# ELECTRIC VEHICLE (EV) CHARGE CONTROLLER

PROJECT REPORT

Submitted in partial fulfillment for the award of the degree

of

**BACHELOR OF TECHNOLOGY**

**IN**

**ELECTRONICS AND COMMUNICATION ENGINEERING**

SUBMITTED BY

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JUNE 2021

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***JUNE 2021***

**DEPARTMENT OF ELECTRONICS**
**MODEL ENGINEERING COLLEGE**
**THRIKKAKARA, KOCHI-682021**

## CERTIFICATE

This is to certify that this Project entitled ***ELECTRIC VEHICLE (EV) CHARGE CONTROLLER*** is the bonafide record of work carried out by **ABID ALI (MDL17EC002), ANAND RAJ (MDL17EC014), ATHIRA SURESH KUMAR (MDL17EC028)** and **BASIL BABY SAJEEV (MDL17EC032)** in partial fulfillment of the requirements for the completion of Degree of Bachelor of Technology in Electronics and Communication Engineering, at the Department of Electronics, Model Engineering College, Thrikkakara,Kochi.

| | | |
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| **Project Guide** | **Project co-ordinator** | **Head of the Department** |

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Abid Ali

Anand Raj

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# ABSTRACT

The electric vehicle industry in India is a growing industry. The central and state governments have launched schemes and incentives to promote electric mobility in the country and some regulations and standards are also in place. Electric vehicles (EVs) are a great way to save money and cut down on pollution at the same time. Most EVs come with a Level 1 charger that can be plugged into any standard 120-volt outlet, but many people would require a faster, dedicated charging station at home. Since a Level 1 charger could take many hours to charge a car, updating would ensure being ready to go, even if it is only possible to stop at home for a short time before heading out again. In this project, a level 2 charge controller is designed and developed that can either be hardwired to a house's electrical supply or can use a 230-volt outlet. It can charge the car in 2 to 5 hours, and need no professional installation, thus reducing costs.

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# List of Abbreviations

AV - Audio Visual

CCS - Conductive Charge System

CP - Control Pilot

CSMS - Charge Station Management system

DPST - Double Pole Single Throw

EEPROM - Electrically Erasable Programmable Read-only Memory

EV - Electrical Vehicle

EVSE - Electric vehicle supply equipment

GPRS - General Packet Radio Service

GSM - Global System for Mobiles

HDMI - High-Definition Multimedia Interface

IDE - Integrated Development Environment

LED - Light-Emitting Diode

OLED - Organic Light Emitting Diodes

PCB - Printed Circuit Board

PE - Protective Earth

| | | |
|---|---|---|
| PP | - | Proximity Pilot |
| PWM | - | Pulse Width Modulation |
| SAE | - | Society of Automotive Engineers |
| SMS | - | Short Message Service |
| USART | - | Universal Synchronous Asynchronous Receiver Transmitter |
| VCC | - | vehicle charge controller |

# Chapter 1

# INTRODUCTION


Figure 1.1: Electric vehicle charging procedure

The rapid growth of the EV market has led to a proliferation of connection and charging strategies, charger designs and charging networks.Slow chargers are typically rated at 3kW, and are mostly used in homes, ideally through a dedicated wall-box. They're not really suitable for public use because they charge too slowly.Fast chargers are found in public places, such as car parks and shopping centres, and may charge at rates of 7kW or 22kW. A 22kW charger could charge our generic 60kWh EV from zero to a full charge in around two and half to three hours.The rate at which electric vehicles (EV) can be charged is becoming a key differentiator in this rapidly developing market, for a very straightforward reason: charging an EV's battery is currently a lot slower than refilling a tank with petrol to go the same distance.

The dynamism of the EV marketplace is demanding the development of a wide variety of charging options, usually predicated upon where they will be used.Home charging solutions can be as simple as using a standard EVSE (Electric Vehicle Supply Equipment) charging cable to plug into a mains socket, or as complex as installing a wall-mounted charger. The design challenge here is to develop a safe, easy to install, charger suitable for production in relatively large volumes.

