Enabling photodetection electronics for fluorescent diamond based quantum sensing
Project plan

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Contents

Chapter 1

Introduction

This chapter introduces the assignment and some foundational concepts of quantum sensing.

1.1 Background

Nitrogen-vacancy (NV) centers [1] are imperfections in the atomic structure of diamonds, which have the useful property of spin-dependent luminescence. This means that the spin of the NV center affects the frequency of the light emitted by the structure[1]. Using this quality of the NV structure, different environmental metrics (e.g magnetic fields) can be measured.

The Applied Nanotechnology research group is working on a NV-center-based sensor setup. Processing data from the setup requires working with weak signals that are hard to distinguish from the environmental noise. While this is a significant problem, it is also a very common one. Because of this, there is already widely-used system used to isolate signals in such cases: the lock-in amplifier.

1.2 Purpose of the assignment

Implementing a lock-in amplifier is the main purpose of the assignment. To create a complete solution, there are several different functionalities and systems that need to be developed.

Before doing anything else, the raw sensor data needs to be extracted and then fed to a lock-in amplifier. This should be done in a standardized manner, in order to facilitate testing with different devices. After establishing connection, a control interface needs to be implemented. It needs to be programmed so that it can control all necessary features of the lock-in amplifier. Following the development of the program, a custom photodetection circuit needs to be designed. The circuit should accommodate the sensors and lock-in amplifier. Lastly, an OLIA[2] circuit needs to be tested and compared to conventional lock-in systems.

1.3 Assignment specifications

1.4 Methodological approach

[1]The NV center only emits light after absorbing photons, a phenomenon called photoluminescence [2]

[2]Open Lock-In Amplifier (OLIA) is an open-source microcontroller-based lock-in amplifier. It uses common components, which makes it easy to build [3]

Chapter 2

Products and project objectives

2.1 Products

2.2 Objectives

- Goal #1: Complete the learning objectives of the project.
- Goal #2: Complete the professional objectives of the project.

2.2.1 Learning objectives

1. Project plan: outline of the project
2. Technical report: technical documentation of the project
3. Learning report: reflection on the project as a learning activity
4. Final presentation (incl. presenting): communication of the highlights of the project

SMART

- Specific: The deliverables associated with the learning objectives all have to be completed by the student and submitted for review to Saxion. The only exception is the final presentation, which includes both the digital presentation and the in-person presenting done by the student. The learning objectives are set in place so that the student can demonstrate sufficient knowledge and skills in order to obtain a diploma.
- Measurable: Every deliverable has a corresponding grading rubric, which quantifies the proficiency of the student.
- Achievable: The learning objectives build on top of the knowledge that the student has acquired during their study at Saxion. In order to navigate any setbacks that concern the learning objectives, the student can request feedback from the Saxion coach. All other work can be completed by the student with the use of the internet and all publicly available tools and resources.
- Relevant: Goal #1 is aligned with the degree of the student. Learning objectives are set in place to showcase to what level the student has mastered the knowledge and competences acquired during the study.
- Time-bound: Every submission has its own due date, consult Chapter 7 for more information.

2.2.2 Professional objectives

1. Code: main deliverable; includes everything from firmware to scripts
2. Visualizations: graphs corroborating the findings of the project
3. Documentation: a document covering the findings of the project and how to work with the code

SMART

- Specific: The professional objectives were discussed with the company coach before the technical work on the project was started. The main goal of the project is to test the scalability of OpenRemote in order to prove whether or not it can be used in future (industrial) IoT projects carried out by AmI. The auxiliary goals, set in place to ensure the findings of the project are as truthful and useful as possible, are discussed in Chapters 1.3 and 4
- Measurable: The project should result in clear visualizations and numbers. These outcomes should show how the speed and stability of OpenRemote scale with the number of devices. The analysis that can be performed on this data should result in an answer to the question "Is OpenRemote scalable enough?".
- Achievable: The student has the skillset to conduct the technical part of the project successfully. The physical tools that the project requires will all be provided by AmI. AmI also provides technical support in the form of the company coach.
- Relevant: The project is a part of a bigger project within AmI called NOWATT. The results of the professional objectives will directly utilized by the NOWATT team.
- Time-bound: The timeline for the professional objectives needs to align with that for the learning objectives. This is so, because the project is done as a graduation assignment and the graduation deadlines are mandated by Saxion.

Chapter 3

Project activities

3.1 Start phase

3.2 Realization phase

3.3 End phase

Chapter 4

Project boundaries

Must have

- Sensor data extraction
- OpenRemote integration

Should have

- Visualizations using sensor data
- MQTT configuration

Could have

- Physical device implementation
- Data prediction using machine learning
- Firmware implementation for emulated devices

Will not have

- Cross-platform compatibility
- Several implementations for different hardware platforms
- Cloud-based processing

Chapter 5

Quality assurance

Chapter 6

Project organization

6.1 Organization

Name	Work email	Role
Vladislav Serafimov	v.serafimov@saxion.nl	Student
Yanin Kasemsinsup	y.kasemsinsup@saxion.nl	Saxion coach
Eyuel Ayele	e.d.ayele@saxion.nl	Company coach

Table 6.1: People involved in the project

6.2 Communication

Chapter 7

Planning

Chapter 8

Risk analysis

Bibliography

[1] Wikipedia contributors, *Nitrogen-vacancy center — Wikipedia, the free encyclopedia*, [Online; accessed 3-September-2025], 2025. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Nitrogen-vacancy_center&oldid=1301369588.

[2] Wikipedia contributors, *Photoluminescence — Wikipedia, the free encyclopedia*, https://en.wikipedia.org/w/index.php?title=Photoluminescence&oldid=1309081879, [Online; accessed 4-September-2025], 2025.

[3] A. J. Harvie and J. C. de Mello, "Olia: An open-source digital lock-in amplifier," *Frontiers in Sensors*, vol. 4, p. 1 102 176, 2023.