**MINISTRY OF EDUCATION AND TRAINING**

**HO CHI MINH UNIVERSITY OF TECHNOLOGY AND EDUCATION**

**FACUTLTY OF ELECTRICAL AND ELECTRONICS ENGINEERING**

---o0o---



**GRADUATE PROJECT**

**RESEARCH AND DESIGN IMPLEMENTATION**

**FIRMWARE OVER THE AIR FOR CAR LIGHTING SYSTEM**

**Advisor: DO DUY TAN, PhD**

**Team members :**

1. **CHAU THANH DAT 20119332**
2. **DINH THE DANH 20119327**

**Major: Computer Engineering Technology**

**HO CHI MINH City , 27th of December 2023**

# PROJECT ASSIGNMENT

|  |  |
| --- | --- |
| **Student name:** Chau Thanh Dat | **Student ID:** 20119332 |
| **Student name:** Phan Hoang Phuc | **Student ID:** 20119327 |
| **Major:** Computer Engineering technology | **Class:** 201192A |
| **Advisor:** PhD. Do Duy Tan | **Phone number:** 0369393615 |
| **Date of assigment :** | **Date of submission**: |
| **Project title:** Research and Design Implementation firmware over the air for car lighting system | |
| Initial material provided by the advisior: .................................................................... | |
| Content of the project ....................................................................................................... | |
| Final product............................................................................................................... | |

# ADVISOR’S EVALUATION SHEET

Student name: Chau Thanh Dat Student ID: 20119332

Student name: Dinh The Danh Student ID: 20119327

Major: Computer Engineering Technology

Advisor: Do Duy Tan, PhD

**EVALUATION**

1. **Content of the porject**

**………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………**

1. **Strengths**

**…………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………**

1. **Weakness**

**------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------**

1. **Approval for oral defense? (Approved or denied )**

**------------------------------------------------------------------------------------------------------**

1. **Orverall evaluation: ( Excellent, Good, Fair, Poor)**

**........................................................................................................................................**

1. **Mark ……… (in words:…………………………………………………………..)**

**Ho Chi Minh, Day …………Month……..., Year………**

**ADVISOR**

**(Sign wtih full name)**

# Disclaimer

Disclaimer the authors, who are accountable for truth and the accuracy of the content and information presented here, have expressed their views in this report's contents. This document is not aimed as a standard, specification, or regulation.

# Acknowledgements

We, the project team, want to express our deepest gratitude to our guiding lecturer, Dr. Đỗ Duy Tân from the Department of Computer Engineering and Telecommunications. His commitment and unwavering support, along with his insightful guidance on crucial knowledge, provided an ideal environment for our project's success. With his invaluable assistance, we were able to see the project through to completion.

We would also thanks to our families and friends who stood by our side and offered their support throughout this journey. Their genuine advice proved to be instrumental in helping us overcome challenges and achieve the best possible outcome for this project.

To Dr. Tân, we express our sincere appreciation and wish him continued success and good health.

The project teams.

**Chau Thanh Dat**

**Dinh The Danh**

# Table of Contents

[**PROJECT ASSIGNMENT i**](#_Toc161067987)

[**ADVISOR’S EVALUATION SHEET ii**](#_Toc161067988)

[**Disclaimer iv**](#_Toc161067989)

[**Acknowledgements iv**](#_Toc161067990)

[**Table of Contents v**](#_Toc161067991)

[**List of Figure vii**](#_Toc161067992)

[**List of Tables viii**](#_Toc161067993)

[**Abstract ix**](#_Toc161067994)

[**Abbreviations x**](#_Toc161067995)

[**Chapter 1: OVERVIEW 1**](#_Toc161067996)

[**1.1) Introduction 1**](#_Toc161067997)

[**1.2) Research objectives of thesis 1**](#_Toc161067998)

[**1.3) Research scope of thesis 1**](#_Toc161067999)

[**1.4) Research methods 2**](#_Toc161068000)

