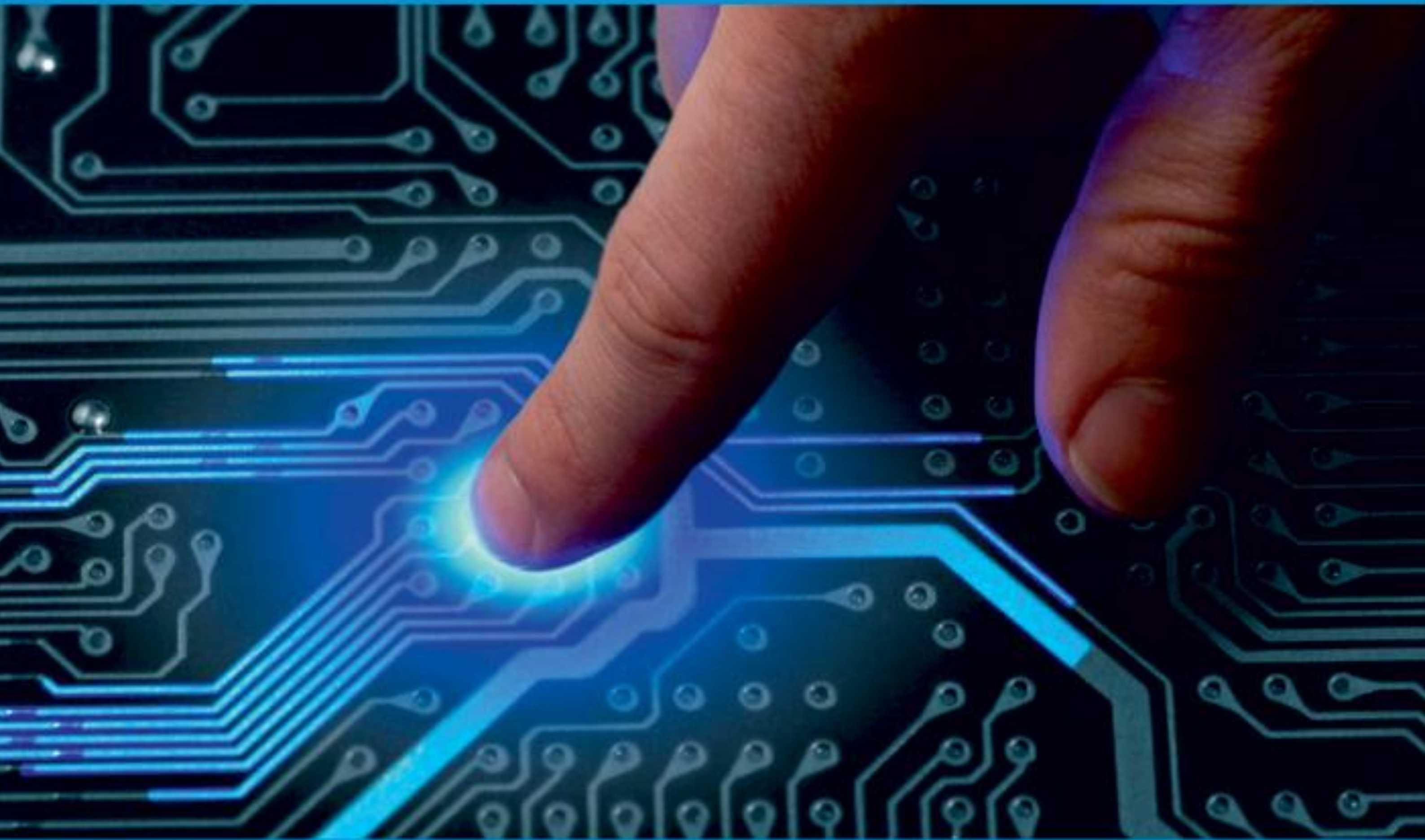
IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 11, Issue 5, May 2023

