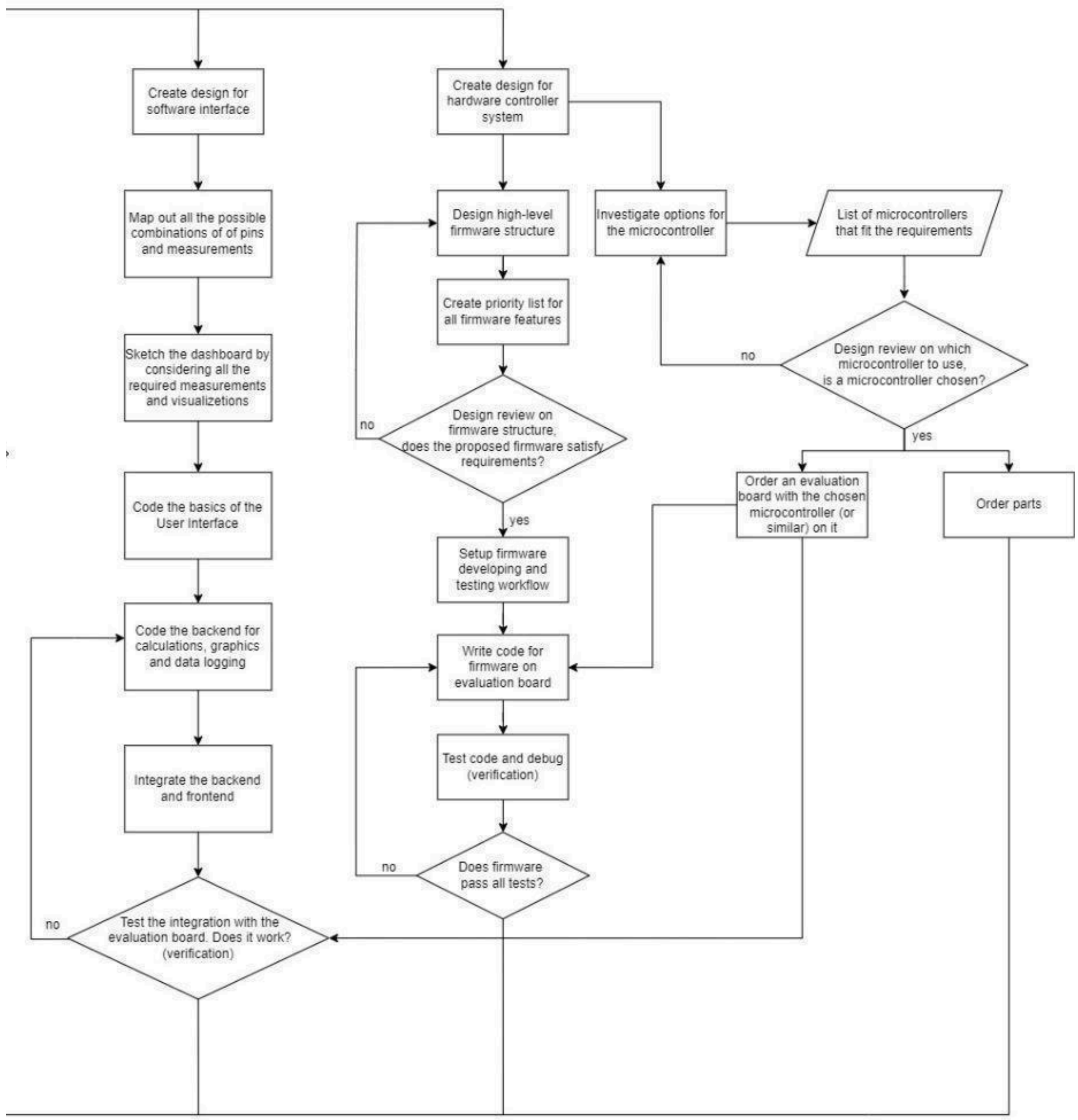


Figure 4: Microcontroller and GUI Design Steps

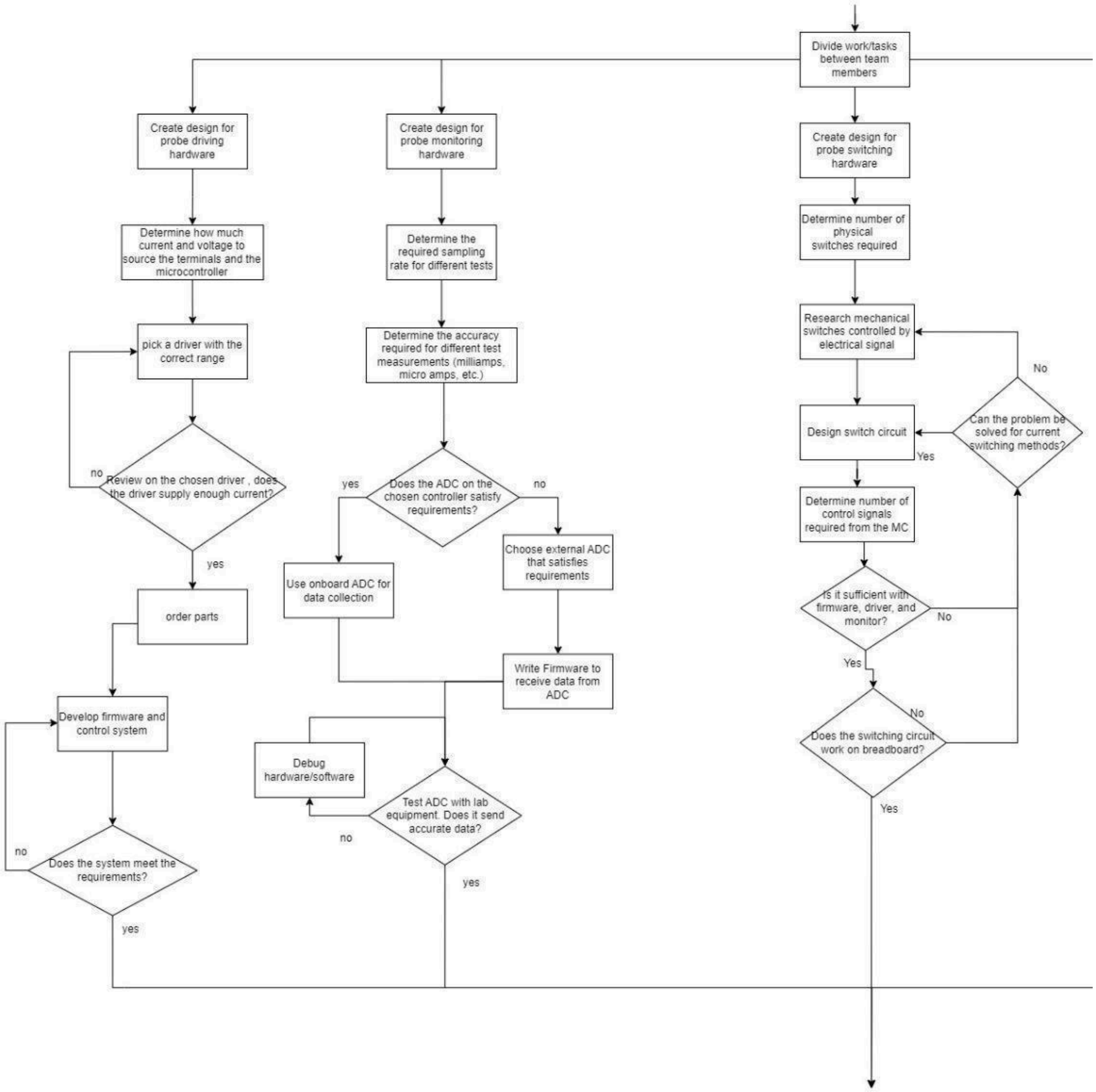


Figure 5: Electrical Hardware Subsystem Design Steps

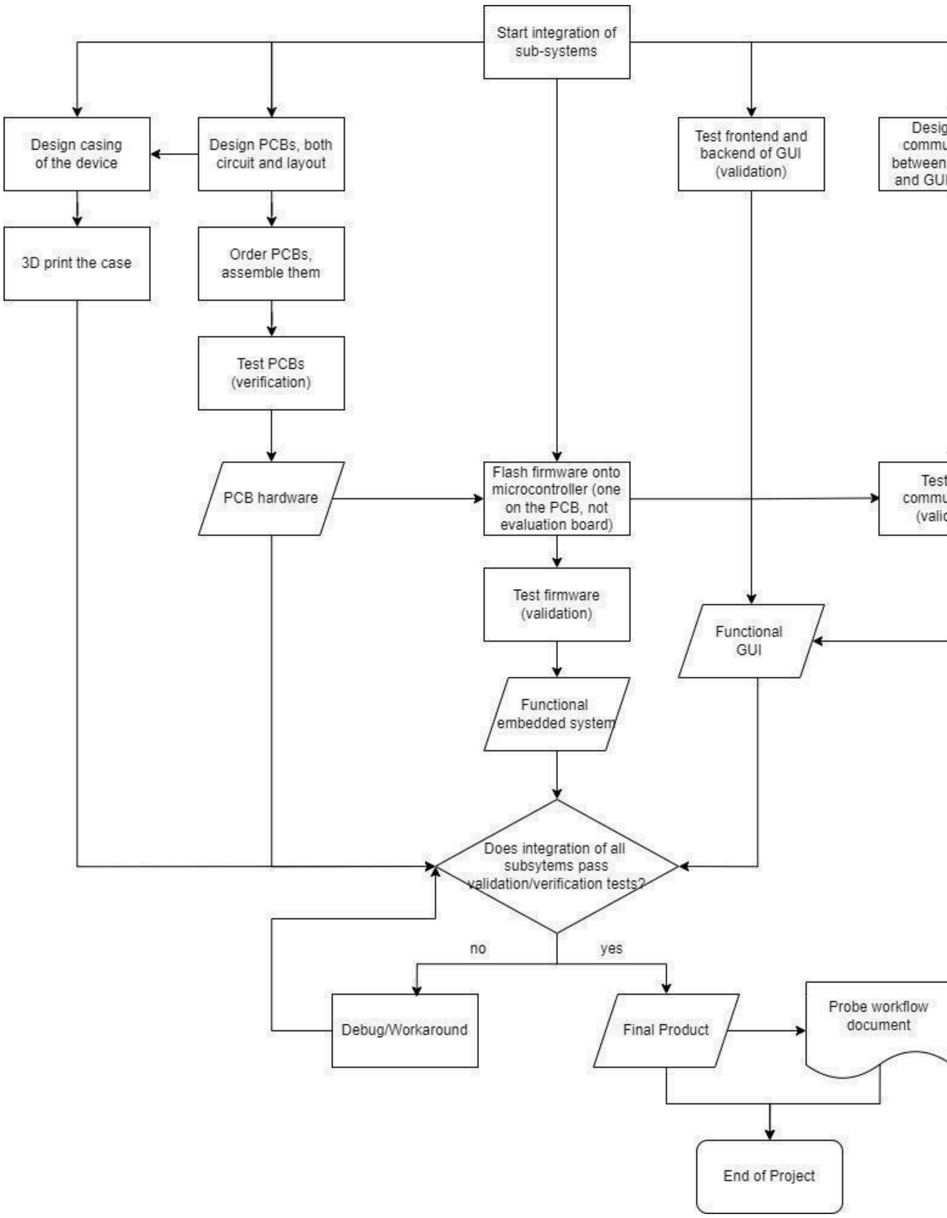


Figure 6: Integration and Final Project Steps

2.3. Knowledge and Skills Gap Assessment

Like any large project, there are knowledge gaps that require additional time and effort to address. Our team has identified specific gaps that we will research and fill to ensure we meet our client's expectations. During team meetings, software design emerged as a primary area where we needed to bridge the gap, with several tasks requiring extra focus. While one team member has expertise in software design, most others lack the skills or interest in developing the GUI. Below is Table 3 detailing our assessment of specific knowledge and skill gaps.

