INTERNSHIP AT L&T TECHNOLOGY SERVICES

A PROJECT REPORT

Submitted by

KRISH MITESH SHAH

190950111004

In partial fulfilment for the award of the degree of

BACHELOR OF ENGINEERING

in

Electronics and communication engineering

ITM Universe, Vadodara

Gujarat Technological University, Ahmedabad

MAY,2023

ITM UNIVERSE

Vadodara, Gujarat

CERTIFICATE

This is to certify that the project report submitted along with the project entitled **Internship at L&T Technology Services** has been carried out by **Krish Mitesh Shah** under my guidance in partial fulfilment for the degree of Bachelor of Engineering in **Electronics and Communication**, 8th Semester of Gujarat Technological University, Ahmadabad during the academic year 2021-22.

18/5/23

(Prof.) Ms. Radhika Shringarpure

Internal Faculty Guide

Academic year (2022-23)

(HOD) Mr. Pradeep Chhawchharia

Head of Department (ECE)

Academic year (2022-23)

L&T Technology Services

INTERNSHIP OFFER LETTER

Ref: LTTS/HR/PT/2022-23/381 **10th February 2023**

To
Mr Krish Shah
B.Tech, ITM (sls) Baroda University

Sub- Project Training / Industrial Training / Vocational Training

Dear Krish Shah,

We are pleased to offer you internship for a period of **5 Months**. Your internship will begin on **13th February 2023** and will end on **13th July 2023**. During internship period you will not be eligible for stipend. You need to take care of accommodation and commuting.

You are requested to report at **L&T Technology Services Limited L&T Knowledge City, SEZ (IT/ITES), N.H. No. 8, Vadodara-390 019, Gujarat, India**

This internship is considered temporary and the same may be discontinued or the terms of the internship may be modified at any time for any reason not prohibited by law. Furthermore, this internship is not construed to be nor may lead to employment with us.

This internship is considered temporary, and the terms of the internship may be modified at any time for any reason not prohibited by law. Furthermore, this internship is not construed to be nor may lead to employment with us. Either party can terminate the internship by giving 21 days' notice to the other. However, the Company reserves the right to terminate the internship immediately for any reason whatsoever which may jeopardise the company's business interests. Internship completion letter will only be provided for completion of internship period.

As an intern, you will not receive any of the employee benefits that regular company employees are entitled to, including, but not limited to, health insurance, vacation or sick pay, paid holidays, or participation in the any of company's retirement plan.

During your internship, you may come across confidential business information. By accepting this internship employment offer, you acknowledge that you must adhere to the company's confidentiality and information security policy. You are responsible for the security of all information including

L&T Technology Services

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prevention of misuse of information / information processing facilities, relevant to the Company affairs and its customers of which you may be cognizant and treat as strictly confidential, in particular the drawings, quotations, specifications and other manufacturing information. You shall also be responsible for maintaining the confidentiality and prevent unauthorized dissemination, in case you are engaged by the Company in the development and use of any product including computer programs.

In addition, upon conclusion of your internship, you must return all company-owned property, equipment, and documents, including electronic mail or other information.

Further you hereby give your consent that the Company will be the legal owner of any right(s) in the Intellectual Property including Patents, Design, Copyright, Trademarks, Topography of Integrated Circuits, etc. generated as a result of your work during your tenure with the Company. By virtue of signing this document, you assign all the rights in said intellectual property to the Company. You also agree that you will cooperate in processing any relevant document related to assignment of said Intellectual Property Right during your internship or even after it in the intellectual property generated during your internship with the company."

Please sign the duplicate copy of this agreement and return it to the undersign as a token of acceptance.

Yours faithfully,

For L&T Technology Services Limited

Prakash Krishnamoorthy
Head – Leadership Hiring and Strategic Talent Initiatives

I have read the letter and accept the same. I will report for Internship at **Vadodara** on **13th February 2023.**

Full Name: - Krish Shah

Signature: - 

Date: - 10/02/2023

GUJARAT TECHNOLOGICAL UNIVERSITY

CERTIFICATE FOR COMPLETION OF ALL ACTIVITIES AT ONLINE PROJECT PORTAL

B.E. SEMESTER VIII, ACADEMIC YEAR 2022-2023

Date of certificate generation : 13 May 2023 (17:29:29)

This is to certify that, ***Shah Krish Mitesh*** (Enrolment Number - 190950111004) working on project entitled with ***Embedded Development of Traction Motor*** from ***Electronics & Communication Engineering*** department of ***INSTITUTE OF TECHNOLOGY & MANAGEMENT, UNIVERSE TECHNICAL CAMPUS,VADODARA*** had submitted following details at online project portal.

Internship Project Report	Completed

Name of Student : Shah Krish Mitesh

Name of Guide : Miss. Radhika Ninad shringarpure

Signature of Student :

*Signature of Guide : 18/5/23

Disclaimer :
This is a computer generated copy and does not indicate that your data has been evaluated. This is the receipt that GTU has received a copy of the data that you have uploaded and submitted as your project work.

*Guide has to sign the certificate, Only if all above activities has been Completed.

ITM UNIVERSE

Vadodara, Gujrat

DECLARATION

We hereby declare that the Internship report submitted along with the Internship entitled **Internship at L&T Technology Services** submitted in partial fulfilment for the degree of Bachelor of Engineering in **Electronics and Communication** to Gujarat Technological University, Ahmedabad, is a Bonafede record of original project work carried out by me at **L&T Technology Services** under the supervision of **Ms. Radhika Shringarpure** and that no part of this report has been directly copied from any students' reports or taken from any other source, without providing due reference.

Name of the Student	Sign of Student
1. Krish Mitesh Shah	----------

ACKNOWLEDGEMENT

I am indebted to several people who have helped and supported me in supporting me with their constant guidance and encouragement.

I would like to thank the Department of Electronics and Communications Engineering and the Faculty members for their support in my work. I am thankful to Mr. Pranav Mehta (Program Manager) and Mr. Himanshu Patel (Senior Delivery Manager), for their aspiration, advice, and guidance, by giving timely suggestions throughout the tenure of my work. I would also like to thank Mr. Ravinder Kalsi (Tech lead) for supporting me in developing on power electronics domain.

I would like to extend my sincere thanks to L&T Technology Services Pvt. Ltd., who provided me with the opportunity to conduct my project work in their esteemed organization.

Krish shah

(190950111004)

ABSTRACT

L&T Technology services is a service based MNC which focuses on e-R&D. It designs and patents latest products and technologies. I was placed in Trucks and Off-Highway department where SOLIS was developing a new electric vehicle. This was the first EV vehicle being developed by SOLIS, and before this product the company outsourced all the components and subsystems and integrated them into their requirements to develop a vehicle.

But instead of sourcing the systems from outside the company was developing the vehicle in-house. Initially I got familiar with the latest EV systems and designs and communication protocols currently being developed all over the world. I was told to focus on CAN communication protocol used in the vehicles. Then I was placed in Embedded Test Lab where I got first-hand experience on how the communication protocol worked.

I acquired hard skills related to CAN protocol which included CAN protocol in Arduino IDE and Vector CANalyzer software and deep knowledge on higher level CAN protocols such as J1939 & CANopen. I also had to look for wiring protocols and making cross-compatible connectors for different systems. I also enhanced some soft skills such as project planning and management, getting support efficiently by making good problem statements and generating results reports.