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.379

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |

|| Volume 11, Issue 5, May 2023 ||

| DOI: 10.15680/IJIRCCE.2023.1105070 |

EVSE Simulator: A backbone for EV Infrastructure

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ABSTRACT: In developing country like India automotive industry growing rapidly. Growing automotive industry create pollution so government is taking initiative to curb the pollutions through Electric Vehicles. Electric vehicles (EVs) produce zero emissions at the tailpipe, which means that they do not release any pollutants or greenhouse gases into the air. This is in contrast to traditional gasoline-powered vehicles, which are a major source of air pollution and contribute to climate change. By reducing air pollution, EVs can help to improve air quality and protect the health of both humans and wildlife.However, one of the challenges with EV charging infrastructure in India is the lack of a comprehensive and coordinated strategy for its development. Currently, there are a number of different players involved in the development and operation of charging infrastructure, including government agencies, private companies, and electric utilities. This can lead to a fragmented and unevenly distributed charging network, which can be a significant hindrance for EV owners.Manufacturing of Electric vehicle supply equipment(EVSE) is complicated but its more complex to simulate therefore EVSE manufacturer want proper simulator that can measure the capacity, duty cycle, frequency and state change of it. This article includes all the parameter that EVSE manufacture want that can measure by simulator.

KEYWORDS: EVSE simulator, frequency measurement, EV Chargers, Voltage measurement, Duty Cycle

I. INTRODUCTION

Electric Vehicle Supply Equipment (EVSE) is a vital component of the infrastructure required to support the growth of electric vehicles (EVs). It provides a safe and reliable means of recharging EVs by acting as an intermediary between the electric grid and the EV's battery. There are different types of EVSEs available, such as Level 1, Level 2, and DC fast charging, each with their own charging rates and capabilities [9].However, one of the significant challenges in the development of it ensuring their compatibility and interoperability with EVs from different manufacturers. Therefore, it is essential to conduct thorough testing and validation of the charging systems to ensure their functionality, reliability, and safety [1]. It is cost-effective and efficient way to test and validate it before deployment.Most of the people think that EVSE work as phone charger. Electric Vehicle Supply Equipment (EVSE) and phone chargers are two very different types of chargers that serve different purposes. The main differences between EVSE and phone chargers are as follows:

1. *Power Rating:*Itis designed to deliver a much higher power output than phone chargers. This is because EV batteries have a much larger capacity and require a higher amount of power to recharge. In contrast, phone chargers typically deliver lower power outputs to charge the smaller batteries in mobile devices.

2. *Charging Time:*It takes much longer to charge an electric vehicle than phone chargers take to charge a mobile device. This is due to the larger battery capacity of EVs and the higher power output required to recharge them. In contrast, phone chargers can typically charge a mobile device in a few hours or less.

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3. *Charging Protocol:* EVSEs use specific charging protocols, such as the SAE J1772 or CHAdeMO, to communicate with the EV's onboard charger and safely transfer power to the battery. In contrast, phone chargers typically use universal charging protocols, such as USB or Lightning, to transfer power to the device.

4. *Safety Features:*It have several safety features, such as ground fault protection and overcurrent protection, to ensure the safe and reliable operation of the charging system. In contrast, phone chargers may not have the same level of safety features and may pose a risk of electric shock or fire if used improperly.

An EVSE simulator is a device designed to replicate the operation of a real charging station, allowing for various charging scenarios to be simulated. This simulation ensures that the EVSE is compatible and interoperable with different EVs.simulators are used to test the EVSE's communication protocols, safety features, and charging capabilities. Moreover, they can also simulate different charging scenarios, such as low voltage or high voltage conditions, to test the response under different conditions [4]-[6].

In this research paper, we will discuss the significance of EVSEs in supporting the growth of EVs and the challenges faced in their development. We will explore the role of simulators in testing and validating the charging systems and how they ensure compatibility and interoperability of the EVSE with different EVs. Furthermore, we will delve into the different types of EVSE simulators, their features and applications in testing and validating EVSEs [7], [8].