Table 3: Knowledge Gap Assessment

Knowledge gap	Resources to fill the gap
Communication between the host PCB and the probing device	USB documentation, Online tutorials, and Microcontroller datasheet
GUI backend design	Online forums and websites, Peers with similar experience
Thin film materials	Client meetings, existing literature and similar products

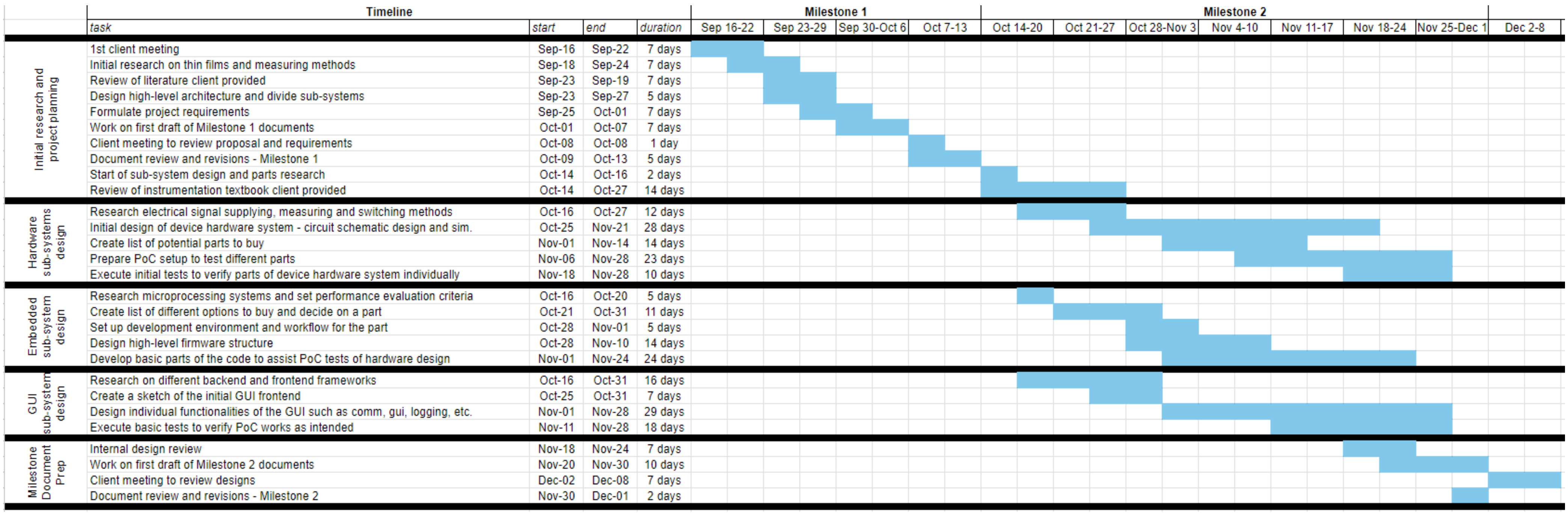
Having identified the knowledge gaps, we plan to utilize a variety of resources to address them effectively. These resources will include online forums, research papers, tutorials, and instructional videos. Additionally, our meetings with the client will provide valuable insights and information essential for our success.

2.4. Team Member Roles and Responsibilities

Team Member	Technical Responsibilities	Managerial Responsibilities
Aaron Loh	• Responsible for the hardware design with a focus on reading measurements from probes	• Serve as the first point of contact for the client and instructional team • Consolidate and summarize team progress to share with the client and instructors
Dipak Shrestha	• Responsible for the hardware design with a focus on the probe functionality switching	• Keep, record, and track inventory parts • Order and supply the required parts to team members during prototyping
Idil Bil	• Responsible for the design and functionality of the Software GUI	• Record key points, decisions, and action items during meetings • Delegate responsibilities to team members
Kerem Oktay	• Responsible for the embedded system and firmware design	• Track documents needed for milestones and submissions • Keep the team drive clean and organized, keep documents up to date and complete
Peggy Yuan	• Responsible for the hardware design with a focus on supplying power to probes • Responsible for the mechanical design, including the chassis and pin slider buttons	• Keep accurate records of all financial transactions, including receipts and invoices • Provide regular updates on the team's financial status

2.5. Gantt Chart

The Gantt charts below in Figure 7 and Figure 8 show the timeline for Term 1 and Term 2 of the 2024W session, respectively.



