

CHAPTER I

NEEDS ANALYSIS

1.1 Background of the Problem

Over the years, electric vehicles have become a common part of daily human lives, especially in advanced countries. This event is driven by the efficiency and technological advancement provided by electric vehicles and the growing awareness towards a healthier way of living for the environment. Here in Indonesia, fossil-fueled vehicles still become society's favorite since most electric vehicles are still out of reach for most Indonesian citizens because of the soaring prices, and the low will to try new technological advancements since society already can rely on fossil-fueled vehicles for decades. Yet, there is growth in Indonesia, in both government and society, in the transition process from fossil-fueled vehicles to electric vehicles. Some societies are already willing to change their vehicle to electric vehicles, both cars and scooters, and the government creates regulations that support the usage of electric vehicles like lower vehicle taxes, free from even-odd regulations, and even infrastructure that supports the usage of electric vehicles such as the rapid growth of charging stations for electric vehicles [1]. Those previous actions created a thriving momentum for using electric vehicles in Indonesia.

In electric vehicles, there is an applied technology called the CAN (Central Area Network) Bus. CAN-Bus is one type of automotive bus. An automotive bus is a communication network that interconnects underlying automotive devices or automotive instruments in the in-vehicle network. CAN bus was originally designed by Bosch in 1989 for automotive monitoring and controls and was used in communications between the measurement and execution components of a car [2]. It can be summarized that CAN-Bus is a protocol that has a direct relation with the components inside the vehicle, which means that through CAN-Bus, it is possible to observe the current condition of the components inside the vehicle. Based on the research document titled "*Pengembangan Sistem Kontrol Mobil Listrik Berbasis CAN-BUS*" by the National Technology Institute, there are several components in electric vehicles that can be integrated with CAN-BUS [3]. These are vehicle control systems, energy storage systems, motor and power inverters, charging station infrastructure, vehicle support systems, and transmission. In this research, the researchers are focused on the energy storage system in electrical vehicles. Since the wiring mechanism is already available through the implementation of CAN-Bus, the technology can become a part of the *Smart Grid* implementation in the electric vehicle industry through the presence of a *gateway*. This can be implemented through the presence of PLC (Power Line Communication). Power Line Communication (PLC) presents some natural advantages that make it

appropriate for this kind of application, such as the advantage of using the already deployed electrical grid as the communication medium [4].

Unfortunately, EV-PLC technology is still uncommonly used in the market nowadays, even in advanced countries. By not using EV-PLC technology, the user needs to go to the workshop only to analyze the complete condition of the EV since not every electric vehicle is built with an embedded network that can analyze the state of the vehicle, especially in electric motorbikes that recently became commonly used by Indonesian drivers. Different kinds of electric vehicles can use different kinds of current and voltage levels which will affect the battery health in the long run. Combining both technologies can bring abundant benefits to both the user of the electric vehicle and the industry because it would enable them to analyze every component that is connected and reprogram it to the user's satisfaction. Following further developments, it can self-diagnose the components in the electric vehicle. In the previous year, a group of students from Telkom University works on research with the title of "*Perancangan Stasiun Pengisian Kendaraan Listrik Umum di Lingkungan Telkom University*" [5]. From that research, the students created a charging station in which the communication system through the power line can be detected with the applied electric vehicle. Yet communication still works on the basic impedance principle. This research aims to form an electronic device that can be implemented in several kinds of charging stations and works as a gateway technology between the electronic vehicle and the charging station. Of course, considering the IEC (International Electrotechnical Commission) standardization that is mainly used for electrical vehicles in Indonesia.

In recent times, there have been a handful of companies that have created this kind of gateway technology. Those companies are Continental Engineering Services (CES) which is based in Frankfurt, Germany; Renault from France; Xingtera and Star Charge from China. As previously mentioned, the goal of this research is to create a working EV-PLC (Electrical Vehicle Power Line Communication) that can be a communication interface between the applied electric vehicle and the charging station. The purpose of this activity is to initiate the research and manufacturing initiative of EV-PLC technology in Indonesia considering the growth of interest in electrical vehicles in Indonesia.