At first, I got familiar with CAN protocol and how the frames work using microcontrollers like Arduino then I was given a rotary sensor based two-way foot paddle, a CAN based motor controller and a differential BLDC motor-based e-axel which all worked on CAN protocol, and I was given tasks to develop and test them. Finally gave a demonstration for the developed designs.

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Abbreviations

CAN - Control Area Network

EV – Electric Vehicle

LTTS – L&T Technology Services

HIL – Hardware in Loop

VCU – Vehicular Control Unit

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CHAPTER 1
OVERVIEW OF THE COMPANY

L&T Technology Services Limited (LTTS) is a global leader in Engineering and R&D (ER&D) services. With 1033 patents filed for fifty-seven of the Global Top 100 ER&D spenders, LTTS lives and breathes engineering. Our innovations speak for themselves – World's 1st Autonomous Welding Robot, Solar 'Connectivity' Drone, and the Smartest Campus in the World, to name a few.

LTTS' expertise in engineering design, product development, smart manufacturing, and digitalization touches every area of human lives - from the moment one wakes up till the time one goes to bed. With 110 Innovation and R&D design centers globally, we specialize in disruptive technology spaces such as 5G, Artificial Intelligence, Collaborative Robots, Digital Factory, and Autonomous Transport.

LTTS is a publicly listed subsidiary of Larsen & Toubro Limited, the $21 billion Indian conglomerate operating in over thirty countries.

1.1 HISTORY

L&T Technology Services (LTTS) was founded in 2006 as L&T Integrated Engineering Services. In its first year, the company generated $70 million in revenue. Initially, it only operated as the engineering arm of the L&T and in 2013, because of the L&T's strategy, the parent company was split into "nine verticals and six subsidiaries", of which this was one. It began to expand its engineering services as a developer of corporate software under a new brand name L&T Technology Services (LTTS).

In September 2016, LTTS had its initial public offering in the National Stock Exchange, making it the second L&T subsidiary to go public. In 2016, LTTS developed a set of personal safety gear that is based on cloud-enabled technologies. The system includes a set of "helmets, gloves, jackets and shoes that have sensors capturing [the wearers] performance and sending it to a centralized database on the cloud."

In March 2017, it opened a centre of excellence in Munich, Germany. In June 2017, LTTS completed the acquisition of the Esencia, a San Jose, California-based engineering firm involved in development of "wireless connectivity solutions, perceptual computing, Internet of Things and advanced silicon products" for $27 million. In July, the company was upgraded to Group A of the Bombay Stock Exchange.

In May 2022, the company opened an engineering, research, and development (ER&D) centre in Krakow, Poland. In June 2022, LTTS set up an engineering design centre in Toulouse, France.

In January 2023, LTTS announced that it would acquire parent Larsen & Toubro's "Smart World & Communication" business segment, which has interests in communication networks, cybersecurity, and smart spaces, for ₹800 crore.

1.2 DIFFERENT PRODUCTS

The company's business interests include:

- Communication
- Consumer Electronics
- Healthcare
- Industrial Products
- Media & Entertainment
- Oil & Gas
- Plant Engineering
- Public Infrastructure & Smart Cities
- Semiconductors
- Software Products
- Transportation

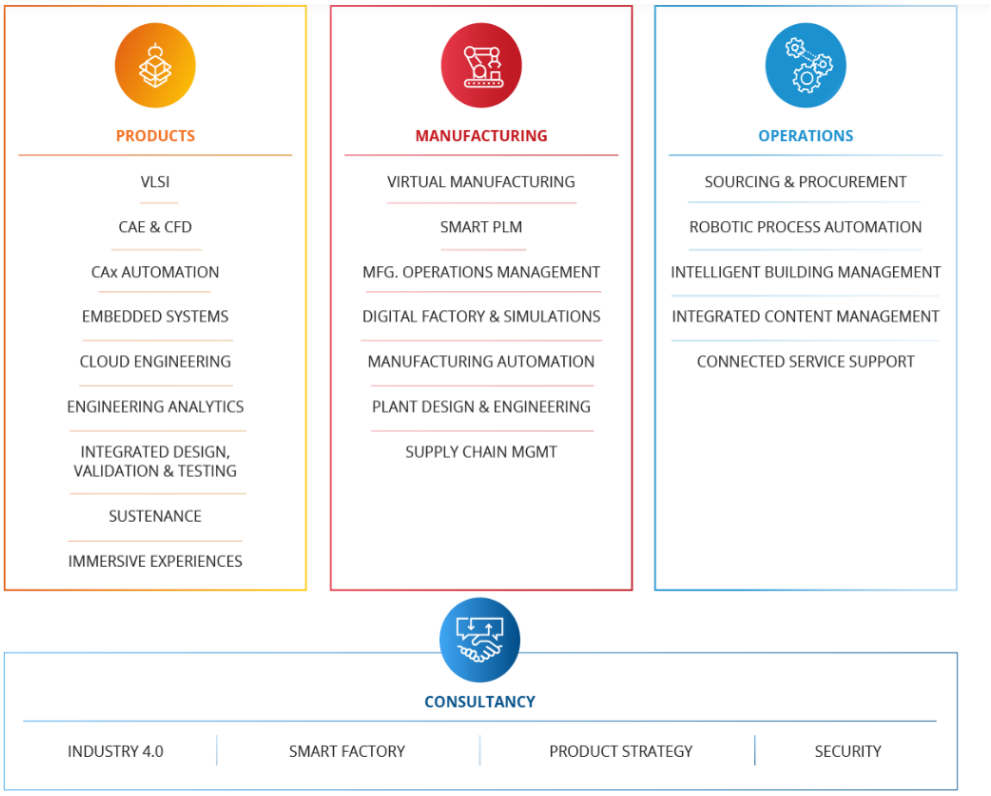


Figure 1.1 Different Products Offered By LTTS

1.3 ORGANIZATION CHART

LTTS' has multi-sectoral presence and domain expertise enables cross-pollination of ideas and best practices leading to differentiated engineering solutions.

The Company's robust horizontal technology practice comprising of Embedded Systems, Mechanical Engineering and Digital Manufacturing Group, which together provide design and development solutions across the entire value chain of product development. And facilitate LTTS' go-to-market strategy.

Embedded Systems & Applications: The company helps customers to engineer and launch ingenious innovations to the market with its exhaustive portfolio of solutions in embedded design, application software and field testing.

Mechanical Engineering: Technology dependent OEMs, ODMs, and Tier-1 & Tier-2 suppliers rely on its mechanical engineering services for driving business success. It brings efficiency & innovation to customer's product design and development strategies.

Digital Manufacturing Group: Its integrated smart manufacturing services facilitate real time visibility of plant operations along with timely insights. This leads to leaner and faster processes, quicker and informed decision-making, better quality products and improved plant safety.