## 1.1 Motivation

Growing concern of carbon dioxide emissions, greenhouse effects and rapid depletion of fossil fuels raise the necessity to produce and adopt new eco-friendly sustainable alternatives to the internal combustion engine (ICE) driven vehicles in india . For this reason, in the last decade, EVs have become in some way widespread, principally because of their negligible flue gas emissions and lesser reliance on oil. But charging infrastructure, mainly setting up of level 2 charging at public level is the toughest challenge in terms of service integration for India. For normal charging, the charging time poses a serious problem as it ranges from 6 to 8 hours whereas for fast DC charging; cost and high renewable energy are the biggest factors which could pose a problem. It is also assumed that 10 percentage of the charging infrastructure required in India shall be composed of fast charging station and rest 90 percentage shall come from level 2 public charging setups.This project brings a cost effective solution for EV charge controller.

## 1.2 Aim

This project provides a COST EFFECTIVE SOLUTION to make an electric vehicle charge controller compliant with SAE J1772 standards.It covers the general physical, electrical, communication protocol, and performance requirements for the electric vehicle charge system. The charger will be type 2 AC, 30 Amps charger.

## 1.3 Scope and Relevance

AC charging is most common among electric vehicles. The Indian electric car market size was valued at 71.1 million USD in 2017 and is projected to reach 707.4 million USD by 2025. The price of a basic level 2 charging system can go as high as 20,000 Rs. In India Most cost effective chargers are imported from other countries.

# Chapter 2

# LITERATURE SURVEY

## 2.1 Literature Review

**Design and Implementation of AC Conductive Charging System for Electrical Vehicles**

An AC conductive charge system (CCS) based on SAE J1772 for electrical vehicle (EV) is proposed in this paper. This system is instituted by charge station management system (CSMS) and vehicle charge controller (VCC). The functions of CSMS include identifying the legal user ID, starting the charging management procedure, transmitting the control pilot signal to EV and waiting EV connector connected for charging. The VCC is used to confirm EV connector latched, transmit the charging messages to battery management system (BMS) and enable the onboard charger to charge the power battery pack. Finally, a CCS and 4kW onboard charger based on 48V/60Ah lithium-ion battery is implemented in this paper to verify the AC conductive charging for EV and the SAEJ1772 Standard.

**Modelling of Hybrid Electric Vehicle Charger and Study the Simulation Results**

The Plug in Hybrid Electric Vehicles are driven by the energy stored in the battery. Through conductive AC charging method, Electric vehicle supply equipment (EVSE) is connected to Electric vehicle(EV) for charging the battery. Apart from charging it can also help in creating trustworthy equipment ground track and exchange control data among EV and EVSE. This paper discusses electrical and physical interface between EV and EVSE to facilitate conductive charging and design of an on-board charger for fast charging of the hybrid electric vehicle. The aim of this project is to design interfacing system between EV and EVSE as per automotive industry standard and to design prototype of 3.45 kw on-board charger using Matlab software. By modelling the charger, charging of Li-ion battery can be done which is used for providing propulsion torque and through various stages of charger voltage and current level is controlled and make them desired for charging.

**Overview of SAE standards for plug-in electric vehicle**

With the increase in momentum in the transformation of the current grid to smart grid, there is an immediate need of proper standards in place for various distributed resources of energy. Electric vehicles are one such resource and have tremendous potential to play a part in the transformation of the grid and also to make the customers participate in clean technology initiatives. As with all new technologies, equipment, or processes, there is a requirement of body of standards that will govern the functioning of the electric vehicles and will also pave the way for easy assimilation into the fabric of consumer's lifestyle and vendors alike.

## 2.2 Objectives

Our objective is to Implement an electric vehicle charge controller compliant with SAE J1772 standards.The charge controller can configured for type 2 AC, 30 Amps charger.The charge controller also sends Relevant information to User regarding the charging state to the user.