1.2 Supporting Information

The Government of Indonesia (GOI) is preparing to become a major player in the electric vehicle economy. Under President Joko Widodo's administration, several targets for EV uptake have been pledged since 2017, the latest announced in the new National Energy Grand Strategy [6]. Based on the issuance of Presidential Regulation Number 55 of 2019 concerning the Acceleration of the Battery

Electric Vehicle (BEV) Program. The transition from the use of conventional cars to electric cars in Indonesia is driven by the agreement of countries in the world to achieve Net Zero Emissions (NZE) in 2060. Likewise in Indonesia, the future of the Indonesian automotive industry is undergoing a transition towards a more environmentally friendly industry [7]. Indonesia has been significantly relying on imported fuels for transportation and households, which has been costly to Indonesia's annual budget spending. Energy imports consist of about two-thirds of Indonesia's annual import spending. In addition, these conditions limit Indonesia's dependence on its own domestic petroleum resources as the country's petroleum lifting has been declining due to aging wells, resulting in decreased foreign investment and long-term contract commitment to petroleum exports. Understanding this long-standing energy issue and acknowledging the abundant renewable energy resources, the Indonesian government has declared recently that the country is in the energy transition phase as moving from fossil fuel to clean/ new and renewable energy. In line with the energy transition, one of the initiatives undertaken by the government is to progressively move from fossil fuel vehicles to electric vehicles (EV), thus also showing its commitment to the world's climate change effort to achieve a net zero target by 2060 [8].

enable smooth flow of communication [9]. Before CAN was introduced, each electronic device was connected to other devices using many wires to enable communication. But when the functions in the automobile system increased, it was difficult to maintain because of the tedious wiring system. With the help of the CAN bus system, which allows ECUs to communicate with each other without much complexity by just connecting each ECU to the common serial bus [10]. The CAN bus protocol was initially designed as an alternative to field-bus technology in automobiles that would improve functionality [9]. The first car to ever feature this technology was the BMW 850 Coupe that entered the market in 1986. It was able to reduce in-vehicle wiring by 2km, which consequently significantly reduced its weight by over 50kg. Not to mention, the vehicle systems and sensors were able to communicate with each other at speeds up to 25kbps - 1Mbps [9].

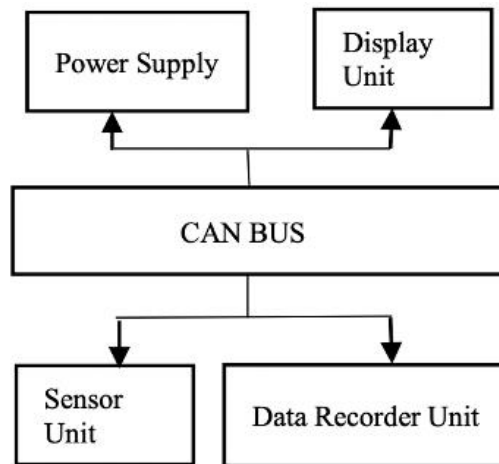


Figure 1. 1 CAN Work System Illustration

CAN bus integration offers the potential to significantly enhance communication within the electric vehicle industry, bringing diverse benefits to both users and the industry. In addition to CAN bus technology, another noteworthy communication method known as Power Line Communication (PLC). Power Line Communication (PLC) is a technology that uses the existing electrical vehicle as a communication medium. PLC is used during charging of electric vehicles around the world and is a must-have in today's electric vehicle (EV) market. PLC allows the charging station and the EV to negotiate charging sessions, allowing various charging modes such as AC or DC-Fast charging, Plug and Charge, and High-Level Charging Communication. The communication interface between the Electric Vehicle Supply Equipment (EVSE) and the Electric Vehicle Central Control Unit (vehicle charging functions) is provided by the Electrical Vehicle Power Line Communication controller (EVPLC) [11].

EVPLC nowadays it is mostly adopted for power utilities communication and remote control, automatic remote meter reading, and home and building automation. Savings in cable deployment that, within a modern reliable car, can reach up to 2 km length, with many interface nodes, seems to be a reason significant enough to propose this solution to be adopted even in the automotive domain. It has several natural advantages, such as infrastructure compatibility and cost-effectiveness, that make it an attractive field of application and research. In the context of electric vehicles, PLC can complement Controller Area Network Bus (CAN-Bus) technology, which is already widely used in coordinating the dozens of intelligent subsystems in today's fossil-fuelled cars and trucks.

Here are some ways in which PLC can complement CAN-Bus technology in electric vehicles:

- **Seamless communication:** In an electric vehicle, the CAN-Bus plays a crucial role in enabling seamless communication and coordination between the different systems and components. PLC can complement this by providing high-level communication between the vehicle and the charging station, enabling efficient and coordinated operation of the charging process.
- **Simplified wiring:** Unlike traditional wiring systems, the CAN-Bus uses a single twisted-pair or shielded cable to connect multiple components. PLC can complement this by using existing power lines to transmit data signals, eliminating the need for additional wiring, and reducing costs.
- **Enhanced safety:** The CAN-Bus system provides enhanced safety features such as real-time monitoring of braking systems, traction control, and stability control. PLC can complement this by providing additional safety features such as real-time monitoring of the charging process and automatic shut-off in case of a failure.

