RV Power and Environment Monitoring

DESIGN DOCUMENT

Team SDMAY22-34
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Executive Summary

Development Standards & Practices Used

- IEEE 802.11: Wireless communication protocols
- ANSI C84.1-1989: System Voltage Standards
- OSHA 1919.303: Electrical Safety Standards
- Waterfall software development model
- Test driven development
- Code reviews

Summary of Requirements

- Provide power usage statistics for AC shore, AC generator, and DC battery power systems within an RV
- Collect current and historical data on power monitoring systems
- Provide instantaneous and historical power data to the user through an intuitive web interface

Applicable Courses from Iowa State University Curriculum

CPRE288 - Embedded Systems

EE230 - Electronic Circuits and Systems

EE303 - Power Electronics and Energy Systems

SE309 - Software Development Practices

SE319 - Construction of User Interfaces

New Skills/Knowledge acquired that was not taught in courses

Current sensing designs

AC voltage monitoring designs

Wireless communication protocols

Querying remote data sources

Table of Contents

List of figures/tables/symbols/definitions (This should be the similar to the project plan)

1 Team

1.1 Team Members

1) Nickolas Moser
2) Jace Kunkel
3) Peter Rothstein
4) Michael Woo
5) Kent Mark
6) Doug Bullock
7) Utsavee Desai
8) Matt McCarthy

1.2 Required Skill Sets for Your Project

Embedded Systems

Power Sensor Design

Web Server Data Storage

User Interaction

1.3 Skill Sets covered by the Team

Embedded Systems - Nick, Doug

Power Sensor Design - Jace, Michael, Utsavee, Matt, Doug

Web Server Data Storage - Kent

User Interaction - Peter, Kent

1.4 Project Management Style Adopted by the team

Waterfall project management style

1.5 Initial Project Management Roles

- Nick will serve to facilitate communication between client and team, lead technical documentation
- Utsavee will keep track of the organization and weekly meetings.
- Peter will lead the software design and implementation
- Kent will lead the development of application UI
- Jace will lead the testing aspect of the project
- Mike will lead the power systems analysis
- Doug will lead circuit design and anything else
- Matt will lead circuit implementation.

2 Introduction

2.1 Problem Statement

One issue RV users face is the lack of knowledge on power usage, difficulty in leveling the RV, and a lack of knowledge of current temperature. The goal of this project is to implement a power and environment monitoring system within an RV. The goal of the system is to monitor power usage by the RV as well as monitoring environmental variables such as leveling and temperature. The system will then offer the power and environment information to the user through a web server which has instantaneous and historical data.

2.2 Requirements & Constraints

Quantitative:

- The web browser application should use dynamic components and update instantaneous data every 1-5 seconds.
- System should be able to monitor power usage for both 240VAC and 12VDC systems.
- System should be able to store historical usage data for up to a month.
- The server for the system should be online at all times.
- The cost of the system should not exceed $400 per project budget.

Qualitative:

- The web interface should be easy to navigate.
- The web browser application should store user credentials and be able to verify them.
- The web browser application should be accessible from anywhere.
- The system should be able to monitor the AC shore power and generator power as well as the DC power form the batteries
- The system should have a shutdown functionality for extended periods of time without use
- The system should be modular such that it can be installed within another RV

2.3 Engineering Standards

- IEEE 802.11
    - Required as our onboard web server will likely have to utilize some form of wireless communication, and wifi is readily accessible
- ANSI C84.1-1989
    - Required as our project deals with transmission. This standard defines all systems within the RV as low voltage, as they fall below the 600V threshold, and associates safety standards with the system.
- OSHA 1919.303

- Required for anyone who intends to work with the implementation of the project. Describes electrical work and safety standards to be followed in implementation and installation of system.

2.4 Intended Users and Uses

- Primary Use Case: RV Owners
  - Power usage and reduction by an RV Owner
  - Leveling status of the RV for operating purposes
  - Internal temperature for lower tech RVs without thermostat
- Secondary Use Case: Owners of small homes or trailers
  - Could be used in homes which are not mobile, but utilize similar power systems
  - Leveling status would not be necessary, but power monitoring and temperature useful

3 Project Plan

3.1 Project Management/Tracking Procedures

The group chose to follow the waterfall project management method. This method was chosen because the development of the project was felt to be very progressive; development would grow on previous accomplishments, which hinder an agile project management style should one portion of the project become backlogged. Our group is using Discord, Google Drive, and Git to keep track of progress throughout the semester.