A. *Fundamental of EVSE:*

EVSE is the infrastructure that provides electrical energy to charge electric vehicles (EVs). An EVSE typically consists of a charging station, a connector, and an interface between the station and the EV's onboard charger. The charging station provides the electrical energy to the EV's battery, and the interface communicates with the EV's onboard charger to ensure safe and efficient charging.EVSEs come in various types and power levels, from Level 1 (120-volt AC charging) to Level 2 (240-volt AC charging) to Level 3 (DC fast charging). Level 1 charging is typically done using a standard household electrical outlet, while Level 2 and Level 3 charging require special charging stations that provide higher power outputs.EVSEs can be installed in a variety of locations, such as residential homes, commercial buildings, and public charging stations. They play a critical role in the adoption and growth of electric vehicles by providing a reliable and convenient way to recharge EVs [3], [9], [10].

B. *EVSE Charging Plug:*

The charging plug used by EVSE can vary depending on the type of connector and charging protocol used by the EV and the EVSE [2], [11]-[13]. Some common typescharging plugs include:

1. SAE J1772: This is the most common charging plug used in North America and is used by most EVs produced by American and Asian automakers. The plug consists of five pins and is designed to deliver up to 80 amps of current.

2. CCS (Combined Charging System): This plug is a DC fast charging plug used by some EVs produced by American and European automakers. It combines the standard J1772 plug with two additional pins for high-power DC charging.

3. CHAdeMO: This is a DC fast charging plug used by some EVs produced by Japanese automakers. It consists of a large, round plug that delivers up to 125 amps of current.

4. Tesla Supercharger: This is a proprietary DC fast charging plug used by Tesla vehicles. It consists of a rectangular plug that delivers up to 250 amps of current.

In addition to the physical plug, EVSEs also use a variety of communication protocols to communicate with the EV's onboard charger and ensure safe and reliable charging. These protocols include CAN bus, Power Line Communication (PLC), and Ethernet.

International Journal of Innovative Research in Computer and Communication Engineering

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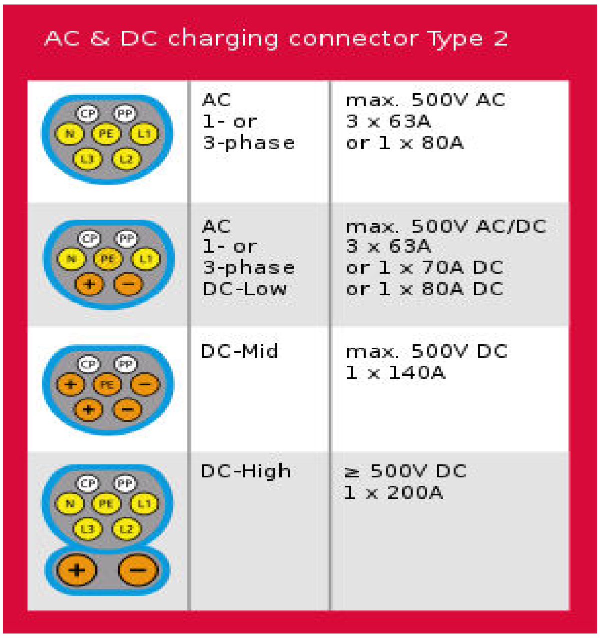

Fig.1. AC & DC Connector Type

C. *GUN PIN DIAGRAM: -*

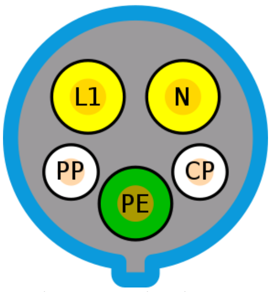

Fig. 2. Gun Pin Diagram

Table 1 Pin Description

PIN	DESCRIPTION
L1	AC line 1
N	AC Neutral
PE	Protective Earth (Ground)
PP	Proximity Pilot /Plug Present, which provides a signal to the vehicle's control system so it can prevent movement while connected to the electric vehicle supply equipment, and signals the latch release button to the vehicle.
CP	"Control Pilot" is a communication line used to signal charging level between the car and the EVSE, and can be manipulated by vehicle to initiate charging as well as other information.The signal is a 1 kHz square wave at ±12 volts generated by the EVSE to detect the presence of the vehicle, communicate the maximum allowable charging current, and control charging begin/end.