## 2.3 Novelty

In this project, a cost-effective and affordable charge controller is developed.The electric vehicle industry in India is a growing industry and The price of a basic level 2 charging system can go as high as 20,000 Rs . thus we have designed a level 2 charge controller that combines all necessary elements; easily available electronic equipment, affordable solution with less software complexity Providing a cost effective solution. The Hardware is implemented in such a way that, the reliance on the code is reduced. Hence the code can be ported to a different micro-controller easily.In this project

# Chapter 3

# METHODOLOGY

## 3.1 Block Diagram

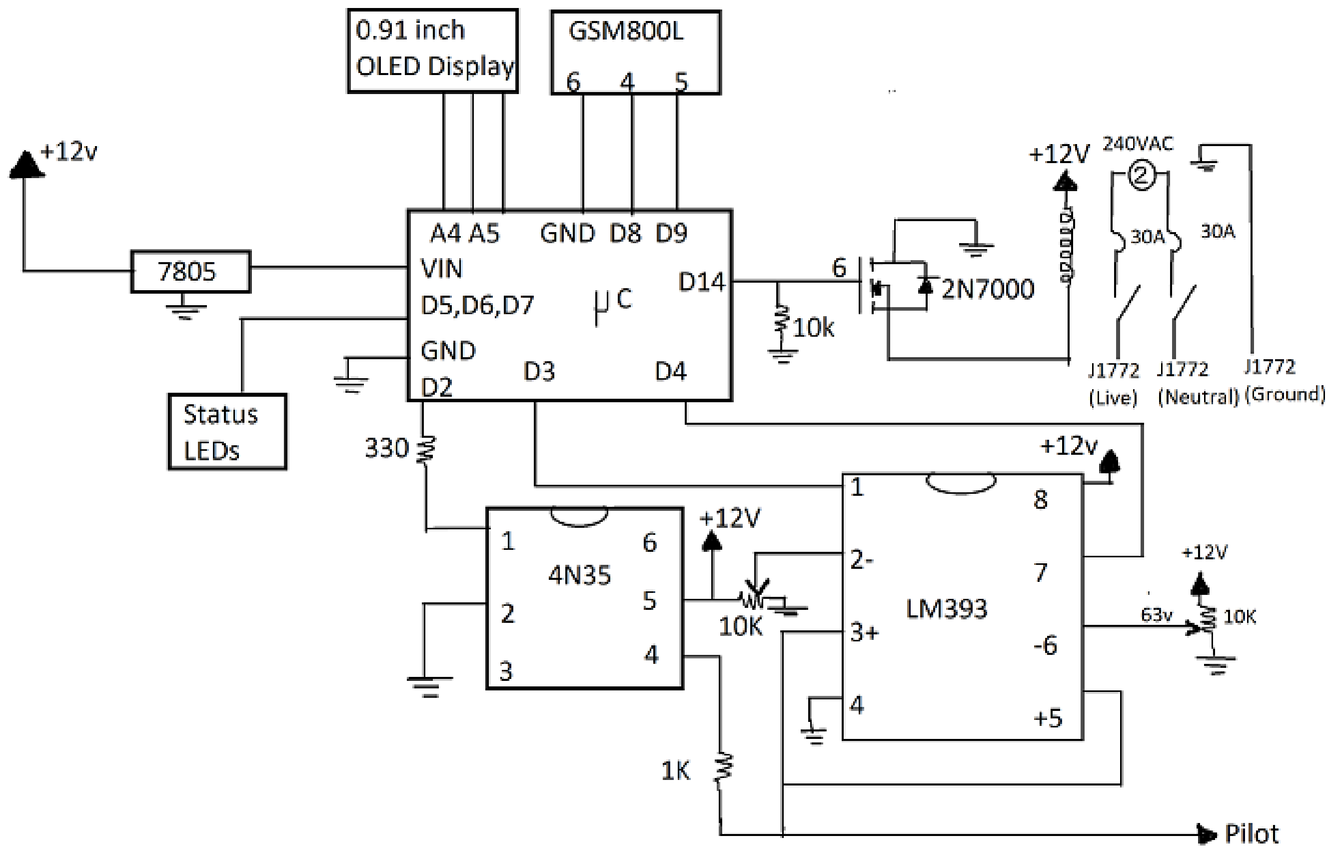


Figure 3.1: Block Diagram

## 3.2 Theory

SAE J1772 (IEC 62196 Type 1), also known as a J plug, is a North American standard for electrical connectors for electric vehicles maintained by the SAE International and has the formal title "SAE Surface Vehicle Recommended Practice J1772, SAE Electric Vehicle Conductive Charge Coupler". It covers the general physical, electrical, communication protocol, and performance requirements for the electric vehicle conductive charge system and coupler. The intent is to define a common electric vehicle conductive charging system architecture including operational requirements and the functional and dimensional requirements for the vehicle inlet and mating connector.

