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Study of Wiring Harness and Study of Power Line Communication in Electric Vehicle

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Abstract— This abstract delves into two crucial aspects of electric vehicle (EV) technology: the study of wiring harnesses and the study of Power Line Communication (PLC). It examines the intricate design considerations involved in optimizing wiring harnesses for EVs, focusing on factors like efficiency, wire reduction, weight reduction, and thermal management. Additionally, it explores the potential of PLC in enhancing communication infrastructure within EVs Power line communication will transmit data over same power cable which provides power to sensor module. Power line communication will be the solution for reducing wiring harness of vehicles. As electrical vehicles are becoming popular against IC engine vehicle, the weight of EV is the most critical and one of the design challenges for engineers.

Index Terms— Electrical vehicle, Sensors, DCAN500 device, Wiring harness, Power Line Communication (PLC)

I. INTRODUCTION

Power Line Communication (PLC) system for vehicle that allows in-vehicle communication for the transmission of sensor messages/data. Now-a-day's more sensors are inserted in vehicles as functional safety features PLC will offer low cost, less complexity of wire networking. This Power line communication will add advantage of lower cost of wires, wiring manufacturing process and hence increase productivity. This technology is very useful for future electric vehicles (E – Vehicles) because to increase the distance coverage of E – vehicle manufacturers are more focusing on reducing the weight of vehicle so that vehicle can cover more distance in single charge of battery.

II. LITERATURE SURVEY

1. Title: "DC - PLC Modem design for PV module monitoring"

Authors: Seong - Duc Ma, Min - Su Park and Jae Eon Kim (2016)

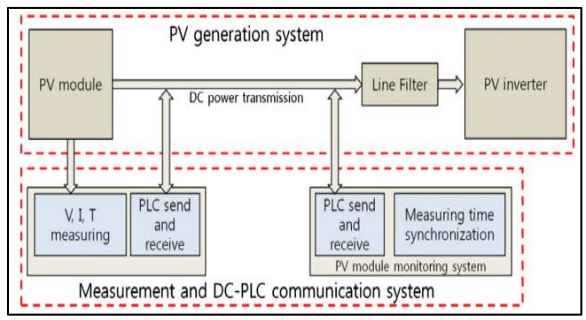

Figure 1 – DC - PLC PV module monitoring system structure in PV system

The research explores the development and deployment of an affordable DC PLC modem designed for monitoring photovoltaic (PV) modules in expansive PV generation facilities. It focuses on using power line communication (PLC) to transmit data from PV modules to a central monitoring system. The article proposes the use of digital filters and multi-carrier communication to enhance performance and communication speed. The modem's effectiveness is verified through simulation and experiment, offering benefits for monitoring the efficiency and performance of PV modules in a PV system. Additionally, the article covers the design and attenuation and distortion caused by PV inverters.

The article discusses the development of a cost-effective DC-PLC modem for monitoring PVmodules in large-scale PV plants. It utilizes power line communication to send data from the modules to a central monitoring system. The authors suggest using digital filters and multi- carrier communication to enhance performance and speed. The modem's efficacy is confirmed through simulation and testing, offering advantages for monitoring PV module efficiency in a PV system. Additionally, the article explores the design and simulation of line filters to reduce signal distortion caused by PV inverters.

2. Title: “A Review on Power Line Communication Systems”

Authors: Sriharan R, Dharaganthu S, Abishek Francis P, Janakiraman G

The article provides an overview of power line communication systems, addressing transmission issues, modelling, communication techniques, and reliability. It highlights the potential for improvement in PLC technology and mentions broadband PLC devices and fieldtrials by utility companies. Power line modems, which use power cables as communication mediums, are categorized into three types. The article suggests new PLC modems for PWM networks, offering reliable transmission without extra cables. Over 45 million Home Plug devices are deployed globally, with various organizations supporting different power line networking standards. Power line communications can be used for home networking, OTTvideo streaming, and internet access, but service provisioning is challenged by network variations and the lack of IEEE standards.