3.2 Task Decomposition

Every subteam within the project group will decompose their tasks into three subsections: Research/Development, Systems Testing, and Implementation testing. The goal of research and development is to create a plan for the systems testing step. We plan on researching components/softwares to use within the implementation, developing a prototype based on researched parts/softwares, and doing calculations and simulations to verify our designs. In the systems testing phase, we plan on testing the prototypes and simulations completed in the previous project step within a laboratory environment. This testing will be aided by a checklist of functionality defined by both the client and the team. Should the component not function as expected, new iterations of the research/development phase will take place until systems testing is completed. The last step, implementation testing, involves installation of the final product in the vehicle and subjecting the project to both end user tests and real-world testing.

3.3 Project Proposed Milestones, Metrics, and Evaluation Criteria

First Semester Milestones:

- Prototype of power monitoring system should be implemented within either SPICE models or breadboard.
- Microcontroller ADC readings should be understood and mathematical operations should be performed

- Processing power of server host should be capable of handling and interpreting up to one month of historical data.

Second Semester Milestones:

- Current and voltage monitoring circuits should produce measurements which are accurate within 1% of the actual current and voltage of the system
- Microcontroller should perform at minimum 100 samples/second and transmit data to server with minimal latency.
- Server should store at least one month of historical data and interface in a user-friendly manner

3.4 Project Timeline/Schedule

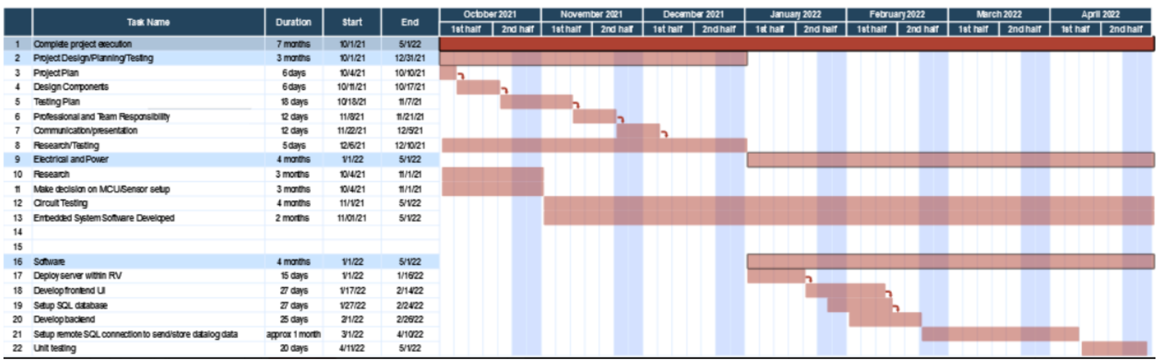

Figure 1: Proposed Project Schedule; Gantt Chart

3.5 Risks And Risk Management/Mitigation

Agile project can associate risks and risk mitigation with each sprint.

1. Time (testing precautions, development, data collection, integration, more testing), 0.7
2. Power hungry microcontrollers, 0.2
3. Web Server capabilities with Raspberry Pi Zero W, 0.4
4. Web Server necessary cores, memory, etc., 0.6
5. Concerns regarding remote connection to database, 0.3
6. No CPRE students within group (integration concern), 0.1
7. Accidents testing electrical components, 0.2
8. Necessary time needed towards being on-site at the RV, 0.6
9. Re-purchasing components, 0.7

Risk Mitigation

- Time: Our plan is to increase hours/week as needed to meet the needs of our client
- Web server cores/memory: Request more capable resources from ETG as needed
- On-site time at RV: Keep good communication with client to work on RV as needed

- Re-purchasing components: Buy multiples of high-wear or failure-prone components

3.6 Personnel Effort Requirements

Time Estimate: 3 hours/week/person

Time Estimate Breakdown

1 Hour: Project Overhead (Team assignment/meetings, progress reports, client interaction)

1 Hour: Subteam engineering operations (research/development, systems testing)

1 Hour: Team engineering operations (systems testing, implementation testing)

3.7 Other Resource Requirements

The primary resource needed is a laboratory to conduct certain experiments, as our subsystems will utilize 240VAC systems. While these are defined as low voltage systems by ANSI C84.1-1989, they are low voltage relative to transmission lines. To practice safety and mitigate the risk of harm from shock, we would like to complete high voltage testing in safe environments.