Figure 3.2: charger plug following SAE J1772

Essentially J1772 is a simple analog-control protocol that uses one data line (the pilot pin) to output a 1kHz pulse wave modulation (PWM) signal to the car. The duty cycle of the signal indicates to the car how much power it is allowed to draw from the house power line. The corresponding duty cycles are listed below: Peak voltage level of the PWM signal on the power pin secondarily is a status indicator of the car's connection to the charger. The status criteria is listed below:
During the charging process, the electric vehicle responds to certain conditions by altering the voltage level of the pilot line, which is then responded to by the microcontroller in the EVSE in order to provide correct

| AMPS | DUTY CYCLE |
|---|---|
| 5 | 8.3% |
| 15 | 25% |
| 30 | 50% |
| 40 | 66.6% |
| 65 | 90% |
| 80 | 96% |

Figure 3.3: J1772 Protocol PWM Duty Cycle and Corresponding Charge Rate

| STATE | PILOT HIGH VOLTAGE | PILOT LOW VOLTAGE | FREQUENCY | RESISTANCE | DESCRIPTION |
|---|---|---|---|---|---|
| State A | 12 V | N/A | DC | N/A | Not connected |
| State B | 9 V | –12 V | 1 kHz | 2.74 kΩ | EV connected, ready to charge |
| State C | 6 V | –12 V | 1 kHz | 882 Ω | EV charging |
| State D | 3 V | –12 V | 1 kHz | 246 Ω | EV charging, ventilation required |
| State E | 0 V | 0 V | N/A | — | Error |
| State F | N/A | –12 V | N/A | — | Unknown error |

Figure 3.4: J1772 Protocol Pilot Pin Charge State Diagram

and safe charging.

### 3.2.1 Connector

The J1772-2009 connector is designed for single phase electrical systems with 120 V or 24. The round 43-millimetre (1.7 in) diameter connector has five pins, with three different pin sizes (starting with the largest), for each of:

- Top left: AC Line 1
- Top right: AC Neutral (120V Level 1) or AC Line 2 (208 to 240V Level 2)
- Middle left: Proximity Pilot pin (PP), also known as ”plug present”
- Middle right: Control Pilot pin (CP)
- Bottom: Ground pin (PE, protective earth)

#### Proximity detection

Provides a signal to the vehicle's control system so it can prevent movement while connected to the electric vehicle supply equipment (EVSE; i.e., the charging station), and signals the latch release button to the vehicle.

### Control pilot

Communication line used to signal charging level between the car and the EVSE, can be manipulated by vehicle to initiate charging as well as other information. A 1 kHz square wave at ±12 volts generated by the EVSE on the control pilot line to detect the presence of the vehicle, communicate the maximum allowable charging current, and control charging begin/end.

### Signaling

The signaling protocol has been designed to supply equipment signals presence of AC input power.The vehicle detects plug via proximity circuit (thus the vehicle can prevent driving away while connected) and can detect when latch is pressed in anticipation of plug removal.