[**1.5) Research limits 2**](#_Toc161068001)

[**1.6) Structure of thesis 2**](#_Toc161068002)

[**Chapter 2: LITERATURE REVIEW 4**](#_Toc161068003)

[**2.1) Hardware Overview 4**](#_Toc161068004)

[**2.1.1) ESP32 Overview 4**](#_Toc161068005)

[**2.1.2) STM32F103C8T6 Overview 4**](#_Toc161068006)

[**2.1.3) SN65HVC CAN Transceiver Overview 4**](#_Toc161068007)

[**2.1.4) Oled SSD1030 4**](#_Toc161068008)

[**2.2) Software Overview 4**](#_Toc161068009)

[**2.2.1) FOTA Overview 4**](#_Toc161068010)

[**2.2.2) Booting Process 4**](#_Toc161068011)

[**2.2.3) UDS Standard 4**](#_Toc161068012)

[**2.2.4) RTE 4**](#_Toc161068013)

[**2.2.5) UART Communications Protocol 4**](#_Toc161068014)

[**2.2.6) CAN Communications Protocol 4**](#_Toc161068015)

[**2.2.7) FireBase Database 4**](#_Toc161068016)

[**2.3) Software Overview 4**](#_Toc161068017)

[**Chapter 3. SYSTEM DESIGN 5**](#_Toc161068018)

[**3.1) System Requirements 5**](#_Toc161068019)

[**3.2) System Specifications 5**](#_Toc161068020)

[**3.3) Hardware Design 5**](#_Toc161068021)

[**3.3.1) Telematic unit 5**](#_Toc161068022)

[**3.3.2) Gateway unit 5**](#_Toc161068023)

[**3.3.3) User MCU 5**](#_Toc161068024)

[**3.4) Software Design 5**](#_Toc161068025)

[**Chapter 4: RESULTS 6**](#_Toc161068026)

[**Chapter 5: CONCLUSION AND RECOMMENDATIONS 7**](#_Toc161068027)

[**5.1 Lessons learned 7**](#_Toc161068028)

[**5.2 Future work 7**](#_Toc161068029)

[**5.3 Project Improvements 7**](#_Toc161068030)

[**Preferences : 8**](#_Toc161068031)

# List of Figure

# List of Tables

# Abstract

Nowadays, modern car lighting systems have a crucial role in ensuring visibility and road safety. However, diagnostic traditional methods of updating lighting control software require a lot of effort, inconvenient for user and workforce of the company. This project introduces Firmware Over-the-Air (FOTA) car lighting system, which enables a remote update to enhance safety, functionality, and user experience.

The system includes Telematics Unit to recognize new update firmware on Cloud then download it and send to Gateway. Gateway receives data, node needs to update and send that firmware to Bootloader of that node to reprogram firmware. This FOTA system provides a reliable, cost-effective, convenient system for users, long-term support for customers, easy to maintain, future improvement.

# Abbreviations

|  |  |
| --- | --- |
| IoT | Internet of things |
| FOTA | Flash over the air |
| OTA | Over the air update |
| MCU | Microcontroller unit |
| UART | Universal asynchronous receiver transmitter |
| GPIO | General Purpose Input/Output |
| CAN | Control Area Network |
| UDS | Unified Diagnostic Services |

# Chapter 1: OVERVIEW

* 1. **Introduction**

The automotive industry is rapidly adopting new technologies, and one key area of development is in-vehicle software updates. Firmware Over-the-Air (FOTA) allows car manufacturers to update the software controlling various vehicle components, including the lighting system, wirelessly. The concept of firmware updates existed before it, but the process was much more cumbersome. It typically involved physically connecting the device to a computer, downloading the update onto the computer, and then transferring it to the device using specialized software or hardware. This process was inconvenient, time-consuming, and often required technical expertise. The development of FOTA technology revolutionized how firmware updates are delivered and installed – it increases mobile connectivity, user convenience and cost effective. Therefore, we decided to choose the graduation thesis topic as: “RESEARCH AND DESIGN IMPLEMENTATION: FIRMWARE OVER THE AIR FOR CAR LIGHTING SYSTEM” as FOTA is a relatively new technology in the automotive industry. Moreover, implementing it securely and reliably in a safety critical system like car lighting presents a significant technical challenge, helps us understand more about the FOTA system in automotive.