4 Design

4.1 Design Context

4.1.1 Broader Context

There is an economic impact to which the project adheres. There are different devices in the market that will measure different phases of voltages with costs that exceed $1500. We plan on using sensors that are used in such devices and making a device of our own which is cheaper and focuses on the scope of our project

There is also an environmental consideration to the project, as a user may be looking to cut back on their power usage. This would mean that less power is used, wasted, etc. This would have an environmental impact as power savings translates to a decrease in pollution and waste.

There is not much of a cultural or social impact to our project, as this does not change, set or effect established precedents among RV users. The level reporting feature within our project may help those looking to increase ease in leveling, since many RV components must be level to function, but as a whole the project does not do much to change, set, or effect the culture.

As far as public health, safety, and welfare are concerned, the only real considerations that need to be made are in regards to the physical implementation of our project. As our project deals with high voltage and relatively high power, we need to be concerned with protecting our users from the higher voltage components.

4.1.2 User Needs

- Primary user group: RV owners

RV owners need a way to monitor their AC shore, AC generator, and DC battery power usage because they are concerned with their power usage, power health, or battery health.

RV owners need to level their RV before using internal components such as water heaters or refrigerators to avoid damaging the fragile components.

RV owners need to monitor temperatures in the coach and potentially other consumables because they want to be able regulate certain areas or avoid unnecessary consumption of power.

4.1.3 Prior Work/Solutions

RV users may own and use devices like multimeters and battery monitors that are readily available to buy on the internet. This gives them some information about the power usage, but not instantaneous or historical usage or other contexts within the scope of the project. See references for researched systems.

Power monitoring systems exist and are readily available, but there is a cost and implementation barrier that makes it difficult for the average RV owner to utilize or fit the scope of the project. For example, a battery analyzer alone costs $3500. In addition, their interfaces may not be user friendly or consider all needs of the end user or fit the scope of the project. See references for researched systems.

4.1.4 Technical Complexity

The technical complexity of the project consists of three separate points:

1. Requires monitoring of both DC and AC power consumption, involving sensor design. Fairly technical component that requires mathematical, physical, and safety challenges. These sensors exist, but come with a cost barrier.
2. Requires embedded systems to intercommunicate, involving communication protocols, embedded systems programming, and datalogging. Finished project may not be complex, but implementation and testing of embedded systems code is technically complex. These solutions exist, but do not fit the criteria of the design.
3. Requires data storage and user interaction, involving UI design, data storage and management, and backend programming processing data. No current industry standard exists, so this can easily set or exceed current standards. This will be done using full stack app development, deploying a server, querying remotely, etc.

4.2 Design Exploration

4.2.1 Design Decisions

Our design decisions break into multiple different categories regarding devices utilized within the project and the housing in which they will be contained.

- Raspberry pi zero w (deploy server, headless)
    - Power Supply min of 1 A
    - Before headless, will temporarily need USB keyboard and mouse, monitor
    - Possibly can combine server and microcontroller if power consumption is not an issue
- Microcontroller
    - Possesses sufficient number of ADCs
    - Possesses ADCs with sufficient resolution to monitor voltage and current
    - Capable of communicating with raspberry pi zero
- Shunt Resistor
    - AC/DC requirements for sensing
    - Resistance will not dissipate excess power in exchange for data points
- Op amp
    - Voltage limits & slew rates
    - can be read by ADC
- Type of housing
    - Can survive RV travel
    - Sufficient to protect internal components from outside elements
    - Sufficient to protect external components from shock/discharge

4.2.2 Ideation

One challenge which exists is the implementation of the housing for the finished power monitoring system. We are going to try to find a general enclosure for the circuit housing. Other options we considered include 3D printing an enclosure, custom ordering an enclosure of a specific size, building an enclosure ourselves from raw materials, repurposing an enclosure from some other device, and not using an enclosure at all.