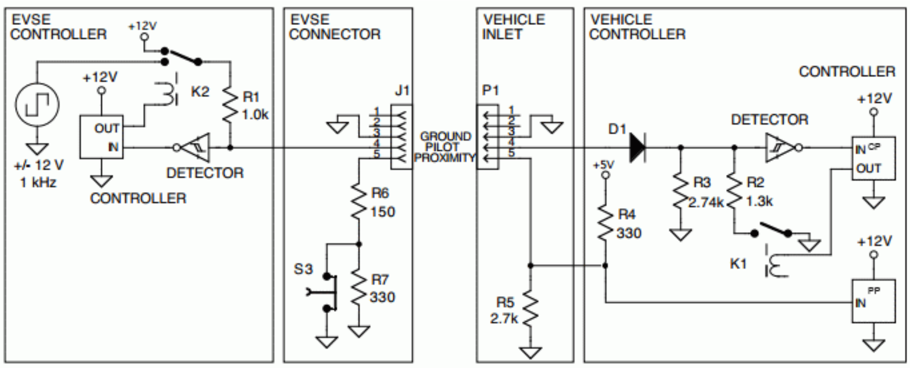


Figure 3.5: J1772 signaling circuit

The Control Pilot (CP) functions begin when supply equipment detects plug-in electric vehicle (PEV) and indicates to PEV readiness to supply energy,The PEV ventilation requirements are determined and the supply equipment current capacity provided to PEV.PEV commands energy flow and supply equipment continuously monitor continuity of safety ground.The charge continues as determined by PEV which may be interrupted by disconnecting the plug from the vehicle. The charging station puts 12 V on the Control Pilot (CP) and the Proximity Pilot (AKA Plug Present: PP) measuring the voltage differences. This protocol does not require integrated circuits, which would be required for other charging protocols, making the SAE J1772 robust and operable through a temperature range of negative 40 degree Celsius to positive 85 degree Celsius.

### 3.2.2 Control

#### Control Pilot (Mode)

The charging station sends a 1 kHz square wave on the control pilot that is connected back to the protected earth on the vehicle side by means of a resistor and a diode (voltage range ±12.0±0.4 V). The live wires of public charging stations are always dead if the CP-PE (Protective Earth) circuit is open, although the standard allows a charging current as in Mode 1 (maximum 16 A). If the circuit is closed, then the charging station can also test the protective earth to be functional. The vehicle can request a charging state by setting a resistor; using 2.7 Kilo Ohms a Mode 3 compatible vehicle is announced (vehicle detected) which does not require charging. Switching to 880 Ohms the vehicle is ready to be charged and switching to 240 Ohms the vehicle requests with ventilation charging in which case charging power is only supplied if the area is ventilated (i.e., outdoors). The Control Pilot line circuitry the charging is activated by the

| Base status | Charging status | Resistance, CP-PE | Resistance, R2 | Voltage, CP-PE |
|---|---|---|---|---|
| Status A | Standby | Open, or ∞ Ω | | +12 V |
| Status B | Vehicle detected | 2740 Ω | | +9±1 V |
| Status C | Ready (charging) | 882 Ω | 1300 Ω | +6±1 V |
| Status D | With ventilation | 246 Ω | 270 Ω | +3±1 V |
| Status E | No power (shut off) | | | 0 V |
| Status F | Error | | | −12 V |

Figure 3.6: base status and charging status of j1772

vehicle by adding parallel 1.3 Kilo Ohm resistor resulting in a voltage drop to +6 V or by adding a parallel 270 Ohm resistor for a required ventilation resulting in a voltage drop to +3 V. Hence the charging station can react by only checking the voltage range present on the CP-PE loop.

### Control Pilot (Current limit)

The charging station can use the wave signal to describe the maximum current that is available via the charging station with the help of pulse width modulation: a 16 percent PWM is a 10 A maximum, a 25 percent PWM is a 16 A maximum, a 50 percent PWM is a 32 A maximum and a 90 percent PWM flags a fast charge option

| PWM | SAE continuous | SAE short term |
|---|---|---|
| 50% | 30 A | 36 A peak |
| 40% | 24 A | 30 A peak |
| 30% | 18 A | 22 A peak |
| 25% | 15 A | 20 A peak |
| 16% | 9.6 A | |
| 10% | 6 A | |

Figure 3.7: PWM duty cycle indicating ampere capacity.

### 3.2.3 Proximity Pilot

Proximity Pilot: The Proximity pin, PP (also known as plug present), in the SAE J1772 , describes the switch, S3, as being mechanically linked to the connector latch release actuator. During charging, the EVSE side connects the PP-PE loop via S3 and a 150 ohm R6; when opening the release actuator a 330 ohm R7 is added in the PP-PE loop on the EVSE side which gives a voltage shift on the line to allow the electric vehicle to initiate a controlled shut off prior to actual disconnection of the charge power pins. However many low power adapter cables do not offer that locking actuator state detection on the PP pin..The resistor is coded to the maximum current capability of the cable assembly.