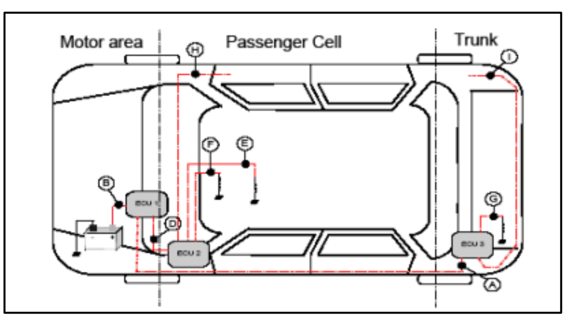

Figure 2 - PLC in vehicle

3. Title: “PLC Systems for Electric Vehicles and Smart Grid Application”

Authors: S. Barmada, M. Raugi, M. Tucci, Y. Maryanka, O. Amrani

The study investigates the noise environment within electric vehicles (EVs) to determine the viability of implementing power line communication (PLC) systems. PLC technology facilitates the transmission of data through the pre-existing power lines, which could be particularly useful for in-vehicle communication networks. The research specifically examines the noise generated by two primary sources in EVs: the electric engine and the AC/DC converter, especially during the battery charging process.

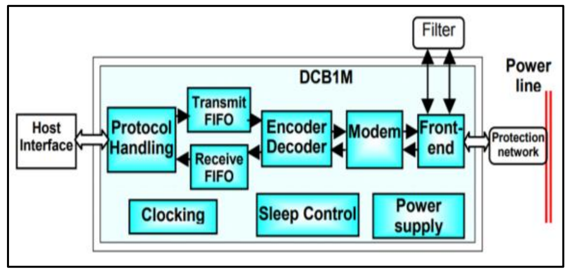

Figure 3 - Block diagram of the DCB1M

To conduct a thorough analysis, the authors collected noise samples from different terminals within the electric vehicle's power system. These samples were then processed to calculate the Power Spectral Density (PSD). It is a metric used to characterize the distribution of power in a signal or time series across different frequencies.

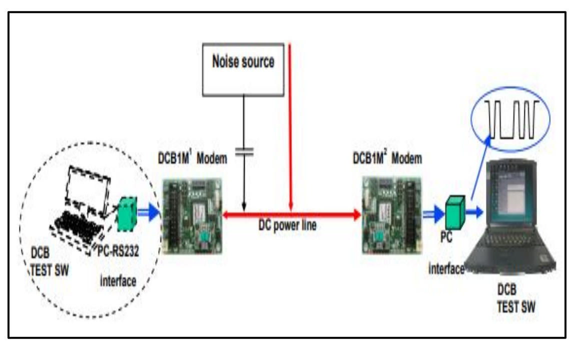

Figure 4 - Setup for DCB1M modem testing

The research results highlight the significance of comprehending the noise characteristics in electric vehicles during the creation of PLC solutions. Top of Form By characterizing the statistical properties of the noise, engineers can design more robust communication systems that can operate reliably in the noisy electrical environment of an EV. This research contributes to the broader effort to enhance in-vehicle communication technologies, which are critical for the performance and safety of electric vehicle.

4. Title: "Low Rate and High Reliable Modulation Schemes for In Vehicle Power Line Communications"

Authors: - Daisuke Umehara, Yasuhiro Yabuuchi, Tetsuo Morita, Masahiro Morikura, Shinichi Ishiko & Satoshi Horihata

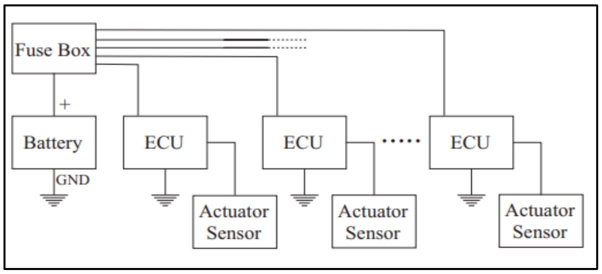

Figure 5 - A model of PLC (Power Line Communication) within a vehicle system

The document explores the utilization of analog limiters to tackle impulsive noise issues in low-rate in-vehicle power line communication (PLC) networks. It assesses different modulation and detection methods (including BPSK, DBPSK, OOK) under impulsive noise conditions, underscoring the effectiveness of employing soft limiters with a threshold set at 2. The research indicates that employing DBPSK with differential detection and hard limiters provides the most cost-efficient performance for low-rate and highly dependable in-vehicle PLC networks. It underscores the feasibility of establishing such networks without intricate digital signal processing (DSP) by leveraging simple binary modulation, detection, and analog limiters. Furthermore, it advocates for further investigation into modulation and coding techniques to realize high-rate and highly dependable in-vehicle PLC networks in impulsive noise environments.