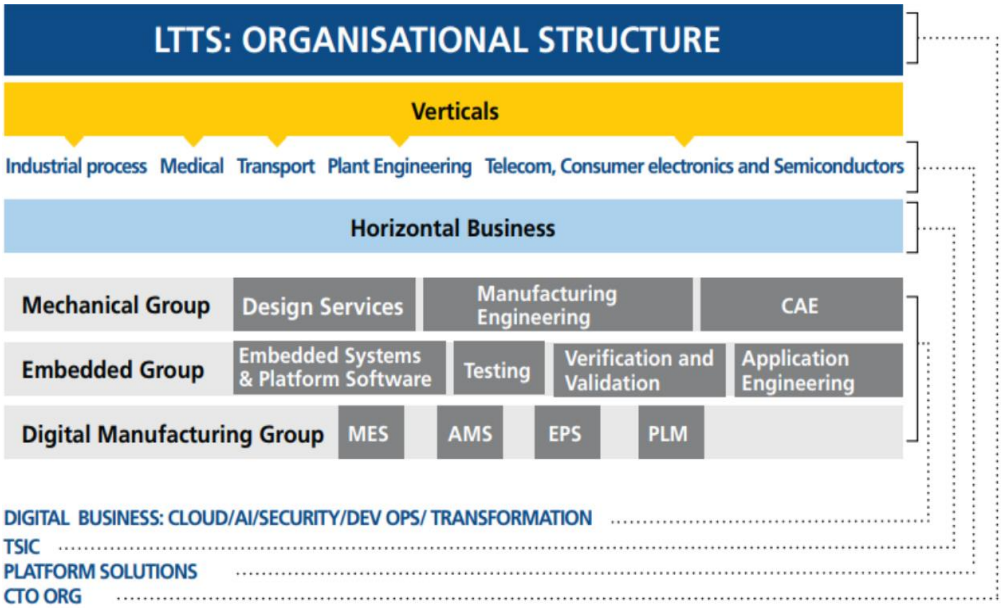


Figure 1.2 Organisational Structure

CHAPTER 2

GETTING FAMILIAR WITH MY DEPARTMENT

TRUCKS & OFF HIGHWAY VEHICLES

Fast-growing urbanization and globalization of the economy have had a major influence on Truck and Off-highway segments and other industries. Manufacturers are adopting new-age technologies, enhancing customer experience, and improving business processes to meet the increased demand for:

- Fleet management system
- Improved equipment utilization
- Higher fleet efficiency
- Electrification
- Alternate fuel powertrain
- Autonomous drive
- Autonomous operations and
- Telematics

At L&T Technology Services (LTTS), they combine rich domain expertise and decades of experience working with some of the leading brands in the Trucks & Off-highway segment to address every customer's requirement.

Their state-of-the-art innovation lab and infrastructure such as Power Electronics, Tear Down, and Smart Manufacturing labs and investing in new-age technologies have positioned them uniquely to address complex business challenges across industries and enable their customers to enhance their business performance indicators.

Figure 2.1 Department's Functional Areas

2.1 DEPARTMENT SPECIALIZATION

The Trucks and Off-Highway department holds specialization in these following fields:

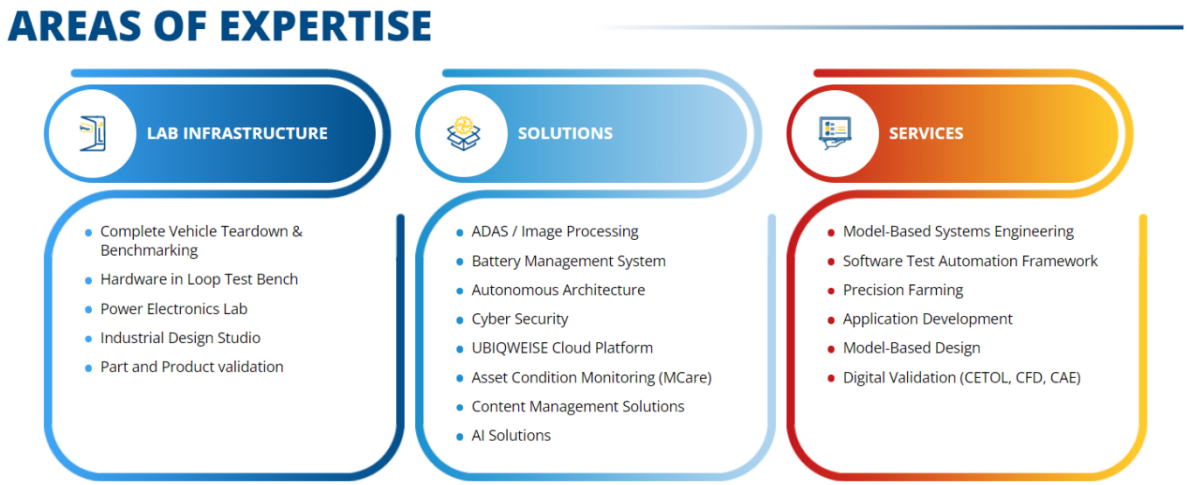


Figure 2.2 Area of Expertise

LAB INFRASTRUCTURE is responsible for researching and testing new technologies which currently being developed in the department. It has following processes covered under it:

- Complete Vehicle Teardown & Benchmarking - Teardown Benchmarking is a key for understanding the strategy of design, material usage, manufacturing, and complicity comparison of your existing product, etc.

- Hardware in Loop Test Bench - Hardware-in-the-loop (HIL) refers to a method of testing and validating complex software systems on specially equipped test benches that receive data inputs from physical devices such as radars and cameras.

- Power Electronics Lab - It helps demonstrate various electronic power concepts, including power semiconductor devices, DC to DC conversion, and AC to DC conversion.

- Industrial Design Studio - Industrial designers develop aspects of a product that create emotional connections with the user. They integrate all aspects of form, fit and function, optimising them to create the best possible user experience.

- Part and Product validation - Validation ensures that all the processes follow the established CGMP standards. Any validation process requires complete documentation that complies with standard operating procedures and ongoing operations.

SOLUTIONS offer efficient ways to solve problems and provide security to the industry. It offers following solutions to the industry:

- ADAS / Image Processing - ADAS Image processing algorithms can be used for identifying the presence of other vehicles, their speed, and direction from the image frames data taken from the front, rear, and sides of the vehicle to help the driver in deciding for proper lane transfer.

- Battery Management System - A BMS monitors the temperatures across the pack, and open and closes various valves to maintain the temperature of the overall battery within a narrow temperature range to ensure optimal battery performance.

- Autonomous Architecture - Autonomous architecture strives to construct and maintain liberatory dynamics outside the dominant culture of mass production, fashion, and class domination.

- Cyber Security - Cybersecurity is crucial because it safeguards all types of data against theft and loss.

- UBIQWEISE Cloud Platform - A secure gateway to connect all your IoT devices & data, on any network, cloud platform, or protocol.

- Asset Condition Monitoring (MCare) - Asset condition monitoring plays a key role in predictive and preventive maintenance.

- Content Management Solutions - It allows non-technical people to publish content. This dramatically cuts the cost of maintaining a website.

- AI Solutions - AI is widely used in data-heavy industries, including banking and securities, pharma, and insurance, to reduce the time it takes to analyse big data sets.

SERVICES are useful for supporting a product with additional technologies which enhances the efficiency of the product and helps to maintain them after they are developed. It offers followings services to the industry:

- Model-Based Systems Engineering
- Software Test Automation Framework
- Precision Farming
- Application Development
- Model-Based Design
- Digital Validation (CETOL, CFD, CAE)

2.2 MY DOMAIN

EMBEDDED SYSTEMS

LTTS is specialized in delivering next-generation embedded software and systems engineering solutions that help OEMs and Tier1s in Trucks and Off-highway industries overcome the business challenges they face. Our end-to-end expertise on complex embedded electronics products and our systematic approach in designing embedded software and electronics helps accelerate time-to-market and ensure a superior quality product.