### 3.2.4 Safety

The J1772 standard includes several levels of shock protection, ensuring the safety of charging even in wet conditions. Physically, the connection pins are isolated on the interior of the connector when mated, ensuring no physical access to those pins. When not mated, J1772 connectors have no power voltages at the pins,and charging power does not flow until commanded by the vehicle. The ground pin is of the first-make, last-break variety. If the plug is in the charging port of the vehicle and charging, and it is removed, the shorter control pilot pin will break first causing the power relay in the EVSE to open, stopping current flow to the J1772 plug. This prevents any arcing on the power pins, prolonging their lifespan. The proximity detection pin is also connected to a switch that is triggered upon pressing the physical disconnect button when removing the connector from the vehicle. This causes the resistance to change on the proximity pin which commands the vehicle's onboard charger to stop drawing current immediately. The vehicle can then release the control pilot which will cause the power relay to release.

## 3.3 Methodology

Here, in this project there are 3 stages.

- First stage is Design a circuit that satisfies the JI772 standards.
- Second stage is testing the designed charge controller with a simulation circuit and verify the results.
- In the third stage, Design a case for the charge controller.

## Flow Chart

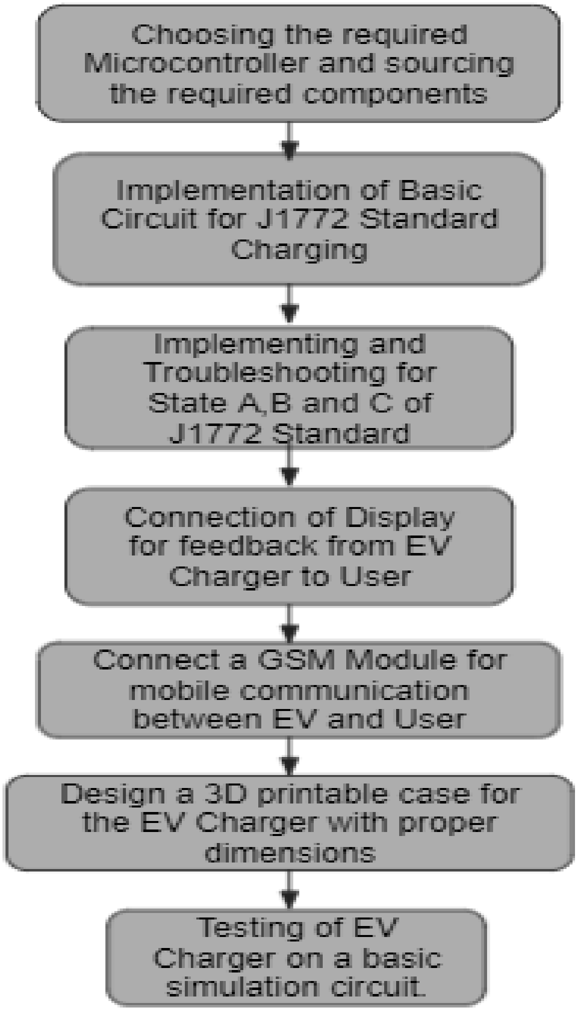


Figure 3.8: flow chart

## 3.4 Feasibility Study

Several gaps in the four-wheeler EV market such as a limited number of products, high prices, insufficient battery promise, low performance and an underdeveloped charging ecosystem are yet to be filled. Given these impediments, the growth of EV four-wheelers is expected to lag behind other segments. Sales are expected to pick up once these gaps are plugged. Through our project, we aim to build an economically feasible and easy to use charge controller for electric vehicles which utilises the J1772 safety protocols. Furthermore, the hardware has also been implemented in such a way that the reliance on the code has been kept to a minimum. Therefore the code is able to be ported to any microcontroller of choice as required. The charge controller along with the display and the gsm module ensure that the user is kept aware of the charging status of the EV at all times and the J1772 protocol that is followed is able to ensure minimal wastage of power during the charging process.