II. NEED OF EVSESIMULATOR

An EVSE simulator is a tool used to simulate the behaviour of an electric vehicle charging station. An EVSE simulator is a valuable tool for anyone working with electric vehicle charging stations, whether it will be for testing, training, development, or research purposes.There are several reasons why it might be necessary, including:

1. *Testing:*it is used to test the functionality of electric vehicle charging stations. They can be used to test whether a charging station is working correctly and whether it is delivering the correct amount of power to an electric vehicle.

2. *Training:*it can be used to train electric vehicle service technicians on how to troubleshoot and repair electric vehicle charging stations.

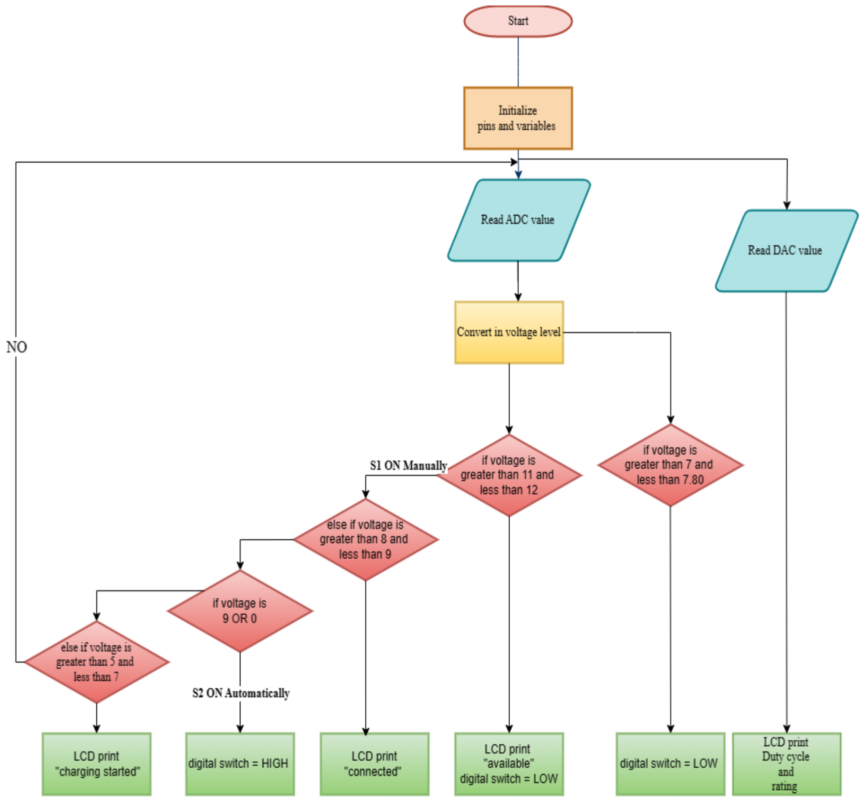

Fig. 3. Flowchart of the System

3. *Development:*it can be used to develop new electric vehicle charging station technologies. By simulating the behaviour of a charging station, engineers can test and refine new technologies before deploying them in the real world.

4. *Research:*it can be used for research purposes, such as studying the impact of electric vehicles on the power grid or investigating the effectiveness of different charging station designs.

