EEE4022F/S - Final Year Project Graduate Attribute Tracking Form

Student name	Sarah Tallack	**DP Awarded?**	Yes ☒ No ☐
Student number	TLLSAR002	**Supervisor name**	R.A. **VERRINDER**
Date	6 October 2023	**Date**	2023-10-06
Student signature		**Supervisor signature**	

GA 1: Problem Solving

Student

Proposal (Problem statement - 100 to 200 words)

The distribution of sea ice in the Southern Ocean's Marginal Ice Zone (MIZ) plays a crucial role in global climate patterns. Despite this, our understanding of this region suffers from lack of in situ data measurement, especially over the winter season. Sea ice acts as both a reflective boundary and physical insulator for the water below, affecting light transfer to the underlying water. This in turn impacts the energy available for phytoplankton growth. Recent studies have shown phytoplankton growth under sea ice in late winter, challenging previous assumptions that sea ice melting preceded or concurred with significant phytoplankton growth [Hague and Vichi, 2021]. Phytoplankton play an important role in the global system, contributing to the carbon uptake of the Southern Ocean, as well as acting as the base of the Antarctic region's food web. Thus, it become imperative to better understand the through-ice and under-ice radiative transfer, especially for this unique region.
Research grade Photosynthetic Active Radiation (PAR) sensors are traditionally very expensive, making them unsuitable for deployment in environments where they may not be recovered. The development of a robust and affordable PAR sensor using off-the-shelf components would greatly improve data measurement capabilities, and thus improve our understanding of this region. By providing an affordable and reliable measurement solution, this project aims to fill the knowledge gaps in Antarctic sea ice radiative transfer properties. This will in turn contribute to a deeper understanding of the role played by the MIZ in the global climate system.

Progress

Two possible sensors that can fulfil the requirements have been identified. The hardware and firmware design process is outlined in Chapters 3 and 4 of the final report. These sensors will then be characterised using various testing procedures, as outlined in Chapter 5 of the final report. The sensors chosen align with the need for a low power affordable solution to PAR measurement. The sensors' reliability still need to be determined.

Supervisor Response

Sarah has clearly identified the specific subject of her investigation from a broad and open ended problem description. This has been described in the initial problem statement and she has made satisfactory progress to date to meet the required project goals.

GA 4: Investigations, Experiments, and Data Analysis

Student

Objectives of investigation (planned investigations, methods, and/or experimental procedure); Scope, assumptions and limitations of study

Experiment Procedure

Once the testing rig has been setup and configured as detailed in Chapter 5 of the final report, the following experimental procedure will be carried out:

- The light input will be set to varying brightness levels (with 10 LED light levels), as well as varying colours (namely red, green, blue, and white). For each brightness level and colour, the sensors will be cycled through different parameters (pertaining to integration time, lux sensitivity, and sensor gain).
- The light input will then be set to a constant colour and brightness that will imitate the spectral response of sunlight. Various mediums will be used to transmit the light to the LEDs (specifically a filter or material that imitates the radiative transfer properties of ice or water). For each medium, varying parameter settings for the sensors will be used.
- The next test will be used to determine the effect of light angle on the sensed value. First, an individual LED directly below the sensors will be turned on and measured. Once this baseline measurement has been taken, the same measurement procedure will be following for 8 other LED placements.

Measurement Procedure: For the above testing, the following measurement procedure will be followed in order to gather meaningful data:

- For each varying experimental parameter, the sensors will be enabled, and allowed to run for approximately a minute before any data is recorded.
- The sensor data will be transmitted via UART and recorded to a .csv file. These readings will come in at fixed intervals.
- Multiple readings (up to 20) for the same experimental procedures will be taken. The average of these values will be used in the results.

Scope

While the overall goal of this project is the development of the optical sensor-chain for through-ice deployment, the scope of this research project is limited to the development, testing and validation of a single sensor node using off-the-shelf components.

The sensor node should be designed so it can be implemented in a sensor-chain. Accommodations will also be made in the node design for additional sensors, such as temperature and conductivity (salinity) sensors.

Limitations

The extreme weather and oceanic conditions prevalent in the Antarctic region play a significant role in shaping the available design options for the sensor node. These conditions also impact the reliability and precision of the sensor, imposing limitations on its performance.