Figure 2.3 Offerings in my Domain

I was placed in Embedded test lab where I was responsible for Hardware Development and Testing and System Testing. There I performed tasks which included Schematic designing and layout, Hardware analysis, Hardware-in-loop testing, Hardware & Software integration, On-Table Development & Optimization.

CHAPTER 3

INTRODUCTION TO INTERNSHIP

3.1 SUMMARY

My mentor during the internship quoted “Embedded development is a game of patience because nothing in embedded development works in the first trial, and if it works it’s bad as you won’t learn anything from it”.

I started with studying electronics in EVs and then began experimenting CAN communication on microcontrollers such as Arduino. I learnt tools such as Vector Analyzer and gained knowledge on higher level CAN protocols such as J1939 & CANopen.

I also learnt about number of other things which I came across in development of the system such as BLDC motors, Motor controllers, automotive engineering, etc. Overall, this was a great exposure to explore the emerging technologies in automotive industry and learn from the brightest and brilliant minds in LTTS.

3.2 PURPOSE

The purpose of embedded development in the automotive industry is to create safe, reliable, and efficient vehicles that meet the needs and expectations of drivers and passengers. Embedded systems in vehicles are responsible for controlling critical functions, such as engine performance, braking, and stability control, and are essential for ensuring the safety and performance of the vehicle.

Embedded development in the automotive industry also involves developing software and firmware that can be updated over the air, allowing manufacturers to improve the

functionality and performance of vehicles over time, as well as fix any bugs or security vulnerabilities.

Overall, the purpose of embedded development in the automotive industry is to create advanced, reliable, and safe vehicles that provide drivers and passengers with an exceptional driving experience.

3.3 OBJECTIVE

The objective of developing a CAN-based traction motor for an EV lawn mower is to create a more efficient and reliable propulsion system that enhances the overall performance of the mower.

Specifically, the objectives may include:

- To improve the responsiveness and accuracy of the motor control system using CAN bus communication, resulting in better acceleration, speed control, and energy efficiency.

- To reduce the weight and size of the traction motor and associated components, thereby increasing the manoeuvrability and ease of use of the lawn mower.

- To enhance the safety of the lawn mower through the integration of advanced safety features, such as overcurrent protection, thermal protection, and fault detection.

- To increase the overall durability and lifespan of the traction motor and other components with high-quality materials and robust design principles.

- To enable remote monitoring and control of the lawn mower through the integration of CAN bus communication, providing owners and operators with greater flexibility and convenience.

By achieving these objectives, the development of a CAN-based traction motor for an EV lawn mower can lead to a more efficient, reliable, and user-friendly propulsion system that delivers exceptional performance and enhances the overall value of the product.

3.3 SCOPE

The following are the key aspects of the project scope:

What it can do:

- Develop a CAN-based traction motor system for lawn mowers that meets the specified power and performance requirements.
- Design and test the hardware and software components of the system to ensure that they work together effectively.
- Integrate the motor system with the lawn mower's control system and ensure compatibility.
- Ensure that the system is safe and reliable for use in lawn mowers.

What it cannot do:

- Develop a completely new lawn mower model or modify existing models beyond the integration of the motor system.
- Guarantee compatibility with all types of lawn mowers or other types of equipment.
- Modify or replace existing components of the lawn mower that are not related to the motor system.
- Address non-engineering aspects such as marketing, sales, or distribution.

In summary, the project scope for developing a CAN-based traction motor for lawn mowers is focused on developing a motor system that can be integrated into existing lawn mower models and meet the specified power and performance requirements. The scope is limited to the engineering aspects of the project and does not extend to other areas such as marketing, sales, or distribution.

3.5 INTERNSHIP PLANNING

3.5.1 Internship Development Approach

Understanding the requirements: The first step in developing a CAN based traction motor for lawn mowers would be to understand the requirements of the system. This would include determining the size and weight of the lawn mower, the type of terrain it will be used on, and the power requirements of the motor.

Selecting the components: Once the requirements have been determined, the next step would be to select the components for the system. This would include selecting the motor, the CAN bus controller, and any other necessary components.

Developing the hardware: The next step would be to develop the hardware for the system. This would involve designing the circuit board, selecting the appropriate connectors, and assembling the components.

Writing the software: Once the hardware has been developed, the software for the system would need to be written. This would involve writing code for the microcontroller that controls the motor, as well as the code for the CAN bus controller.

Testing and validation: After the software has been written, the system would need to be tested and validated to ensure that it meets the requirements. This would involve testing the motor under different load conditions and on different terrains to ensure that it performs as expected.

Integration with the lawn mower: Once the system has been validated, it would need to be integrated with the lawn mower. This would involve designing a mounting system for the motor, as well as integrating the software with the lawn mower's control system.

Manufacturing and production: Finally, once the system has been integrated with the lawn mower, it would be ready for manufacturing and production. This would involve producing the hardware components in large quantities and assembling them into the final product.

3.5.2 Internship Time and Effort

I had on-site internship at L&T Technology services, and it was a 5-day week, i.e., Monday-Friday. Each day I had to complete 9.5 hours of shift time once I punch-in at morning. I remained as regular as possible during my tenure of internship.

3.6 ROLES AND RESPONSIBITIES

As an embedded development intern at LTTS, for developing a CAN based traction motor for lawn mowers, your roles and responsibilities included:

- Conducting research and providing recommendations for the selection of appropriate components and materials.
- Testing and validation of the motor system to ensure it meets the required performance and safety standards.
- Collaborating with the team to integrate the motor system with the lawn mower's control system.
- Providing regular updates on project progress and identifying any issues or challenges that arise.
- Participating in team meetings and contributing to project discussions and decision-making processes.
- Assisting in the preparation of technical reports and documentation related to the project.
- Ensuring that work is completed in accordance with project timelines and budget constraints.
- Adhering to all safety procedures and protocols.

- Continuously seeking to learn and expand your knowledge of electric motor systems and related technologies.

Overall, as an intern for developing a CAN based traction motor for lawn mowers, my primary responsibility was to contribute to the project team and assist in achieving the project goals in a timely and effective manner. I was expected to learn and apply my knowledge and skills for development of a safe and reliable motor system that meets the specified performance requirements.

3.7 INTERNSHIP SCHEDULING (Table 3.1)

Week	Activities	Details
1	• Introduction & Orientation	• Onboarding, formalities, meeting with IS. • Workstation allotment, getting familiar with the department's work and scope. • Meeting with senior employees and know about electronics in Electric Vehicles. • Study block diagram of structure of electronics in Electric vehicles such as lawn mowers. • Review and orientation
2	• Study and research	• Study on Vehicle's ECU (Electronic control unit). • Study on EV's VCU (Vehicular control unit). • Study on Communication protocols in EVs. • Study on CAN (controlled area network). • Study on CAN protocol applications in EVs.
3	• Began hands-on experiments	• Shifted to Embedded Test Lab and setting up lab for projects. • Study on CAN protocols using Arduinos. • Online simulation on tinker-cad. • Making the interface of CAN backbone on

		breadboard and study on MCP2515 CAN transceiver. • Implementing and testing by sending CAN frames.
4	• Study on CAN	• Study on CAN based sensors. • Started to work on CAN based rotary sensor foot paddle. • Study of manual of the sensor and preparing project plan and tasks. • Making connectors and interfacing the sensor on the CAN backbone.