5. Title: "A new multiple access scheme for DC power line communications"

Authors: Amir Rubin & Ofer Amrani

The document discusses an arbitration procedure for bus access in a network environment, focusing on collision probability and contention detection. It outlines the scenarios where contention can occur between nodes accessing the bus simultaneously, and the probability calculations associated with undetected contention. Assumptions regarding bit-level synchronization and the length of preamble sequences are made to support the analysis. The document presents mathematical expressions and derivations to compute collision probabilities for both two and multiple users connected on the DC-bus. It emphasizes the importance of the proposed arbitration procedure in resolving contention and ensuring efficient bus access for connected nodes.

The paper titled "New multiple access scheme for DC power line communications.pdf" introduces an innovative multiple access scheme designed specifically for DC power line communications in automotive environments. This scheme seamlessly integrates contention detection and carrier transmission modes to prevent collisions. It incorporates a random arbitration register and random time-delay mechanisms to facilitate successful transmission. Through a comparative analysis with other MAC protocols, the authors illustrate the effectiveness of the proposed approach in minimizing collision probability. This scheme holds promise for simplifying wiring in vehicles, improving reliability, and optimizing performance. The contention detection mode involves multiple samples of the carrier signal to minimize false alarms, while the carrier transmission mode manages actual transmission on the bus.

6. Title: "Study and Field Test of Power Line Communication for an Electric-Vehicle Charging System"

Authors: Chang - Un Park, Jae - Jo Lee, Sang - Ki Oh, Jung - Mok Bae & Jong - KwanSeo

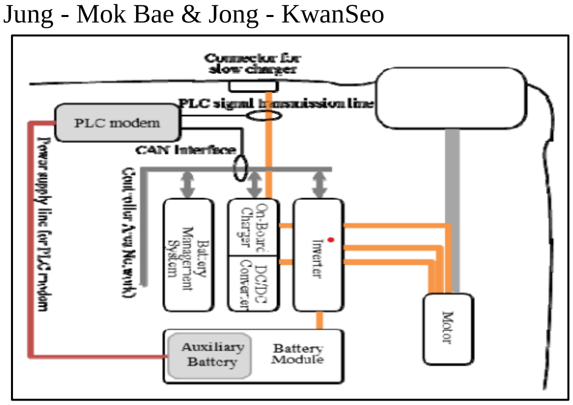

Figure 6 - PLC modem of EV charging system

Electric vehicle (EV) charging systems encompass both AC and DC charging stations, necessitating input/output (I/O) systems, control mechanisms, advanced meters, and communication infrastructure. These systems rely on key technologies like EV-ECU, connectors, OBC, LDC, inverters, BMS, and batteries, each fulfilling critical functions in the charging process. AC charging stations require the EV to be connected via a specific connector, followed by operations involving connect switch circuits, control pilot circuits, and PWM signals. These components facilitate the supply of AC power to the EV, subsequently converted into DC power through the OBC. In-vehicle power line communication channels are a significant area of study, with numerous research endeavors and symposiums delving into the modeling, analysis, and deployment of high-speed communication systems within vehicles. International standards such as IEC 61851-1, ISO/IEC 62196-1, and ISO/IEC 12139-1 establish essential requirements and specifications for electric vehicle conductive charging systems and powerline communication protocols.

7. Title: “Development of Smart Battery Cell Monitoring Vehicle Charging System and Characterization on a Small-Module Through In-Vehicle Power Line Communication”

Authors: James Marco & Timothy A. Vincent

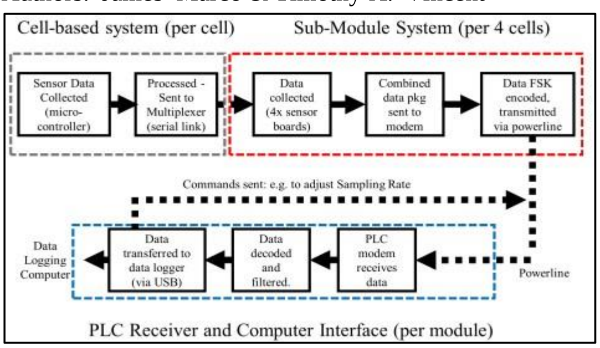

Figure 7 – PLC Receiver and Computer Interface

This research paper focuses on the creation of an advanced smart battery cell monitoring systems tailored for EVs. The system integrates sensors that continuously monitor crucial parameters such as temperature, voltage, and current. By doing so, it enables manufacturers to design battery packs with extended lifespans. One key innovation highlighted in the paper is the utilization of power line communication, which streamlines the wiring harness, reducing both size and complexity. This streamlined approach allows for higher energy storage density within the vehicle, a critical aspect for electric vehicles. The system underwent rigorous testing on a module of cells, demonstrating exceptional performance in terms of communication reliability. The technology showcased in this study has the potential to enhance battery longevity, accelerate charging speeds, and increase the overall range of electric vehicles. The document also recognizes the need for additional research to improve cell instrumentation, reduce expenses, and decrease the physical size of smart cells.