III. ALGORITHM

When the Gun of EVSE either in our hand or not connected to car then EVSE's screen indicates normal blue light and voltage in gun's pin across CP and PE pin it is 12V. Secondly, when user connect gun with car and car connected properly then screen of it indicates yellow icon and voltage level id 9V. Thirdly, when user reach payment interface then voltage level are 9V PWM after complete imbursementEVSE simulator trip the relay and charging starts successfully and voltage level are 6V PWM. Simulator detect all state change and respond capture and give proper

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output like frequency conversation duty cycle measure and also identify the rating of EVSE. Accordingly every output simulator shows every response on its screen. Fig 3 illustrates the Flow chart of system.

IV. SYSTEM ARCHITECTURE

The hardware elements of an EVSE simulator, such as a microprocessor, power supply, and interface circuits, make up its usual system design. The software components of an EVSE simulator typically include firmware that controls the hardware components and simulation software that models the behaviour of EVs and EVSEs. The system architecture seeks to ensure the dependability and safety of EVSEs and EVs by properly simulating real-world charging circumstances. We take analog and digital signal from EVSE's CP pin. Fig. 4 shows the block diagram of the system.

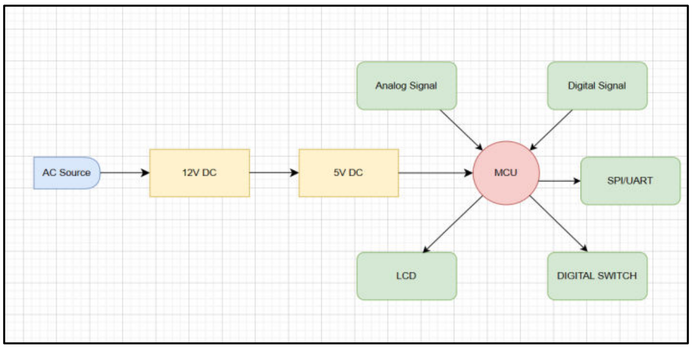

Fig. 4. Block diagram

A. ATmega328: -

ATmega328 is a heart of EVSE simulator. For continuous analog and digital signal analysis Microcontroller unit (MCU) plays vital role in it. Moreover, LCD interfacing is also depending on MCU.It has a 32KB flash memory, 2KB SRAM, and 1KB EEPROM. The ATmega328 has an 8-bit RISC architecture and operates at a clock frequency of up to 20 MHz It is widely used in various applications, including industrial automation, robotics, and consumer electronics. In this project it will continuously measure voltage through voltage divider on analog pin as well as frequency on digital pin. It is also capable to show different output based on voltage on LCD display. ATmega328 shown in Fig. 5.

Fig.5. ATmega328

Fig. 6. 16*2 LCD

Fig.7. LM2596

Fig.8. SMPS

B. 16*2 LCD display: -

A 16x2 LCD is a liquid crystal display (LCD) module that can display up to 16 characters per line and up to 2 lines of text. For display State changes, Duty cycle and rating etc. we used this display in our project.A 16*2 LCD is shown in Fig. 6.

C. LM2596: - Buck Converter:

The LM2596 module is a voltage regulator module based on the LM2596 integrated circuit (IC). The LM2596 is a step-down (buck) switching regulator IC that can convert higher voltage DC power into lower voltage DC power rather than showing IC and its peripheral, we can visualize whole module in Fig.7.

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D. Switched Mode Power Supply:

Switched Mode Power Supply (SMPS), is a type of power supply that uses high-frequency switching to convert electrical power from one form to another. The main advantage of SMPS over traditional linear power supplies is their high efficiency, compact size, and low heat generation. In our project we use SMPS for converting the input power supply to the required output voltage and current levels. They use a switching regulator to efficiently convert the DC voltage from the power source to the desired voltage and components. In our case it will convert 220V AC Supply into 12V DC supply. A SMPS which used in project is shown in Fig. 8.