5	• Learning Vector CANalyzer	• Getting familiar with Vector CANalyzer. • Learning software (Vector CANalyzer) – BASICS 1. • Learning software (Vector CANalyzer) – BASICS 2. • Learning software (Vector CANalyzer) – DATABASE FORMATION AND USE. • Learning software (Vector CANalyzer) – SETUP & CONFIGURATION.
6	• Enhancing knowledge on CAN	• Learning software (Vector CANalyzer) – FRAME IMPLEMENTATION. • Learning software (Vector CANalyzer) – TEST SIMULATION USING TWO VIRTUAL CAHNNELS. • Study on J1939 higher-level protocol. • Study on CANopen protocol. • Study on CANopen protocol instructions in rotary sensor-based foot paddle manual.
7	• Paddle sensor development	• Making D SUB9 - Paddle sensor connector. • Implementing CANopen frames using request-response method. • Debugging for error frames and changing the interface of

		CAN backbone to PCB based interface. • Debugging for error frames. • Acquisition and interpretation of CAN data.
8	• Motor controller study and start of development	• Documentation and generation of report for results. • Study on motor controllers. • Study on CAN based BLDCs (brushless DC motor controllers) • Began to work on CAN based motor controller. • Power up sequence and matching the power requirements.

9	• Development and configuration of motor controller	• Study of instruction manual of motor controller. • Configuration of test mode in motor controller using external handheld LCD programmer. • Debugging in test mode. • CAN communication link successfully have established. • Documentation and generation of report for communication procedure.
10	• Started to develop E-axel	• Study brushless motors and E-axel motors. • Received E-axel motor and studied motor documentations. • Making of required Deutsch 8 pin connector and interfacing the motor with controller's CAN communication link. • Configuring the motor setting using the external handheld LCD programmer. • Debugging of errors in controllers.
		•Implementing the frames on the controller and receiving errors and wrong TPDO assignments. •Finding out power bench is incapable of

11	• Debugging and Demonstration	supplying sufficient current despite of series voltage supply. •Changing operating voltage mode to 24VDC & debugging for errors in physical layer. •Successful in debugging and commands getting accepted. •Mapping and interpretation of errors and demonstration of the system to the team
12	• Documentation and Review	• Documentation of the development • Additional study on CANopen and Review

CHAPTER 4

SYSTEM ANALYSIS

4.1 STUDY OF THE CURRENT SYSTEM

MODBUS and Analog communication are two common types of communication protocols used in Electric Vehicles (EVs).

MODBUS is a serial communication protocol used for transmitting information between electronic devices. In EVs, MODBUS is often used for communication between different subsystems such as the battery management system and the motor controller. The protocol allows for reliable and efficient communication between subsystems, enabling better control and management of the vehicle. MODBUS is also highly flexible and can be used with a wide range of devices and systems, making it a popular choice in EVs.

Analog communication, on the other hand, uses continuous signals to transmit information between devices. In EVs, Analog communication is used for communication between sensors and control systems. Analog signals can be used to measure various parameters such as temperature, pressure, and current, allowing for more precise control and management of the vehicle's subsystems.

Both MODBUS and Analog communication have advantages and disadvantages in EVs. MODBUS is highly reliable and efficient but requires more complex hardware and software components to implement. Analog communication is simpler and less expensive but is less precise and can be more susceptible to noise and interference.

In summary, both MODBUS and Analog communication are important communication protocols used in EVs. MODBUS is typically used for communication between subsystems, while Analog communication is used for sensor and control system communication. The choice of protocol depends on the specific application and requirements of the EV system.

4.2 PROBLEM AND WEEKNESS OF CURRENT SYSTEM

While MODBUS and Analog communication are widely used in Electric Vehicles (EVs), they are not without their problems and weaknesses.

Some of the potential problems and weaknesses of these communication protocols in EVs include:

- Limited bandwidth: Both MODBUS and Analog communication have limited bandwidth, which can impact the speed and efficiency of communication between devices.

- Vulnerability to noise and interference: Analog communication is more susceptible to noise and interference from other electronic devices, which can impact the accuracy and reliability of sensor readings. MODBUS is also vulnerable to noise and interference, which can cause errors in communication between devices.

- Complexity: The implementation of MODBUS can be complex, requiring specialized hardware and software components, and in some cases, custom programming. Analog communication is generally simpler but may require calibration and periodic maintenance to ensure accuracy.

- Compatibility: MODBUS may not be compatible with some older devices and systems, which can limit its usefulness in certain applications. Analog communication also has limitations in terms of the range of signals that can be transmitted.

- Security: Both MODBUS and Analog communication are vulnerable to security threats such as data breaches and hacking, which can compromise the safety and security of the EV.

- Integration with newer technologies: As newer technologies such as Ethernet and wireless communication protocols become more prevalent in EVs, the relevance and usefulness of MODBUS and Analog communication may diminish over time.

In summary, while MODBUS and Analog communication are useful communication protocols in EVs, they have potential weaknesses and limitations that must be considered when designing and implementing EV systems. These weaknesses and limitations may require additional design considerations and safety measures to ensure that the EV system is safe, reliable, and efficient.

4.3 REQUIREMENTS OF THE NEW SYSTEM

While Modbus and Analog communication protocols have been widely used in the past, they are becoming less popular in modern Electric Vehicles (EVs) and other advanced automotive systems. There are several reasons for this:

- Limitations: Modbus and Analog communication protocols have several limitations, such as slower data transfer rates, limited scalability, and reduced reliability compared to modern communication protocols like CAN.

- Incompatibility: Modbus and Analog communication protocols are not always compatible with the latest automotive components and subsystems, which can limit their usefulness in modern EVs.

- Complexity: Analog communication can require additional components and wiring, which can increase system complexity and reduce overall efficiency.

- Interference: Analog signals are more susceptible to electromagnetic interference, which can reduce their reliability and accuracy.

- Standardization: Unlike CAN, Modbus and Analog communication protocols are not widely standardized, which can make it difficult for different components to communicate with each other.

Overall, the limitations, incompatibility, complexity, interference, and lack of standardization of Modbus and Analog communication protocols make them less attractive options for use in modern EVs and other advanced automotive systems. Instead, modern communication protocols like CAN are becoming more popular due to their

higher reliability, faster data transfer rates, greater scalability, and greater compatibility with modern automotive components and subsystems.

4.4 PROPOSED SYSTEM

Controller Area Network (CAN) is a communication protocol that is commonly used in the automotive industry for communication between different electronic control units (ECUs) within a vehicle. It was originally developed by Robert Bosch GmbH in the 1980s and has since become an international standard (ISO 11898).

CAN is a serial communication protocol that enables communication between devices over a twisted-pair cable or a differential bus. It is a message-based protocol, which means that data is transmitted in packets or messages. Each message consists of an identifier, which indicates the message's priority and content, and the actual data or payload.

One of the key features of CAN is its high reliability. It includes a built-in error detection and correction mechanism that enables it to detect errors and recover from them automatically. This is particularly important in automotive applications, where communication between different subsystems must be highly reliable.

CAN also supports high-speed communication, with data transfer rates of up to 1 Mbps. This makes it well-suited for use in applications that require fast and efficient communication, such as EVs and other advanced automotive systems.

Another advantage of CAN is its scalability. It can be used in a wide range of different applications, from simple battery monitoring systems to complex motor control systems. It can also be used in vehicles of different sizes and complexity, which makes it a popular choice in the automotive industry.