4.2.3 Decision-Making and Trade-Off

We weighed the pros and cons of each option by having a group discussion for explored ideas. A group member proposes an idea and explains the benefits and other members discuss the benefits and drawbacks of the given idea. In addition, ideas are often revisited as they are explored more thoroughly as to their efficacy and efficiency. We felt that simple discussion was the best way to finalize decisions, as other methods tend to take more time and energy than is available to the team in a given week.

4.3 Proposed Design

4.3.1 Design Visual and Description

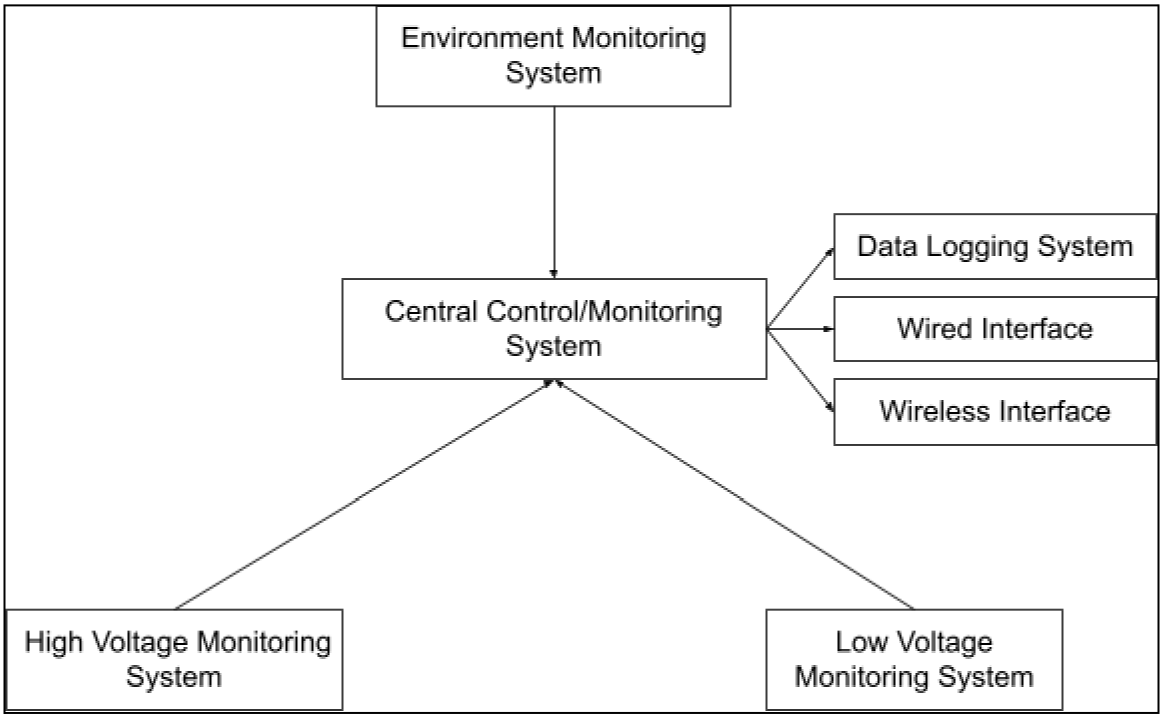

Figure 2: Proposed Block Diagram of Subsystems

Shown above is a high level block diagram of the proposed system. The system consists of sensor modules which give data to the central control and monitoring system as well as interfaces for the system to transmit data to the end user. The first sensor subsystem is the high voltage monitoring system, which can monitor voltage, current, and power from 240VAC shore power or generator power. The second sensor subsystem is the low voltage monitoring system, which can monitor voltage, current, and power from 12VDC battery power. The third sensor subsystem is the environment monitoring system, which can provide temperature readings and a leveling reading. The central control/monitoring system receives data from the previous three systems, stores data in some form of data logging server, and has a web interface for the user, with the possible addition of a small wired interface in the form of buttons, LEDs, a small LCD screen, etc.

4.3.2 Functionality

System operation - The desired data within the RV will be transformed into signals which can be interpreted by the chosen microcontroller by sensors designed within the project. This microcontroller will then communicate signals observed from the sensors wirelessly with a web server that will log and send data remotely to the backend of the web browser application that is run off a raspberry pi zero w, deployed within the RV. This data will be seen via user interface, with both current and historical data stored.