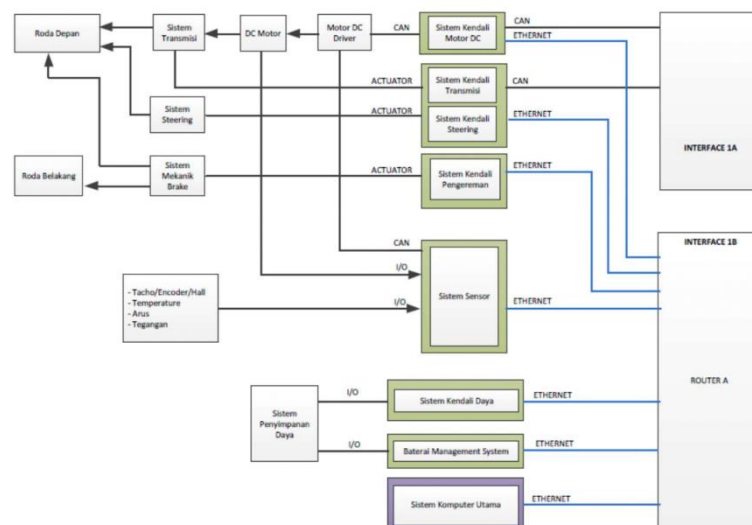


Figure 1. 2 Electrical Vehicle Network Block Diagram for CAN

In figure 2 it shows there are several components in electric vehicles that can be integrated with CAN-BUS. These are vehicle control systems, energy storage systems, motor and power inverters, charging station infrastructure, vehicle support systems, and transmission. In this research, the researchers are focused on the energy storage system, who's the data will be received by EVPLC. The adoption of Electric Vehicle-Power Line Communication (EVPLC) technology in Indonesia holds significant promise, serving as a vital bridge between the established CAN-Bus technology in electric vehicles and the charging infrastructure. This advancement not only facilitates seamless communication

between EVs and charging stations but also opens opportunities for real-time analysis, reprogramming, and self-diagnosis of vehicle components, enhancing the user experience and reducing maintenance costs.

In Indonesia, where the government is committed to transitioning towards clean and renewable energy sources, EVPLC technology can play a pivotal role. It enables efficient communication between electric vehicles and charging stations, streamlining the charging process, and ensuring optimal performance. This not only aligns with the nation's energy transition goals but also supports the global effort to achieve Net Zero Emissions (NZE) by 2060. Moreover, the combination of CAN-Bus and PLC technologies provides a robust communication system that simplifies wiring, reduces costs, and enhances safety in electric vehicles. However, the introduction of EVPLC technology takes this one step further. It enables real-time analysis of vehicle components, making it possible to diagnose issues and reprogram systems on the fly, thereby improving the user experience. This capability not only ensures the vehicle's reliability but also reduces maintenance costs, a significant benefit for both users and the industry. EVPLC technology in Indonesia represents a significant step towards a more environmentally friendly automotive industry, aligning with the government's energy transition goals and global climate efforts. It bridges the gap between CAN-Bus technology in electric vehicles and charging stations, offering real-time analysis, reprogramming, and self-diagnosis of vehicle components, enhancing the user experience, and reducing maintenance costs [12].

The research conducted by a group of students from Telkom University, titled "Perancangan Stasiun Pengisian Kendaraan Listrik Umum di Lingkungan Telkom University," [5] has provided valuable insights into the design and implementation of charging stations with a communication system through the power line. In their study, the students successfully created a charging station where the communication system, based on the basic impedance principle, could be detected with the applied electric vehicle.