## 3.5 Cost Analysis

| Sl.No. | Components | Cost |
|---|---|---|
| 1. | Arduino Nano | 163₹ |
| 2. | T92P7D22-12-AC Relay | 968₹ |
| 3. | 4N35 | 15₹ |
| 4. | LM393 Comparator | 15₹ |
| 5. | SIM800L-GSM Module | 350₹ |
| 6. | 0.96 inch I2C/IIC 128x32-OLED Display | 195₹ |
| 7. | 2N7000 | 9₹ |
| 8. | 12V 2A SMPS | 180₹ |
| Total: 1895₹ | | |

Table 3.1: Cost Analysis

## 3.6 Detailed Analysis and modeling

### 3.6.1 Hardware Overview

#### Arduino Nano

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328P.The Arduino Nano is equipped with 30 male I/O headers, in a dip-30 like configuration, which can be programmed using the Arduino Software integrated development environment (IDE), which is common to all Arduino boards and running both online and offline.[2] The board can be powered through a type-b micro-USB cable, or through a 9V battery.It has a .Flash memory of 32Kb with SRAM memory of Microcontroller board is 8kb.It has an EEPROM memory of 1kb.It has 22 input/output pins in total out of which 14 of these pins are digital pins among this it has 6 PWM pins and 8 analogue pins.It has a crystal oscillator of 16MHz and operating voltage varies from 5V to 12V.

The ATmega328 is a single-chip microcontroller created by Atmel in the megaAVR family . It has a modified Harvard architecture 8-bit RISC processor core. The Atmel 8-bit AVR RISC-based microcontroller combines 32 KB ISP flash memory with read-while-write capabilities, 1 KB EEPROM, 2 KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. The device achieves throughput approaching 1 MIPS per MHz.

ATmega328 is commonly used in many projects and autonomous systems where a simple, low-powered, low-cost micro-controller is needed. Perhaps the most common implementation of this chip is on the popular Arduino development platform, namely the Arduino Uno and Arduino Nano models.