User access - The user will be monitoring real time power usage and other consumables through a web interface. If said user decides they want to check on the power or consumable levels, they can navigate to a web browser application on their phone/tablet/computer and look at dynamic data that is updating real time. The user may also want to check their historical data, which they can navigate to a button on the web interface, allowing them to see past data. TBD: While in the RV itself, the user can access an on-board wired interface (LED, etc.) to show the same statistics as the website.

By identifying our necessary requirements within the block diagram above, we feel that we will satisfy all functional requirements outlined by the client. As we work more to finalize and implement designs, we will revisit the block diagram to make sure that we met the functional requirements the client outlined before we bring the final product to the client for user testing

4.3.3 Areas of Concern and Development

One major concern is testing the circuits that we are designing, since our client wants sensors which work with 240VAC. This could be resolved by locating a lab where we can safely test 240VAC systems to ensure they work correctly before implementing it on the RV.

Another concern for this project is the physical testing within the RV. While we know we can obtain a safe test environment, it will be difficult to test the system within an RV as it would not only have to be installed into the RV, but would need to operate for a period of time to determine sensing and data logging capabilities in addition to ruggedness during traveling.

4.4 Technology Considerations

The most important trade off is power consumption vs accuracy of our system. We know that we need to be able to reduce our power consumption, as it defeats the purpose of the power monitoring system if it creates a large load on the system. However, we do not want to sacrifice accuracy or functionality of our measurements. While we are working to minimize our power footprint with lower power microcontrollers, well designed sensors, and a main computer with only necessary processing power, we also know that there will be some parasitic power consumption by the monitoring circuits.

Our solutions for power consumption involve lowering the power consumption of the subsystems. With microcontrollers, this could be in the form of reducing clock speed, introducing more efficient voltage regulation, or taking advantage of a built-in sleep more. For the sensors, we can work to use newer parts or shunts that fit the quantity being monitored that reduce parasitic power consumption. Lastly, for the main computer, we would like to utilize software that can minimize computational activity while still providing the necessary collection and interaction outlined within our constraints.

4.5 Design Analysis

Analysis has yet to be performed, as the timeline of our parts arrival has pushed back our prototyping time frame relative to the end of the semester.

For power monitoring, we are investigating different kinds of circuits we can use to measure power efficiently and accurately. We can easily modify the circuits as needed as our initial designs will be created using solder/breadboards/screw terminals. For the network that interacts with the sensors, we will compare and contrast different kinds of wireless sensors to find the ones that are the most power efficient and accurate. We will take note of any weaknesses in our design so we can address them and find a different solution.

4.6 Design Plan

As of now, our plan is to split into smaller teams and work on the different parts of our project. A majority of our requirements/constraints deal with either electrical/power or software, so said requirements and constraints will be split up by these groupings to people who specialize in these areas. Once the separate pieces are designed and tested, we are going to develop a plan to integrate our subsystems. While the design may consist of one larger system, the group feels confident that the subsystems can be developed somewhat independently as the components chosen allow for integration later in the development process.

5 Testing

5.1 Unit Testing

The units we plan on testing are voltage sensors(AC & DC), temperature sensors, leveling sensors, microcontroller ADC interpretation, data transmission to the web server, and interaction with the user interface. These will be tested with multimeters to test sensor quantities, serial monitoring of the microcontroller ADC, reception of data within the web server, and user satisfaction with the interface.

5.2 Interface Testing

Web browser application:

Front-end and backend testing will occurusing a unittest framework called Jest. We will follow a test suite with multiple test cases covering different functionality and user interface points (buttons, etc.).

Physical wired LED screen interface (TBD):

We will test the screen manually using Ad Hoc, live, and system testing. Testing in this order is important to follow. The testing will follow a physical checklist, checking off functionality and user interface points.

5.3 Integration Testing

The most important integration testing will be between sensor and microcontroller and microcontroller and server. With the sensor, it will need to produce a signal at a resolution that can be read and interpreted by the microcontroller. This will be tested by comparing observed sensor values with observable values as defined by the microcontroller datasheet. With the microcontroller, it will need to have a robust enough communication protocol to send the required data at a speed that prevents bottleneck. A test program will be written such that the reading from the sensor can be read from a serial communication between the microcontroller and a computer. The same can be done at a server level by checking whether it is receiving data and making sure it is not “backing up” on the microcontroller via serial communication.