* 1. **Research objectives of thesis**

This thesis investigates the design and development of a secure and efficient FOTA system for updating the software of car lighting systems using ESP32 and STM32, learning related knowledge (UART, CAN, …), analyzing the potential benefits, addressing the associated challenges, and proposing a comprehensive implementation approach. Finally, performance of the system will be evaluated in a reality environment.

* 1. **Research scope of thesis**

This thesis focuses on addressing the following problems:

* Design and implement Bootloader to reprogram application of Light System and handle error when reprogram failed.
* Design of communication between Gateway - MCU on CAN bus.
* Design of Cloud and wireless communication Cloud - Telematic Unit.
* User interface for reprogram progress.
  1. **Research methods**

This research will employ a multi-pronged approach, utilizing:

* Literature review: Examining existing research on FOTA technologies, UART, CAN bus, …
* System design and development: Designing the FOTA protocol, communication framework, and update management system specifically for car lighting systems.
* Performance evaluation: Evaluating the efficiency and reliability of the FOTA system in a simulated environment.
  1. **Research limits**

There are some limitations of this project, including:

* The Telematic Unit needs to connect with Cloud via Wi-Fi. Therefore, the operation depends on stable Wi-Fi connection, without it, system will not work properly.
* The security of firmware should be considered in real project as it can involve human life if hackers manipulate that firmware. Because of scope of thesis, we will not consider that aspect.
* The thesis will not delve into the business aspects of FOTA adoption, such as cost analysis or market potential.
  1. **Structure of thesis**

The thesis is structured as follows:

*Chapter 1: Introduction*

An overview of the thesis, the reason we choose this topic, research objectives, scope, limitations.

*Chapter 2: Literature Review*

This chapter discusses existing research on FOTA and car lighting systems, more detail about the component will be used in the project: STM32, ESP32, Oled\_SSD1030, SN65HVC CAN Transceiver. This section also cover the theory of booting process on MCU, UDS, RTE, communication protocol: CAN, UART, …

*Chapter 3: System Design and Implementation*

This chapter presents system specifications and requirements, the design for both hardware and software include System diagram, Bootloader design, Telematic Unit, Gateway system, Lighting System, present and explain software flowchart, then we discuss about the implementation.

*Chapter 4: Results*

This chapter will present the archived result of the researched topic by observation and evaluation.

*Chapter 5: Conclusion and Future Work*

This chapter provides a comprehensive overview of the research objectives, scope, methods, and limitations of the study. The subsequent chapters will delve deeper into each aspect, ultimately proposing a secure and efficient FOTA implementation approach for car lighting systems.

**Chapter 2: LITERATURE REVIEW**

1. **Hardware Overview**
2. **ESP32 Overview**
3. **STM32F103C8T6 Overview**
4. **SN65HVC CAN Transceiver Overview**
5. **Oled SSD1030**
6. **Software Overview**
7. **FOTA Overview**
8. **Booting Process**
9. **UDS Standard**
10. **RTE**
11. **UART Communications Protocol**
12. **CAN Communications Protocol**
13. **FireBase Database**
14. **Software Overview**

# Chapter 3. SYSTEM DESIGN

1. **System Requirements**
2. **System Specifications**
3. **Hardware Design**
4. **Telematic unit**
5. **Gateway unit**
6. **User MCU**
7. **Software Design**

# Chapter 4: RESULTS

# Chapter 5: CONCLUSION AND RECOMMENDATIONS

* 1. **Lessons learned**
  2. **Future work**
  3. **Project Improvements**

# Preferences :