	task	start	end	duration
Initial research and project planning	1st client meeting	Sep-16	Sep-22	7 days
	Initial research on thin films and measuring methods	Sep-18	Sep-24	7 days
	Review of literature client provided	Sep-23	Sep-19	7 days
	Design high-level architecture and divide sub-systems	Sep-23	Sep-27	5 days
	Formulate project requirements	Sep-25	Oct-01	7 days
	Work on first draft of Milestone 1 documents	Oct-01	Oct-07	7 days
	Client meeting to review proposal and requirements	Oct-08	Oct-08	1 day
	Document review and revisions - Milestone 1	Oct-09	Oct-13	5 days
	Start of sub-system design and parts research	Oct-14	Oct-16	2 days
	Review of instrumentation textbook client provided	Oct-14	Oct-27	14 days
Hardware sub-systems design	Research electrical signal supplying, measuring and switching methods	Oct-16	Oct-27	12 days
	Initial design of device hardware system - circuit schematic design and sim.	Oct-25	Nov-21	28 days
	Create list of potential parts to buy	Nov-01	Nov-14	14 days
	Prepare PoC setup to test different parts	Nov-06	Nov-28	23 days
	Execute initial tests to verify parts of device hardware system individually	Nov-18	Nov-28	10 days
Embedded sub-system design	Research microprocessing systems and set performance evaluation criteria	Oct-16	Oct-20	5 days
	Create list of different options to buy and decide on a part	Oct-21	Oct-31	11 days
	Set up development environment and workflow for the part	Oct-28	Nov-01	5 days
	Design high-level firmware structure	Oct-28	Nov-10	14 days
	Develop basic parts of the code to assist PoC tests of hardware design	Nov-01	Nov-24	24 days
GUI sub-system design	Research on different backend and frontend frameworks	Oct-16	Oct-31	16 days
	Create a sketch of the initial GUI frontend	Oct-25	Oct-31	7 days
	Design individual functionalities of the GUI such as comm, gui, logging, etc.	Nov-01	Nov-28	29 days
	Execute basic tests to verify PoC works as intended	Nov-11	Nov-28	18 days
Milestone Document Prep	Internal design review	Nov-18	Nov-24	7 days
	Work on first draft of Milestone 2 documents	Nov-20	Nov-30	10 days
	Client meeting to review designs	Dec-02	Dec-08	7 days
	Document review and revisions - Milestone 2	Nov-30	Dec-01	2 days

Figure 7: Timeline of 2024W Session Term 1 (Milestones 1 and 2)

	Timeline				Milestone 3					Milestone 4									
	task	*start*	*end*	*duration*	Jan 6-12	Jan 13-19	Jan 20-26	Jan 27-Feb 2	Feb 3-9	Feb 10-16	Feb 17-23	Feb 24-Mar 2	Mar 3-9	Mar 10-16	Mar 17-23	Mar 24-30	Mar 31-Apr 6	Apr 7-13	
Chassis Design	Casing design for the chassis	Jan-13	Jan-19	7 days															
	OTS button parts search	Jan-20	Feb-2	14 days															
	3D printing the chassis and verifying robustness	Feb-3	Feb-9	7 days															
	Assembling buttons, probes and 3D printed chassis	Feb-24	Mar-2	7 days															
PCB Design & Testing	PCB circuit schematic layout design	Jan-6	Feb-2	28 days															
	PCB layout verification via simulation or other available means	Jan-15	Feb-2	18 days															
	PCB parts order and assembly	Feb-3	Feb-16	14 days															
	PCB hardware verification testing and debugging - probe circuitry	Feb-13	Mar-9	24 days															
	PCB hardware verification testing and debugging - microcontroller circuitry	Feb-13	Mar-9	24 days															
Firmware Design & Testing	Design the remaining parts of the firmware code that was not captured in PoC testing	Jan-6	Feb-9	35 days															
	Execute unit tests and verification tests for the firmware	Jan-13	Feb-2	21 days															
	Execute probe device tests by integrating firmware with the PCB	Feb-5	Feb-28	24 days															
	Execute USB comm. tests by integrating firmware with the GUI	Jan-27	Feb-16	20 days															
	Execute full-system integrationg tests (hardware + firmware + GUI) - verification tests	Mar-1	Mar-9	9 days															
GUI Design & Testing	Complete backend design of the GUI by building onto skeleton code	Jan-12	Feb-16	35 days															
	Complete frontend design of the GUI by building onto skeleton code	Jan-6	Jan-26	20 days															
	Execute verification tests for the full GUI	Feb-17	Mar-5	16 days															
Final Product	Full probing system (hardware and GUI) benchmarking tests - validation tests	Mar-10	Mar-30	20 days															
	Create workflow documents for the system + course deliverables	Feb-17	Mar-30	20 days															