The experiments conducted in this study aimed to verify the effectiveness and suitability of power line communication for monitoring cell sensors. The findings indicated that data transmission from the sensors remained reliable and free from corruption, and the miniature sensors utilized were sufficiently accurate in measuring standard cell parameters. Furthermore, the research illustrated that there exists adequate bandwidth to transmit data for multiple cells utilizing a single frequency division of the power line. This study establishes the foundation for the future development of intelligent instrumented cells within electric vehicles. It underscores the essentiality of monitoring temperature at the individual cell level to detect hotspots and mitigate premature aging. The integration of in-situ sensors for temperature, voltage, and current holds significant potential to enhance the safety and efficiency of electric vehicles. Moreover, the paper emphasizes the importance of considering factors such as cost, weight, and physical dimensions of components in the design of electric vehicles, with power line communication emerging as a pragmatic solution to tackle these considerations.

8. Title: “Powerline Communication in Electric Vehicles”

Authors: Ezio Bassi, Francesco Benzi, Luis Almeida & Thomas Nolte

The paper delves into the alignment of onboard communication traffic with stringent protocol requirements, highlighting the benefits of adopting a PLC-based architecture to minimize weight and complexity. Special recognition is extended to Andrea Albini and Daniele Caprini for their substantial contributions to the experimental setup and measurements.

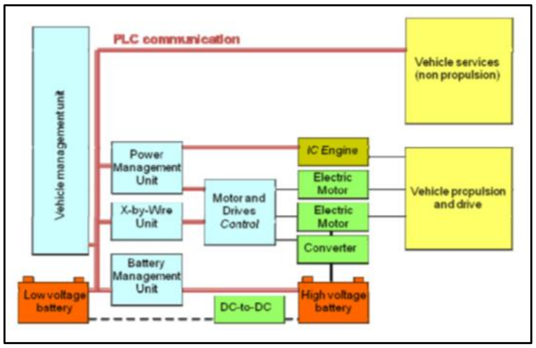

Figure 8 - PLC architecture for main EV units

The document references various studies and proceedings related to automotive communications, power line communication, and electric vehicles. It includes schematics and details of the experimental setup, along with figures depicting the throughput and electromagnetic interference of the power line communication system. The analysis of the physical layer and its performance is based on the experimental setup utilizing ECUs, DCB500 transceivers, and a Real-Time OS, offering insights into overall performance and immunity from EMI and noise.

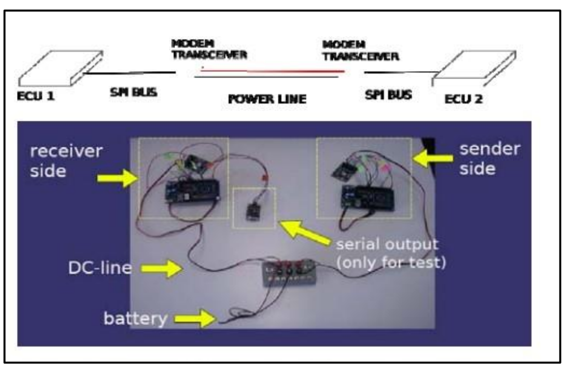

Figure 9 - Implementation of the experimental setup

9. Title: “Power Line Communication for Vehicle”
Authors: Vaibhav V Rajguru & A. U Wagdarikar
The document explores the application of power line communication (PLC) in full electric vehicles for transmitting data between electronic equipment. It compares results obtained using a deterministic propagation model and highlights the challenges posed by traditional cable harnesses in vehicles. Implementing Power Line Communication is viewed as an effective solution to reduce the complexity, weight, and cost associated with traditional wiring harnesses in vehicles. The document underscores the growing number of connection points in modern vehicles and the potential advantages of using power lines for command-and-control purposes. It also discusses the benefits of power line communication in terms of weight, space, and cost savings, as well as its potential to address diagnostic and maintenance challenges in vehicle communication systems.