5.4 System Testing

Our system testing will be conducted on a complete integrated system to evaluate the system's compliance with its specified requirements. This will be the software, server, and electrical/power sub systems. These sub-systems will be tested chronologically, combining both the unit testing for electrical/power, interface testing for the user interface on the web browser application, and the program to test the server connection and reading/writing data. These are tied to the requirements that have already been decided by our group. Again, these requirements are seen within each of the different sub-systems and will be tested during acceptance testing individually.

5.5 Regression Testing

We hope that we can take an integrated approach to mitigate the amount of regression testing necessary in the design. This will involve adding functionality at a rate that will allow us to identify which components create issues so that we can circle back and rework the component which does not integrate well to resolve the issue. In addition, test points in circuits and print statements in code will be utilized to identify and mitigate "weird" behavior.

5.6 Acceptance Testing

We will demonstrate that the functional requirements of our project are being met by showing that we have a project which meets the specified functionality from the client. Because each aspect of this project is connected to the others, integration is vital to a final product. We will involve the client by having them assist in user interface testing to ensure that we meet their needs in interfacing. Additionally, the client will likely assist in testing our system's ability to withstand travel and operation within the RV.

5.7 Security Testing (if applicable)

Securing testing was not seen to be necessary, as the data measured and contained within the web server was not deemed a security risk. While a login functionality is considered, the data contained will not put the user at risk should it be obtained maliciously. Lastly, we feel that security by obscurity (our implementation being the only existing implementation) will deter hackers as they will have no prior knowledge of the system.

5.8 Results

While physical prototype testing has not occurred, tests which help to determine component values yields promising results in terms of implementing a physical prototype.

6 Implementation

Describe any (preliminary) implementation plan for the next semester for your proposed design in 3.3. If your project has inseparable activities between design and implementation, you can list them either in the Design section or this section.

Currently, there is no implementation as of this semester due to a delay in the arrival of parts causing a slowing in the prototyping timeline. Fortunately, our plan allows us some room to change our schedule. Our plan is to begin prototyping over break and pushing to complete the prototype early in the semester, hopefully near the first week of february, to maximize the time spent testing the implementation of the project.

7 Professionalism

This discussion is with respect to the paper titled " Contextualizing Professionalism in Capstone Projects Using the IDEALS Professional Responsibility Assessment", *International Journal of Engineering Education* Vol. 28, No. 2, pp. 416–424, 2012

7.1 Areas of Responsibility

Area of Responsibility	Definition	NSPE Canon	IEEE Standards
Work Competence	Perform work of high quality, integrity, timeliness, and professional competence.	Perform services only in areas of their competence; Avoid deceptive acts.	to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to disclose promptly factors that might endanger the public or the environment
Financial Responsibility	Deliver products and services of realizable value and at reasonable costs.	Act for each employer or client as faithful agents or trustees.	to avoid unlawful conduct in professional activities, and to reject bribery in all its forms
Communication Honesty	Report work truthfully, without deception, and understandable to stakeholders.	Issue public statements only in an objective and truthful manner; Avoid deceptive acts.	to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems
Health, Safety, and Well-Being	Minimize risks to safety, health, and well-being of	Hold paramount the safety, health, and welfare of the public.	to hold paramount the safety, health, and welfare of the public,

	stakeholders.		to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to disclose promptly factors that might endanger the public or the environment;
Property Ownership	Respect property, ideas, and information of clients and others.	Act for each employer or client as faithful agents or trustees.	to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, to be honest and realistic in stating claims or estimates based on available data, and to credit properly the contributions of others
Sustainability	Protect environment and natural resources locally and globally	Adhere to the principles of sustainable development	to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems
Social Responsibility	Produce products and services that benefit society and communities	Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession	to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist

Table 1: Professional Areas of Responsibility

7.2 Project Specific Professional Responsibility Areas

Area of Responsibility	Relevant?	Context	Performance
Work Competence	Yes	We want to ensure that we are able to finish the project in a timely manner while also meeting all the requirements provided to us by our client. Each team member will work on aspects of the project that match their background.	High
Financial Responsibility	Yes	We are operating on a limited budget supplied by our own course fees so we want to ensure that we are careful about what we use our resources on.	High
Communication Honesty	Yes	We hold weekly in-person meetings every Monday and virtual Zoom meetings every Thursday. We also make use of two group chats, one via sms text and the other through Discord, to discuss relevant information in regards to the project.	High
Health, Safety, and Well-being	Yes	We will be working with high voltage equipment and will be using all necessary safety requirements to ensure our experiments/tests are done safely and protects the user(s) at all costs. We will do so by following all safety rules and regulations while keeping our components in a safe	High

		and controlled area such as the power lab.	
Property Ownership	Yes	We will be implementing the project within an RV, which can be an important and potentially valuable possession for a multitude of people. Therefore, we must hold the utmost respect for property, as the project provides a modification to a very relevant and valuable possession of the user.	High
Sustainability	Yes	While sustainability is not on the forefront of development and parts sourcing, the final project will allow the end user to monitor and potentially cut their power usage, reducing the overall carbon footprint of a relatively inefficient RV	High
Social Responsibility	Yes	The completed product within the RV will benefit the RV community with new technical features to check in on consumption levels from anywhere. This will make the QOL much better for avid RV enthusiasts.	High

Table 2: Areas of Responsibility Related to Project

7.3 Most Applicable Professional Responsibility Area

One area which is important to the project which we have demonstrated so far is Health, Safety and Well Being. With the project making modifications to the method in which power is monitored and distributed within the RV, it is important to ensure that the operation of the RV remains safe for the user. Most importantly, we want to ensure that there is no scenario where the user or other people/animals near the RV could be exposed to high voltages or currents which could be potentially harmful. Most of our current planning involve safety procedures regarding testing and implementation within a lab where safe design can occur. In addition, high voltage components are rated to operate within margin for error, and will be enclosed when implemented to prevent accidental exposure to high voltage. By concerning ourselves with safety, we can ensure that the end user will receive a product which improves their current state without possibility of harm.

8 Closing Material

8.1 Discussion

The main results that we were able to accomplish this semester were simulation results for our measurement system. We have a circuit that we plan to implement for measuring the voltage and current, but we were not able to develop a physical prototype. Instead, we ran the circuit through a program called Spice to test its functionality. The results of the simulation were favorable and we got the appropriate results from various input voltages. Now that we have a functional design, the next step is to implement a working prototype.

8.2 Conclusion

Due to many delays through the semester related to parts ordering, our plans do not extend beyond simulations of results and learning involving datasheets and code bases. However, as we have spent a large amount of time in development, we are more than prepared to take on prototype implementations next semester, and have a plan to accelerate development as needed due to our planning time.

8.3 References

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8.4 Appendices

8.4.1 Team Contract

Team Members:

1) Nickolas Moser	2) Jace Kunkel
3) Peter Rothstein	4) Michael Woo
5) Kent Mark	6) Doug Bullock
7) Utsavee Desai	8) Matt McCarthy

Team Procedures

Day, time, and location (face-to-face or virtual) for regular team meetings:

- Weekly In-person meeting: 4PM Mondays, location determined by weather
- Weekly Virtual meeting: 4PM Thursdays, through Discord

2. Preferred method of communication updates, reminders, issues, and scheduling (e.g., e-

mail, phone, app, face-to-face):

- Team is to utilize in-person meetings, Discord, and email to communicate between each other as well as the client

3. Decision-making policy (e.g., consensus, majority vote):

- Decisions will be made by group consensus, as it allows for better discussion between the group and allows for satisfaction with discussion.

4. Procedures for record keeping (i.e., who will keep meeting minutes, how will minutes be

shared/archived):

- Group meeting agendas will be sent the morning of meetings. While group meetings tend to stick to the agenda, any updates which were not initially described in the agenda will be emailed to the group.

Participation Expectations

1. Expected individual attendance, punctuality, and participation at all team meetings:

- Attendance is expected at all meetings, but is excused in extenuating circumstances.
- Should half the team not be able to meet at a given time, a new meeting time will be arrived upon.

2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines:

- Tasks should be completed on time with extra time allocated for proofreading before submission.
- If a task cannot be completed, it should be reallocated to another group member who is capable of completing the task in the time frame.