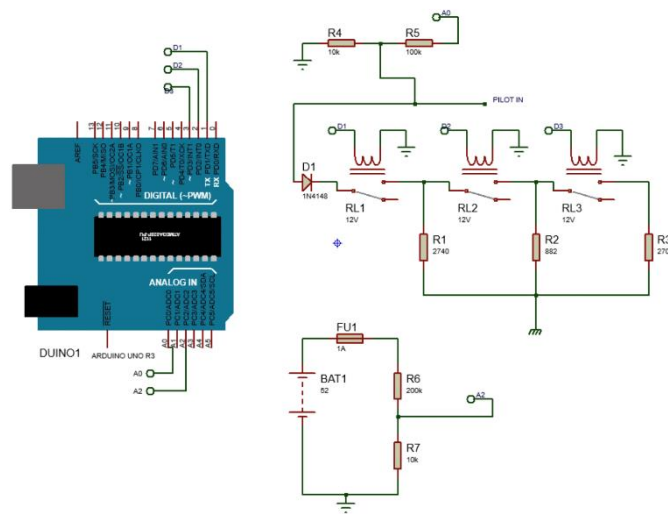


Figure 1. 3 Design of Public Electric Vehicle Charging Stations in the Environment

Telkom University Communication Subsystem

Despite the achievements of the previous group, there is room for further development and enhancement in the field of electrical vehicle power line communication. Specifically, their communication system was unable to accurately read important parameters such as voltage, frequency, duty cycle, and amplitude in certain value. successfully addressed these limitations by implementing the Frequency Shift Keying (FSK) method and meet the IEC standard. This innovative approach effectively overcame the shortcomings of the communication system, allowing for the accurate detection and communication with the applied electric vehicle.

In general Frequency Shift Keying (FSK) is a modulation technique applied in power line communication for electric vehicle charging stations to transmit crucial parameters such as voltage, frequency, duty cycle, and amplitude. FSK operates by switching between two discrete frequencies to represent binary values, with each frequency corresponding to a binary state (0 or 1). In this context, binary data encoding information about the electric vehicle is transmitted through frequency variations in the carrier signal. For instance, specific frequencies may signify different values for parameters like voltage and frequency. At the receiver end, the signal is demodulated to extract the original binary data, allowing for an accurate reading of the electric vehicle's key parameters. FSK thus ensures efficient and precise communication, enhancing the overall performance of power line communication systems in electric vehicle charging stations.

1.3 Constraint

Constraints are aspects that limit the outcome of this research. The researchers divided the constraints into 3 aspects, the economic, manufacturability, and capabilities aspects. The breakdown for each aspect is as follows:

Table 1. 1 List of Constraint

No	Aspects	Explanation of related aspects
1	<i>Economic</i>	This research needs to create a prototype, yet the prototype is supposed to be affordable which means that the capital that is used for this research is supposed to be budget friendly. Activities like purchasing an example of a product already available on the market are off-limits. Most of the budget will go to the components of the prototype that is going to be the result of this research.
2	<i>Manufacturability</i>	The prototype that will be created is focused more on functionality than aesthetics. The researchers will work on the prototype's mechanism to ensure it fulfils the capabilities aspect of this research and design the body of the prototype in the researchers' spare time.
3	<i>Capabilities</i>	The prototype that will be produced through this research will have the capability to be a gateway between a CAN-Bus simulator or other device that represents the role of the CAN-Bus in this research which runs through kHz of frequency and ... bits, with EVCS (Electrical Vehicle Charging Station) with the available interface that can be programmed with language. The primary data that will be available for display are the value of the current and voltage that runs to the charged battery, the battery real-time percentage, and the estimated time to reach full capacity of charging. The secondary objectives are that the

		device can diagnose the health of the battery and the conditions of the EVCS.
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1.4 Requirements to Be Fulfilled

The needs that must be met based on the existing background are as follows:

1. The instrument can convert the given PLC signals into recognizable data for the EVCAN Simulator.
2. The instrument can communicate data bidirectionally between Electric Vehicle Charging Stations (EVCS) with an EVCAN Simulator.

1.5 Purpose

This research proposes the development of an Electrical Vehicle Power Line Communication (EVPLC) system in Indonesia. The system aims to establish reliable communication between the Electric Vehicle Charging Stations (EVCS) and the CAN Bus system in electric vehicles. It simplifies wiring, enhances safety, and allows for real-time analysis and diagnosis of vehicle components. The document highlights the limited availability of domestically manufactured EVPLC systems in Indonesia and the benefits of combining EVPLC with CAN Bus technology. The proposed solution prioritizes functionality over aesthetics and focuses on improving data transmission accuracy, communication capabilities, casing quality, and programming language. The objectives include developing an efficient and accurate instrument for signal conversion, designing the instrument to operate with AC current, equipping it with diagnostic capabilities, manufacturing it domestically, and ensuring scalability. The document emphasizes the alignment of the proposed EVPLC system with Indonesia's clean energy goals and global efforts to achieve Net Zero Emissions.