Figure 8: Timeline of 2024W Session Term 2 (Milestones 3 and 4)

Milestone 1 period has involved initial research and project planning. Initial requirements, high-level architecture and work division have been done. Moving forward, Milestone 2 will be used for completing sub-system design with an initial focus on 2-probe measurement methods for small-scale integration. A complete Bill-of-Materials will be achieved at the end of Milestone 2. Milestone 3 will be used for building and assembling the final product while doing integration work to get all 2, 3, and 4-probe measurements working. Using the previous experience from Milestone 2 will be crucial in Milestone 3 to scale the design for all measurements. Milestone 4 will involve the full completion and validation testing of the system. In the end, formal benchmarking tests will be carried out to find all the remaining issues, solve them and finalize the product.

2.6. Budget

Our project requires the purchase of several materials and services. We summarize the following major costs:

1. **PCB Fabrication and Assembly**: This includes the design and outsourcing of printed circuit board (PCB) fabrication, which costs around $400.
2. **Import Customs Fee:** Since the Rev1 PCB is pre-semi-assembled to allow for faster hand assembly, we incur a customs clearance fee of approximately $60.
3. **Probes and Mechanical Components:** For the reconfigurable probe system, we need high-precision mechanical parts, including probes and switches for configuration toggling. This ends up costing around $10.
4. **Electronic Components:** We need electronic components such as resistors, capacitors, and ICs for the probe system's circuit prototyping and final production, with a cost of $590.
5. **Delivery Fee:** An additional cost applies for purchases below the minimum order requirement set by the electronic distributor. This fee is estimated to be $170.
6. **Testing and Benchmarking Equipment:** While we expected to use standard laboratory equipment provided by UBC and our client for testing and validation, we may need additional specialized equipment.

Our current budget provided by the ECE department is $650. So far, we have spent a total of $1,230, exceeding the budget by $580. Our client has agreed to cover $300, and the APSC department will contribute $180 toward the cost of PCB Rev2. The team will cover the remaining $100. We proceed with the production of Rev2 despite exceeding the budget because Rev1 is primarily for verifying that the circuit works with limited functionalities, while Rev2 is a more complete version that meets all project requirements. Additionally, to help offset the additional cost, we minimize expenses by reusing components from Rev1 wherever possible.

Appendix A: Contributions

Section	Major Contribution	Minor Contribution	Author	Reviewer
1.1. Team Goals and Values	AL, DS, IB, KO, PY	-	IB	DS
1.2. Team Commitment and Participation	AL, DS, IB, KO, PY	-	AL	PY
1.3. Criteria for Major / Minor Project Contributions	AL, DS, IB, KO, PY	-	KO	IB
1.4. Decision-making Process	AL, DS, IB, KO, PY	-	DS	AL
1.5. Conflict Negotiation Process	AL, DS, IB, KO, PY	-	PY	KO
1.6. Team Member Profiles	AL, DS, IB, KO, PY	-	AL, DS, IB, KO, PY	PY, AL, DS, IB, KO
2.1. Project Technical and Values Alignment	AL, DS, IB, KO, PY	-	DS	AL
2.2. Project Process Diagram	AL, DS, KO	IB, PY	AL	PY
2.3. Knowledge and Skills Gap Assessment	AL, DS, IB, KO, PY	-	DS	AL
2.4. Team Member Roles and Responsibilities	IB	AL, DS, KO, PY	IB	DS
2.5. Gantt Chart	KO	AL, DS, IB, PY	KO	IB
2.6. Budget	PY	-	PY	KO