E. Relay with driver circuit:

Relay is an electromechanical switch which can only operate by signal which one fed by MCU. In EVSE simulator we use relay for automation purpose.Relays play a crucial role in the EVSE simulator by controlling the flow of power to the simulated EV. Relay will operate according to EVSE state change and relays also protect the EV and the EVSE from damage due to overvoltage, overcurrent, or short circuits. Its precise and reliable operation ensures the safety and accuracy of EVSE simulations. For driving relay separate driver circuit needed which is shown in Fig.9.

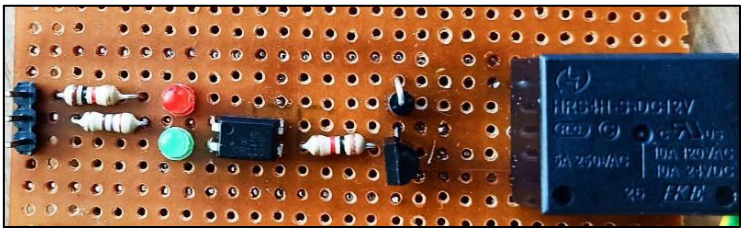

Fig.9. Relay Driver Circuit

F. Software toolsArduino IDE:

The Arduino Integrated Development Environment (IDE) is an open-source software tool used for programming and developing Arduino boards. It provides a user-friendly interface for writing, compiling, and uploading code to Arduino boards. The IDE supports various programming languages, including C++, and offers a wide range of libraries and examples to facilitate development. The IDE is cross-platform and can run on Windows, Linux, and macOS. Its simplicity, versatility, and community support make it a popular choice for hobbyists and professionals alike in the development of embedded systems. Fig. 10 shows Arduino IDE window.

V. SYSTEM IMPLEMENTATION

The prototype can be divided into four major functional parts.

A. Control circuit

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This part serves as the brain of the EVSE Simulator. ATmega328P accepts the signal coming from the sensing circuit and is responsible for the control and coordination of all the different components used in the project. Fig. 11 show the PCB layout of the control circuit as well as final PCB.

B. *Sensing unit*

For frequency and constant voltage measurement we have made sensor from various voltage divider circuit. signal pass through voltage divider and divider gives output to MCU.

C. *Display/status indicator unit*

State change of EVSE, frequency, duty cycle and EVSE rating and other relevant data displayed to the user on LCD (Liquid Crystal Display).

D. *Power circuit*

It includes a 3.3V and 12V power supply which is required to power the MCU and display. The circuit is simple andit includes a SMPS, capacitors used as filters and voltage regulators.