The project faces limitations due to the availability of required components within South Africa. The expenses and potential delays associated with shipping these components introduce additional constraints, which will affect the project's overall progress.

Additionally, another limitation may arise from getting access to a research-grade PAR sensor. This will be vital to validating measurements and calibrating the sensor node.

Finally, the tight design timeline of 13-weeks adds further limitations to what can be achieved in this project. This timeline will influence the extent of design refinement, testing and validation.

Assumptions

This project assumes that the observed late winter phytoplankton growth is indicative of potential radiative transfer through sea ice, justifying the need for improved data measurement capabilities.

Progress

The hardware, firmware, and software have all been developed and individually tested. Thus, it is all ready to be setup in the testing configuration and data collection can begin. While the data is being collected, software will be developed to analyse and present the data.

Supervisor Response

Sarah has taken the subject of this investigation and broken it down into clear and well defined experiments. She has completed all experiments listed above and is currently analysing the results. She has made satisfactory progress to date to meet the outcomes.

GA 6: Professional and Technical Communication

Student

The final year project will be compiled and written up as a final year project report of not more than 70 pages. All sources will be referenced using the Harvard referencing style. The report layout will follow the recommended final year project report guidelines and I will endeavour to ensure that the report is as error free as possible. All figures, tables and illustrations will be appropriate for the content and will be correctly captioned.

Plan of development (Chapter headings)

Chapter 1: Introduction
Chapter 2: Literature Review
Chapter 3: Hardware Design
Chapter 4: Firmware Design
Chapter 5: Experimental Procedure
Chapter 6: Experimental Results
Chapter 7: Discussion
Chapter 8: Conclusion
Chapter 9: Recommendation for Future Work

Detailed Table of Contents

Chapter 1: Introduction
- 1.1. Problem Statement
- 1.2. Project Objectives
- 1.3. Scope, limitations and assumptions
- 1.4. Plan of Development

Chapter 2: Literature Review
- 2.1. The Importance of Antarctic and Southern Ocean Research
- 2.2. Phytoplankton
- 2.3. Photosynthetically Active Radiation (PAR)
- 2.4. PAR Measurement

Chapter 3: Hardware Design
- 3.1. System Overview
- 3.2. Sensor Subsystem Design
- 3.3. LED Array Subsystem Design
- 3.4. Subsystem Testing Procedures
- 3.5. Subsystem Testing Results

Chapter 4: Firmware Design
- 4.1. System Overview
- 4.2. Sensor Subsystem Design
- 4.3. LED Array Subsystem Design
- 4.4. Subsystem Testing Procedures
- 4.5. Subsystem Testing Results

Chapter 5: Experimental Procedure
- 5.1. System Overview
- 5.2. System Variables and Parameters
- 5.3. Testing Rig Configuration
- 5.4. Testing Procedures

Chapter 6: Experimental Results
- 6.1. VEML6040 Testing Results
- 6.2. AS7341 Testing Results

Chapter 7: Discussion (Discuss various tests done, compare two sensors, refer back to literature)
Chapter 8: Conclusion (Hardware design + firmware design conclusions, experimental conclusion)
Chapter 9: Recommendation for Future Work

Supervisor Response

This GA will be evaluated once the final report is examined. However, the outline of the work is sensible given the project details and outputs.

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GA 8: Individual, Team and Multidisciplinary Working

Student

This final year project is an individual effort, other than the normal guidance of my supervisor(s). All contributions and assistance from other parties are acknowledged in my report acknowledgements and cited, where appropriate.

Supervisor Response

Sarah has worked in an independent and professional manner throughout the project. All contributions to the work from other staff and students will be acknowledged in the final report.