Overall, CAN is a reliable, high-speed, and scalable communication protocol that is widely used in the automotive industry. Its built-in error detection and correction mechanisms, high data transfer rates, and flexibility make it a popular choice for communication between different electronic control units within a vehicle.

4.5 FEATURES OF NEW SYSTEM

CAN (Controller Area Network) is a communication protocol that is commonly used in Electric Vehicles (EVs) for communication between different subsystems, such as the battery management system and the motor controller. There are several advantages of using CAN in the scenario of developing a CAN-based traction motor for lawn mowers:

- High reliability: CAN is a highly reliable communication protocol, which ensures that data is transmitted accurately and efficiently between different subsystems. This is critical in EVs, where safe and reliable operation is paramount.

- High speed: CAN is capable of high-speed communication between devices, which enables fast and efficient control and management of EV subsystems. This allows for faster response times and better control over the vehicle.

- Flexibility: CAN is highly flexible and can be used with a wide range of devices and systems, making it a popular choice in EVs. It also supports a variety of different communication modes, such as broadcast and multicast, which makes it easier to integrate different subsystems.

- Scalability: CAN is highly scalable, which means that it can be used in EVs of different sizes and complexity. It can also be used to support a wide range of different applications, from simple battery monitoring systems to complex motor control systems.

- Cost-effective: CAN is a cost-effective communication protocol, which makes it an attractive option for use in EVs. It requires relatively simple hardware and software components, which can help to reduce the overall cost of EV development.

In summary, the advantages of using CAN in the scenario of developing a CAN-based traction motor for lawn mowers include high reliability, high speed, flexibility, scalability, and cost-effectiveness. These advantages make CAN a popular choice for communication between different subsystems in EVs and ensure that the vehicle operates safely and efficiently.

4.6 SELECTION OF THE HARDWARE

CAN protocol is widely used in modern Electric Vehicles (EVs) for communication between different electronic control units (ECUs). This includes CAN-compatible sensors, which can provide important data on factors like temperature, speed, and pressure to other ECUs in the vehicle. CAN-based motor controllers are also used to manage the speed and direction of electric motors in the vehicle, while CAN-based smart motors can provide advanced features like torque and position control. These different components can communicate with each other over the CAN bus, enabling more efficient and effective management of the vehicle's various systems. Overall, the use of CAN-compatible sensors, motor controllers, and smart motors is becoming increasingly important in modern EVs, as it enables more reliable and efficient communication between different subsystems within the vehicle.

CAHPTER 5

SYSTEM DESIGN

5.1 SYSTEM DESIGN & METHODOLOGY

System design and methodology are critical components of developing a traction motor for any application, including lawn mowers. Developing a new traction motor requires a comprehensive understanding of the application requirements, system specifications, and design parameters.

I was provided with compatible and pre-tuned components which made developing and testing them an easy task. The instruction manual and CAN details of components were most crucial during individual development and testing.

The instruction manual provided with the components had all the information required such as wiring diagrams, connectors description, operating parameters like voltage and current, etc. The system was on-bench design, so no structure design was needed for development.

5.2 CIRCUIT DESIGN

In starting stages of learning CAN, I made various configurations of CAN bus on breadboard using MCP2515 and Arduino.

During development, mostly all the components were functional and working but on the other hand I was also constantly working on better interface and for that I made the CAN backbone on PCB for ending suspicions of lose connection on breadboard.

While interfacing the motor and the controller there was a mismatch in the number of PINS given for Hall sensor as there were 4 pins for 3 phase hall sensors, but the motor had only 3 output pins. To solve the problem, I had to test the 4^{th} PIN using a test circuit consisting of pull-down resistors to identify the active PIN while I manually rotated the axel shaft.

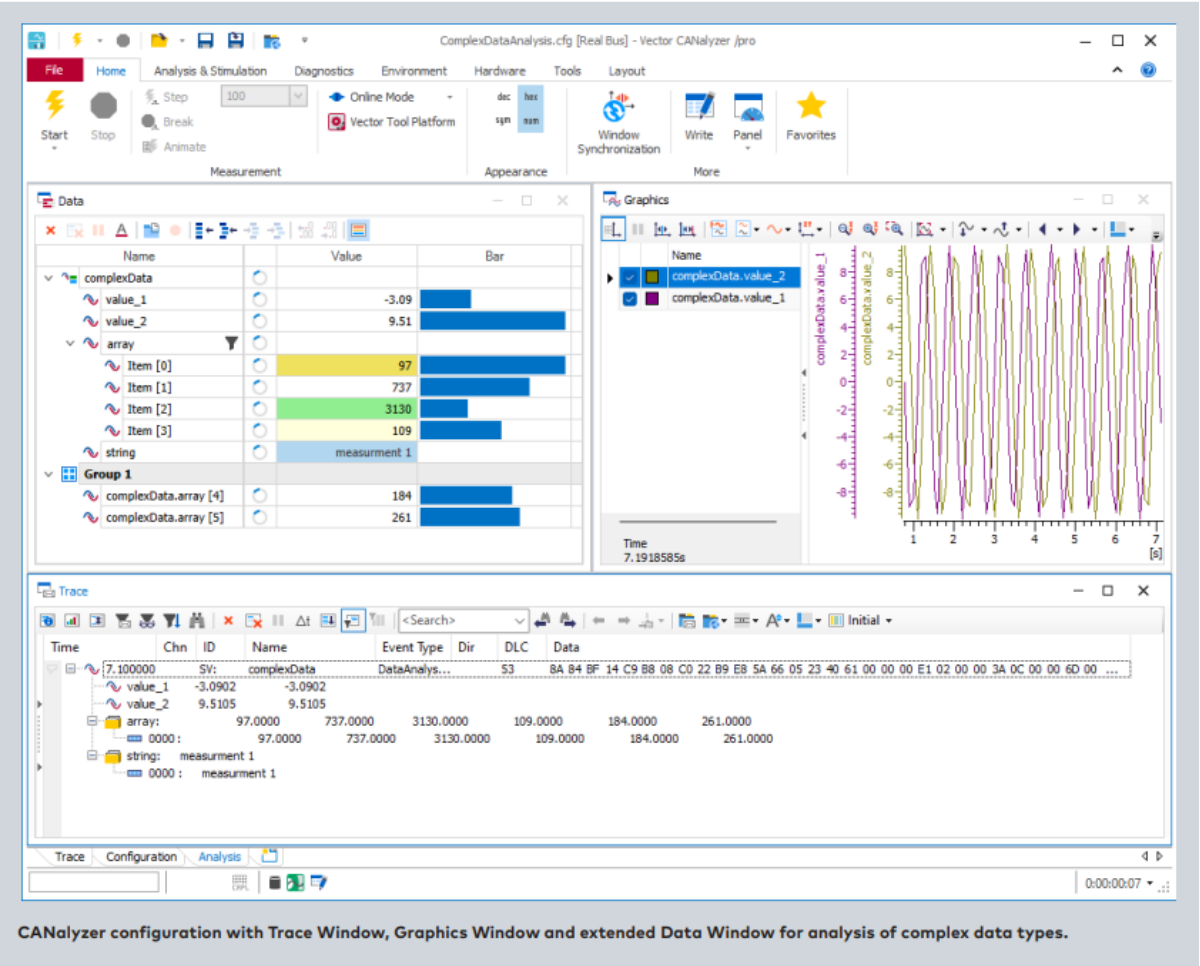
I had to debug the physical faults in the motor, to do that I made Analog interface for the motor controller using an empty cardboard box as controller panel on which I embedded Analog peripherals like switches, potentiometers, and push buttons.