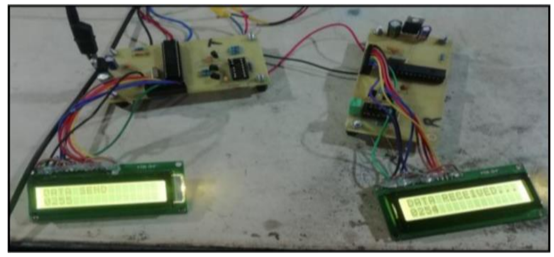

Figure 10 - Power Line Project setup

This study proposes a power line communication (PLC) system for vehicles, utilizing existing power cables to transmit data between the vehicle's control unit and the body control module. This eliminates the need for additional signal wires and reduces the vehicle's wiring harness. The PLC system serves as a reliable alternative network medium for in-vehicle communication. The technology allows for reducing the number of wiring harnesses in the vehicle, resulting in cost savings, complexity reduction, and weight decrease.

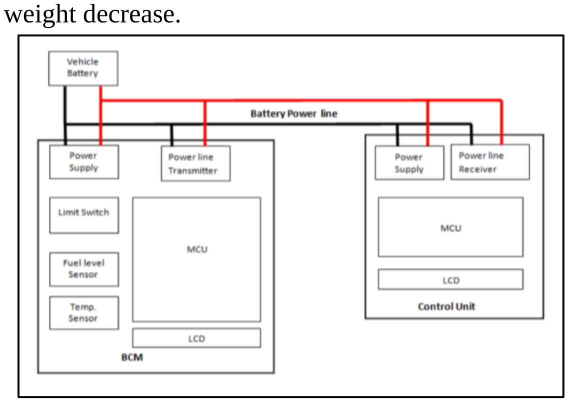

Figure 11 - Power Line Communication Block Diagram

The paper presents a PLC transceiver design tailored for power line communication in vehicles, specifically designed to be compliant with FlexRay communication systems. This design incorporates a 16-QAM scheme, offering a high-reliability solution without adding to the weight, volume, or cost of wiring harnesses. The study delves into the compatibility of the PLC system with existing network systems such as CAN, LIN, MOST, and J1850 protocols, highlighting its seamless integration into established vehicle communication frameworks.

The research also addresses the problem statement regarding the limitations posed by the weight & space constraints of traditional wiring harness in vehicle. It discusses the project scope, emphasizing the advantage of Power Line Communication in terms of cost reduction, complexity reduction, and increased productivity in vehicle manufacturing processes.

Overall, the study provides a comprehensive overview of the benefits of the PLC system and its potential applications in electric vehicles, covering aspects like propagation channel characteristics, PLC transceiver design, and its compatibility with various network protocols. III.

10. Title: - "Development of an in-vehicle power line communication network with in-situ instrumented smart cell"

Authors: - Timothy A. Vincent, Begum Gulsoy, Jonathan E. H. Sansom & James Marco

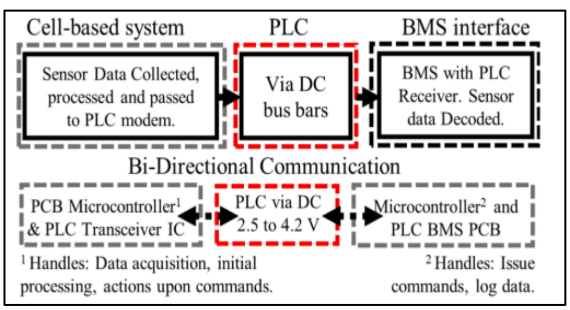

Figure 12 - Block diagram - Showing components in Power Line Communication system and operation of bi - directional communication

Researchers at the University of Warwick have created a prototype smart cell designed for integration into a Power Line Communication (PLC) network. This innovative cell is equipped with sensors and interface circuitry, enabling real-time monitoring of critical parameters within individual cells in a lithium-ion battery pack. The technology shows promise in enhancing energy density and simplifying communication cabling, particularly in electric vehicles and aerospace settings.

Additionally, the team has developed a compact modem and interface circuitry system capable of operating across the full voltage range of an individual cell while being powered by it. Through testing, this system has demonstrated reliability over extended periods, transmitting and receiving thousands of messages per hour with transient sensor data.

Internally, the cells feature flexible-thermistor circuitry for core-temperature monitoring during cycling experiment. The article delves into the rationale behind using PLC for instrumented cells, outlines the experimental setup, presents initial findings, and discusses ongoing research. The overarching goal is to overcome current limitations in battery pack instrumentation, enhancing safety and reliability, especially in challenging environmental conditions.

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