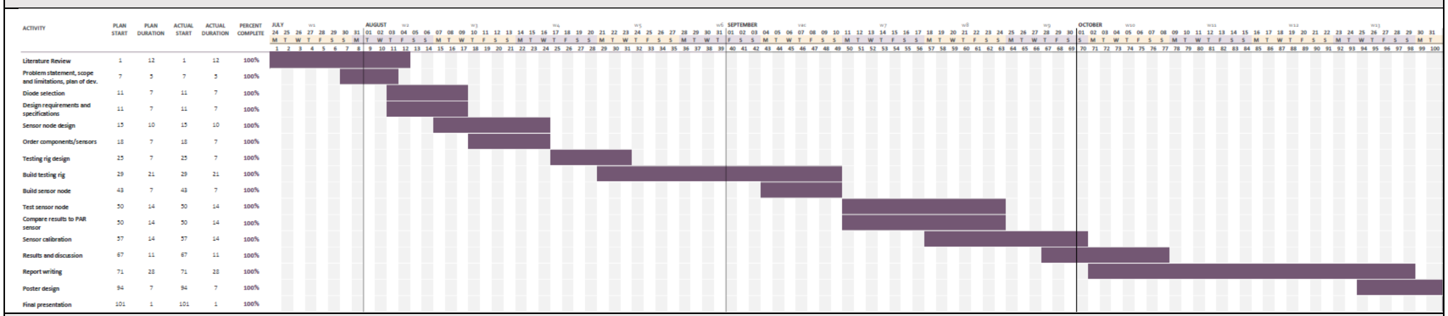
GA 9: Independent Learning Ability

Student

I acknowledge that the final year project will require me to identify and learn new knowledge and skills based on my topic. I take personal responsibility for these processes. I will attend weekly meetings with my supervisor(s) and set weekly goals for the project. If I am unable to attend a weekly meeting I will provide a brief written update on my progress using MS Teams. I have engaged with the ethical considerations of my research and complied with the EBE ethics process by completing, submitting and receiving approval for my work through the EBE EiR.

In the course of this project, I have had the opportunity to improve my PCB design, which has allowed me to engage with reading datasheets, comparing components and making informed decisions with regards to component selection. Additionally, I have improved my C coding, specifically with the development of firmware to be used with an STM32 microcontroller. I have also engaged with Veroboard design, which offers unique challenges. All of the above was done while still keeping in mind the context of the project and placing importance on not only individual sections working well, but these sections being able to seamlessly work together within the overall system.

Project timeline (milestones)



EBE ethics approval reference number

STU-EBE-2023-PSQ000510

Supervisor Response

Sarah is on track to submit her work by the required date and has actively acquired new skills and knowledge throughout the project.

Instructions

Students must explain in this document what they **have already done** and what they **plan to do** to satisfy each Graduate Attribute. Descriptions of each GA are provided below. Supervisors may then respond to the student's plans and current progress, providing additional comments or advice as they see fit. If the student's progress is sufficient, they may indicate that DP is awarded.

GA 1: Problem Solving

Identify, formulate, analyse and solve complex engineering problems creatively and innovatively.

GA 4: Investigations, Experiments and Data Analysis

Demonstrate competence to plan and conduct investigations and experiments. The balance of investigation and experiment should be appropriate to the discipline. Research methodology to be applied in research or investigation where the student engages with selected knowledge in the research literature of the discipline. Note: An investigation differs from a design in that the objective is to produce knowledge and understanding of a phenomenon and a recommended course of action rather than specifying how an artefact could be produced.

GA 6: Professional and Technical Communication

Demonstrate competence to communicate effectively, both orally and in writing, with engineering audiences and the community at large. This course evaluates the long report component of this outcome at exit level. Material to be communicated is in an academic or simulated professional context. Audiences range from engineering peers, management and lay persons, using appropriate academic or professional discourse. Written reports (10 000 to 15 000 words plus tables, diagrams and appendices) should cover material at exit-level. Methods of providing information include the conventional methods of the discipline, for example engineering drawings, as well as subject-specific methods.

GA 8: Individual, Team and Multidisciplinary Working

Demonstrate competence to work effectively as an individual, in teams and in multidisciplinary environments. This course evaluates the **individual** working component of this learning outcome at exit level.

GA 9: Independent Learning Ability

Demonstrate competence to engage in independent learning through well developed learning skills. Operate independently in complex, ill-defined contexts requiring personal responsibility and initiative, accurately self-evaluate and take responsibility for learning requirements; be aware of social and ethical implications of applying knowledge in particular contexts.