3. Expected level of communication with other team members:

- While a weekly email with meeting agenda is sent, it is expected that the group member should be responsive within a few hours to communicate group needs and progress as necessary.

4. Expected level of commitment to team decisions and tasks:

- It is expected that group members that everyone should not only be aware of design decisions which are being made, but reasoning why group decisions are being made.

Leadership

1. Leadership roles for each team member (e.g., team organization, client interaction,

individual component design, testing, etc.):

a. Nick will serve to facilitate communication between client and team, lead technical documentation
b. Utsavee will keep track of the organization and weekly meetings.
c. Peter will lead the software design and implementation
d. Kent will lead the development of UI
e. Jace will lead the testing aspect of the project
f. Mike will lead the power systems analysis
g. Doug will lead circuit design and anything else
h. Matt will lead circuit implementation.

2. Strategies for supporting and guiding the work of all team members:

a. Make sure individual voices are heard and considered in decision making.
b. Assist others with development, brainstorming, etc when needed.
c. Motivate each other to apply knowledge and contribute to projects.

3. Strategies for recognizing the contributions of all team members:

a. Give project reports weekly to recognize everyone's contributions and accomplishments

Collaboration and Inclusion

1. Describe the skills, expertise, and unique perspectives each team member brings to the team.

- Doug: Electrical Engineering major, focus in circuit. Experience with embedded system project work (288), electrical components and system testing, circuit design and troubleshooting
- Utsavee: Electrical Engineering major, with focus in Power Systems. Experience with system planning in power distribution and transmission, with some experience with using an accelerometer.
- Jace: electrical engineering, focus in power systems and energy distribution, experience with various high voltage sources, troubleshooting electrical components, hands-on work (assembly, testing, installation)
- Nick: Electrical Engineering major, focus in VLSI and embedded systems, project work in embedded systems, PCB design, 3d printing, systems testing
- Mike: Electrical engineering major focusing in VLSI and power, experience in testing PCBs and laboratory work
- Peter: Software Engineer major, fields of interest in testing, automation, and embedded systems. Two years of internship experience with software testing, both manual (embedded systems) and automated (mock testing). Has a background working with raspberry pi's, microcontrollers, and IoT in general.
- Matt: Electrical Engineering major with a focus in power and systems. Experience in circuit design and implementation.
- Kent: Software Engineering major with experience in Android Studio, C, Python, Java, C#, Javascript, SQL, HTML, and CSS

2. Strategies for encouraging and support contributions and ideas from all team members:

- Listen to all ideas presented, reach decisions as a group, show respect for others contributions

3. Procedures for identifying and resolving collaboration or inclusion issues (e.g., how will a team member inform the team that the team environment is obstructing their opportunity or ability to contribute?)

- Directly address issue with people involved to make sure all opinions are heard and necessary changes can be made.

Goal-Setting, Planning, and Execution

1. Team goals for this semester:

   a. Develop a preliminary design for RV system monitoring
   b. Identify necessary components to take necessary AC & DC measurements
   c. Find methods to integrate monitoring systems to a viewing dashboard/data logger

2. Strategies for planning and assigning individual and team work:

   a. Identify each group members strengths/weaknesses
   b. Assign roles based on our experiences and preference of work

3. Strategies for keeping on task:

   a. Hold each other accountable and designate times for work

Consequences for Not Adhering to Team Contract

1. How will you handle infractions of any of the obligations of this team contract?

   a. Directly address issue with necessary parties, reach out to other group members if necessary.

2. What will your team do if the infractions continue?

   a. Address issue with project advisor

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a) I participated in formulating the standards, roles, and procedures as stated in this contract.

b) I understand that I am obligated to abide by these terms and conditions.

c) I understand that if I do not abide by these terms and conditions, I will suffer the

consequences as stated in this contract.

1) Nickolas Moser DATE: December 1, 2021

2) Utsavee Desai DATE: December 1, 2021

3) Michael Woo DATE: December 2, 2021

4) Jace Kunkel DATE: December 2, 2021

5) Matt McCarthy DATE: December 2, 2021

6) Doug Bullock DATE: December 2, 2021

7) Peter Rothstein DATE: December 2, 2021

8) Kent Mark DATE: December 3, 2021