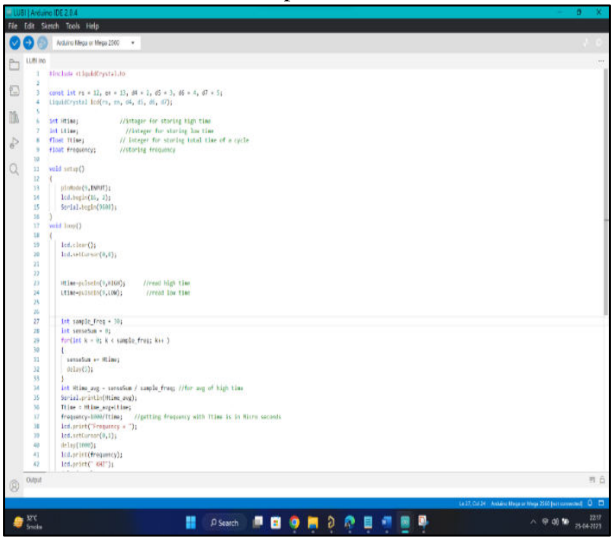

Fig. 10. Arduino IDE program

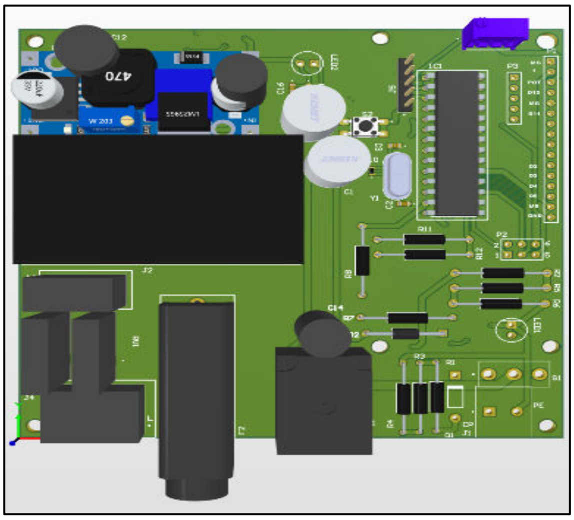

Fig. 11. PCB of simulator

VI. Test Results

The final result and analysis we obtain by testing the product was quite productive and with no errors after several testing and analysis. Fig 12 shows the test setup and the results. The various result analysis is shownthroughthe figures givenbelow:

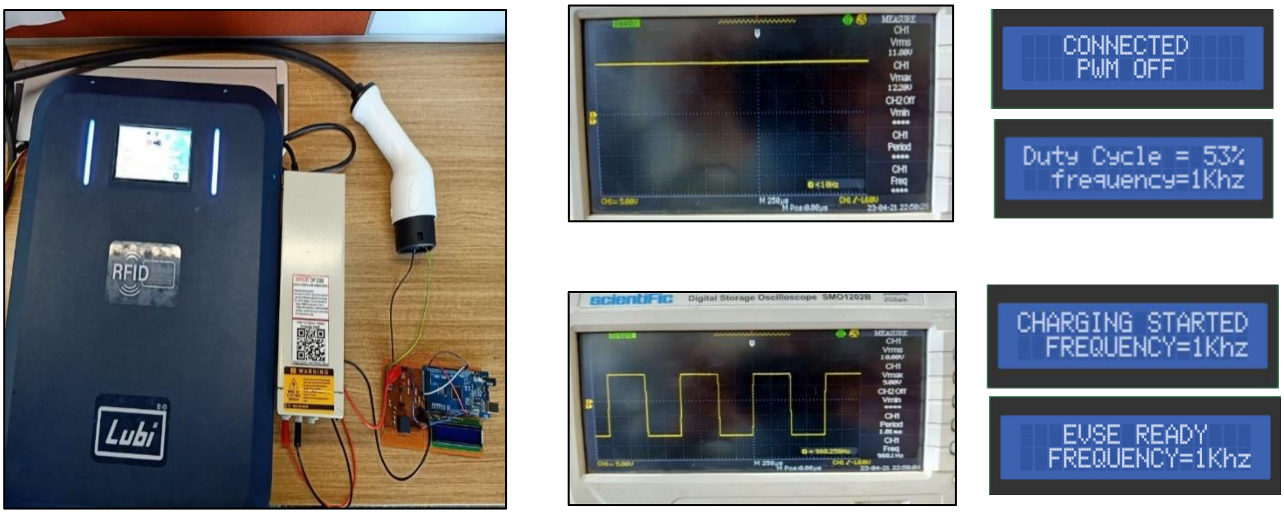

Fig. 12. Test Setup and results on simulator screen (Courtesy by: Lubi Industries LLP, Gujarat, India)

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VII. Conclusion and Future Work

The development of an EVSE simulator is an important step towards the wider adoption of electric vehicles. This simulator can be used to test and evaluate different charging scenarios, which can help in the design and implementation of more efficient and reliable EVSE infrastructure. The research paper illustratesthe effectiveness of the proposed simulator. The simulator provides a realistic environment for testing various charging scenarios, and it can help in identifying potential issues before they occur in real-world scenarios. The prototype is still in its early stages and a lot of work still needs to be done. There are several limitations of EVSE simulator which is compatible with all AC Standards but not compatible with DC chargers. Secondly, due to the constant power supply, it may get damage due to overheating or power supply may get off. Thirdly, we can replace 10-bit MCU. Moreover, we can add new functionality like Ground Fault Detection Features and Over Current measurement features.

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