5.3 INPUT / OUTPUT INTERFACE

In developing the CAN-based traction motor for lawn mowers, I utilized the Vector CANalyzer tool for the input/output interface. The Vector CANalyzer is a powerful software tool used for analysing, simulating, and testing CAN networks, and it provides a range of capabilities for designing and testing CAN-based systems.

By using CANalyzer, I was able to monitor and analyse the data communication between the different components of the motor system, including the CAN-based sensors, motor controller, and smart motor. I could also simulate and test different scenarios to evaluate the motor's performance and identify any potential issues.

The Vector CANalyzer tool provided me with a user-friendly interface for monitoring and analysing the CAN bus communication. The tool enabled me to capture and visualize the CAN messages, filter, and sort data, and analyse the network's behaviour. The tool also allowed me to simulate and test different scenarios to evaluate the motor's performance under different conditions.



CANalyzer configuration with Trace Window, Graphics Window and extended Data Window for analysis of complex data types.

Figure 5.1 Vector CANalyzer Interface

CHAPTER 6

IMPLEMENTATION

6.1 IMPLEMENTATION PLATFORM

The implementation platform for the CAN-based traction motor system for lawn mowers can be achieved using various hardware and software tools.

Some of the commonly used tools for developing and implementing CAN-based systems include:

Microcontrollers: Microcontrollers are small, integrated circuits that can be programmed to control and monitor the system's components. They are commonly used in developing CAN-based systems because they are low-cost, efficient, and have the capability to interface with a wide range of sensors and actuators.

Development kits: Development kits provide an all-in-one solution for developing and testing CAN-based systems. They typically include a microcontroller board, software development tools, and CAN communication hardware, making it easy to prototype and test the system.

CAN Bus Analyzers: CAN bus analyzers are hardware devices used for analyzing and testing the CAN bus communication. They can be used for monitoring the traffic on the bus, identifying errors, and evaluating the system's performance.

Simulation tools: Simulation tools such as MATLAB Simulink and PSpice can be used for developing and testing the system's control algorithms and evaluating the motor's performance under different conditions.

Programming languages: Programming languages such as C, C++, and Python can be used for developing the control software and interfacing with the CAN bus hardware.

The implementation platform for the CAN-based traction motor system can be achieved using a combination of hardware and software tools. The choice of tools depends on the system's requirements, design specifications, and the development team's expertise.

By carefully selecting and integrating the right tools, it is possible to develop a reliable and efficient CAN-based traction motor system for lawn mowers and other applications.

6.2 PROCESS

Embedded development is the process of designing and developing software and hardware systems that are embedded in electronic devices. It involves developing software that controls the device's hardware, enabling it to perform specific tasks. The process of embedded development can be broken down into several stages, including:

- Requirements gathering: This stage involves identifying the device's functional and non-functional requirements, including the hardware components, input/output requirements, and user interface.

- System design: Based on the requirements gathered, the system's architecture is designed, including the hardware and software components, algorithms, and data structures.

- Hardware development: The hardware development involves designing and implementing the electronic circuitry, including the microcontroller, sensors, and actuators.

- Software development: The software development involves designing and implementing the software that will control the hardware, including device drivers, firmware, and application software.

- Integration and testing: In this stage, the hardware and software components are integrated, and the system is tested to ensure that it meets the design requirements.

- Deployment: After successful testing, the device is deployed to the market or used in the intended application.

- Maintenance and updates: After deployment, the system requires maintenance and updates to ensure continued functionality and compatibility with the latest technology.

The process of embedded development requires a team of engineers with expertise in different areas, including hardware design, software development, testing, and project management. The development team must work together to ensure that the system meets the design requirements, is reliable and efficient, and meets the user's needs. By following a structured development process, it is possible to develop high-quality embedded systems that are reliable, efficient, and meet the intended application's requirements.

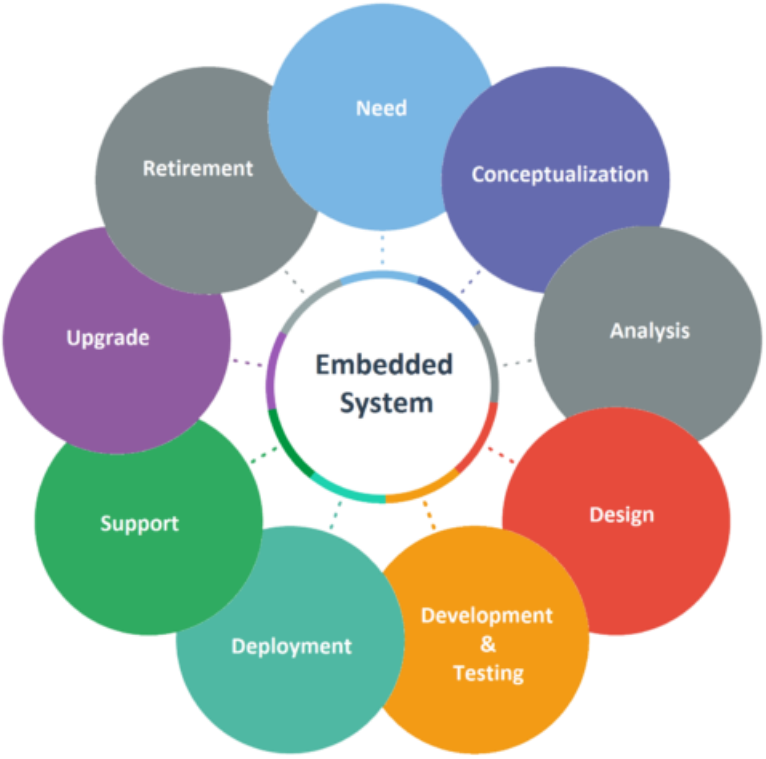


Figure 6.1 Embedded Systems Development Process

6.3 RESULTS

Using my knowledge and skills in CANopen and embedded systems, I was able to design the hardware components of the traction motor system, including the microcontroller, sensors, and actuators. I carefully selected the hardware components to meet the design requirements and ensure maximum efficiency and reliability.

To ensure that the system operated effectively, I used Vector CANalyzer to analyze the input/output interface and to test the system's communication efficiency. Vector CANalyzer provided detailed analysis of the system's communication and helped to identify any issues or inefficiencies in the system. I used the feedback from the Vector CANalyzer testing to optimize the system and to ensure that it met the design requirements.

In addition to the hardware development and Vector CANalyzer testing, I also worked with the project team to implement the software for the traction motor system. While I did not design the software, my knowledge and expertise in embedded systems allowed me to provide valuable input during the software development phase. I worked closely with the software developers to ensure that the software was optimized for the hardware and that it met the design requirements.

Through my dedication and expertise in CANopen, Vector CANalyzer, and embedded systems, I was able to deliver a high-quality product that met the expectations of the project team. The traction motor system operated effectively and efficiently, thanks to the careful design of the hardware components and the thorough testing and analysis using Vector CANalyzer.

CHAPTER 7

TESTING

7.1 TEST PLANNING

A test plan for testing a CAN-based system include the following steps:

Test the system's communication: Using Vector CANalyzer, test the system's communication efficiency and accuracy. Check if the messages are being transmitted and received accurately and if there is any delay in communication. Identify any issues in the communication and optimize it for maximum efficiency.

- Test the system's functionality: Test the system's functionality by simulating various scenarios and test cases. Check if the system is responding appropriately to different input signals and if the output signals are being generated accurately.

- Test the system's safety: Test the system's safety features by simulating various safety scenarios. Check if the safety features are activated when required and if the system is capable of responding quickly to safety issues.

- Test the system's performance: Test the system's performance by simulating different operating conditions and loads. Check if the system is capable of handling different loads and operating conditions without any issues.

- Test the system's reliability: Test the system's reliability by running different test cases over a period of time. Check if the system is reliable and consistent in its performance over an extended period.

- Test the system's integration: Test the system's integration with other systems and components. Check if the system can communicate effectively with other systems and if there are any issues with integration.

- Test the system's compliance: Test the system's compliance with industry standards and regulations. Check if the system is compliant with all the relevant industry standards and regulations.

By following a comprehensive test plan like the one outlined above, the CAN-based system can be thoroughly tested and validated, ensuring that it operates effectively, safely, and reliably.

CHAPTER 8

CONCLUSION

8.1 OVERALL ANALYSIS OF THE INTERNSHIP

During my internship, I had the opportunity to develop a CAN-based traction motor for lawn mowers. Throughout this process, I was able to apply my knowledge and skills in CANopen, Vector CANalyzer, and embedded systems, which proved to be invaluable in developing a complex system from scratch and testing it to ensure its reliability and functionality.

My main responsibility was to design the system architecture and select the appropriate components for the system, including the sensors, motor controller, and CAN-based smart motors. Using an embedded platform, I developed the system by writing software and integrating different components.

To ensure that the system was reliable and functional, I developed a thorough test plan, which included testing the system's communication, functionality, safety, performance, integration, and compliance with industry standards and regulations. This helped me to identify any issues and optimize the system for maximum efficiency.

During the internship, I faced several challenges, such as learning new software and tools, dealing with hardware compatibility issues, and optimizing the system for optimal performance. However, with the guidance of my mentor and other team members, I was able to overcome these challenges and develop a successful system.

Overall, the internship provided me with a valuable opportunity to apply my theoretical knowledge in a real-world context, develop new skills, and gain practical experience working with complex systems. The knowledge and skills I gained during this internship will undoubtedly be beneficial in my future career as an engineer.

8.2 PHOTOGRAPH OF THE WORK

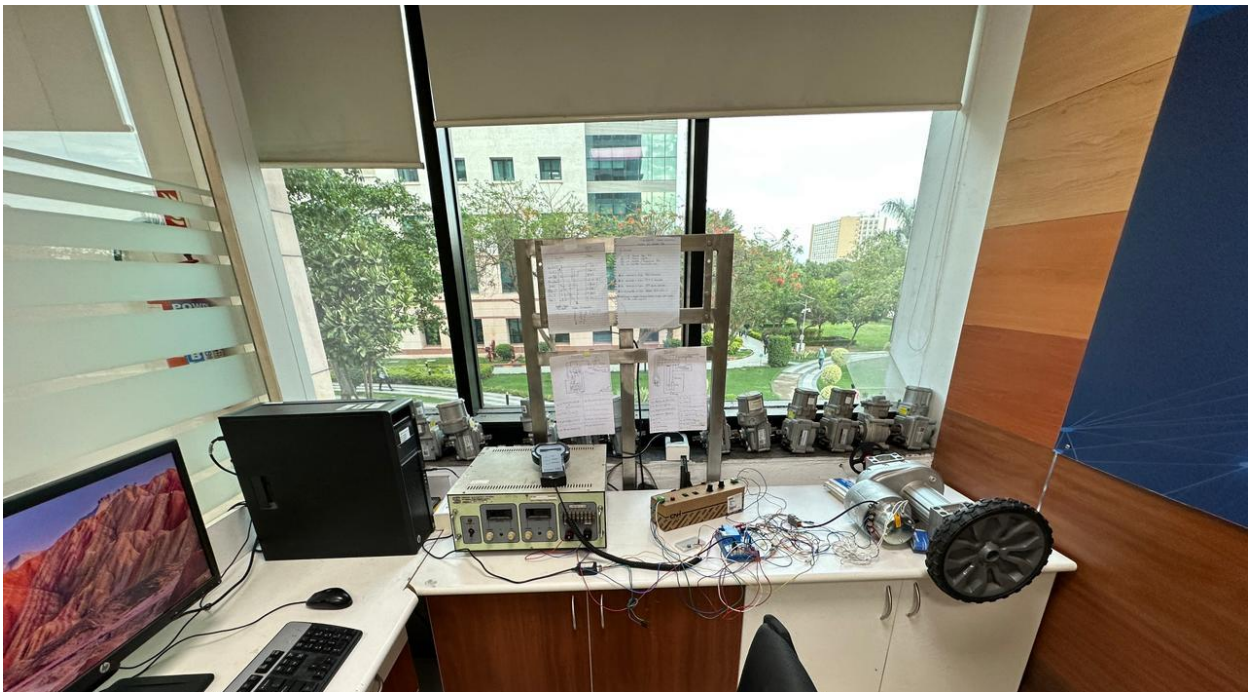


Figure 8.1 Photograph of the work

8.3 SUMMARY OF INTERNSHIP

L&T Technology services is a service based MNC which focuses on e-R&D. It designs and patents latest products and technologies. I was placed in Trucks and Off-Highway department where SOLIS was developing a new electric vehicle. This was the first EV vehicle being developed by SOLIS, and before this product the company outsourced all the components and subsystems and integrated them into their requirements to develop a vehicle.

But instead of sourcing the systems from outside the company was developing the vehicle in-house. Initially I got familiar with the latest EV systems and designs and communication protocols currently being developed all over the world. I was told to focus on CAN communication protocol used in the vehicles. Then I was placed in Embedded Test Lab where I got first-hand experience on how the communication protocol worked.

I acquired hard skills related to CAN protocol which included CAN protocol in Arduino IDE and Vector CANalyzer software and deep knowledge on higher level CAN protocols such as J1939 & CANopen. I also had to look for wiring protocols and making cross-compatible connectors for different systems. I also enhanced some soft skills such as project planning and management, getting support efficiently by making good problem statements and generating results reports.

At first, I got familiar with CAN protocol and how the frames work using microcontrollers like Arduino then I was given a rotary sensor based two-way foot paddle, a CAN based motor controller and a differential BLDC motor-based e-axel which all worked on CAN protocol, and I was given tasks to develop and test them. Finally gave a demonstration for the developed designs.

8.4 LIMITATIONS AND ENHANCEMENT

One potential area for future enhancements of the system could be to improve the embedded coding. During my internship project, the focus was on developing a functional system, and the coding was optimized to achieve this goal. However, with additional time and resources, it may be possible to further optimize the coding to achieve better performance, reliability, and functionality.

For example, the system could be enhanced by implementing advanced algorithms for better control and efficiency of the traction motor. Additionally, the integration of additional sensors and actuators could be optimized to provide more accurate and precise control of the system.

Furthermore, the implementation of advanced diagnostic capabilities and predictive maintenance features could improve the system's overall reliability and reduce downtime.

Overall, there are many potential areas for future enhancements of the system, with an emphasis on improving the embedded coding to achieve better performance and reliability. With continued development, the system has the potential to become a highly efficient and effective solution for lawn mower traction motors.

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