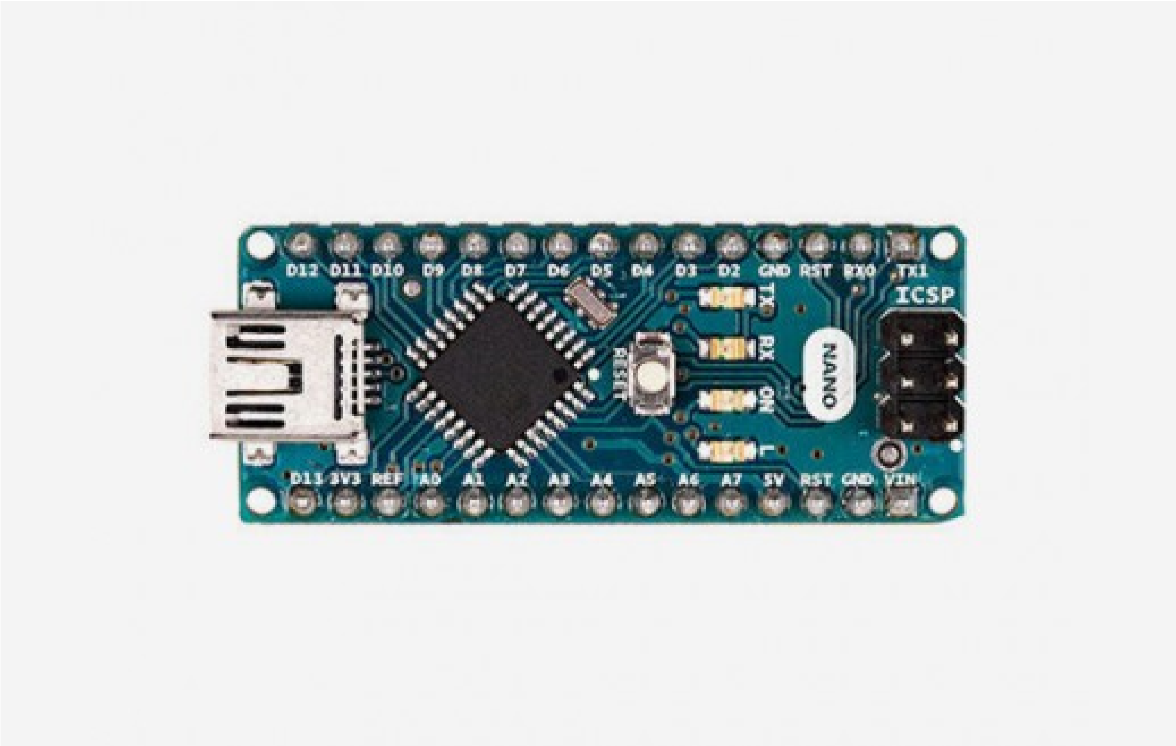


Figure 3.9: Arduino Nano

### T92P7D22-12-AC Relay

General Purpose Relay DPST-NO (2 Form A) 12VDC Coil Chassis Mount. It has 30/40/50A switching capability n Designed to control compressor loads to 3.5 tons, 110LRA / 25.3FLA n Meets requirements of UL 508 and UL 873 spacings - 8mm through air, 9.5mm over surface n Meets requirements of VDE 8mm spacing, 4kV dielectric coil-tocontact n Meets requirements of UL Class F construction n UL approved for 600VAC switching (1.5HP) n Screw terminal version .

Figure 3.10: T92P7D22-12-AC Relay

### 4N35 Opto-coupler

The 4N35 is an optocoupler that consists of a gallium arsenide infrared LED and a silicon NPN phototransistor. When the input signal is applied to the LED in the input terminal, the LED lights up. After receiving the light signal, the light receiver then converts it into electrical signal and outputs the signal directly or after amplifying it into a standard digital level. Thus, the transition and transmission of electricity-light-electricity is completed. Since light is the media of the transmission, meaning the input terminal and the output one are isolated electrically, this process is also be known as electrical isolation.It is used to prevent interference from external electrical signals. 4N35 can be used in AV conversion audio circuits. Broadly it is widely used in electrical isolation for a general optocoupler.

The Forward Diode Voltage:0.8 V with Minimum current:0.30ma and Max Collector-Emitter voltage is 30V

Figure 3.11: 4N35

### LM393 Comparator IC

LM393 is a Low Offset Voltage Dual Comparator IC, it has two comparators inside a single 8-pin package. The LM393 IC can be considered as the equivalent comparator version of the most popular LM358 Op-Amp.The LM393 proves itself to be advantages by providing an open collector output making it suitable to drive loads.The output transistor can drive loads upto 50V and 50mA which is suitable for driving most of the TTL, MOS and RTL loads. The transistor can also make the Load to be isolated from the system ground. It has a Wide power supply Range with Singe supply – 2V to 36V Dual supply – ±1V to ±18V The Drain Current of only 0.4mA and Input Offset Voltage is ±5mV maximum The Power Dissipation: 660mW and also the Output can be Isolated from System Ground. LM393 also has an Inverting Pin and a Non-Inverting Pin. If the voltage at the Non-Inverting Terminal (pin 2) is high than the Inverting Terminal (pin 2) the output (pin 7) will also be high else the output will be low.


Figure 3.12: LM393

### 12V 2A SMPS

Switching regulated 12VDC power supplies, sometimes referred to as SMPS power supplies, switchers, or switched mode power supplies, regulate the 12VDC output voltage using a complex high frequency switching technique that employs pulse width modulation and feedback.

The transistor in SMPS is used as a controlled switch.SMPS circuit is operated by switching and hence the voltages vary continuously.The switching device is operated in saturation or cut off mode.The output voltage is controlled by the switching time of the feedback circuitry.Switching time is adjusted by adjusting the duty cycle.The efficiency of SMPS is high because, instead of dissipating excess power as heat, it continuously switches its input to control the output. Input Voltage: AC 100 - 264V 50 / 60Hz Output Voltage: 12V DC, 2A Output voltage: Adjustment Eange: ±20


Figure 3.13: SMPS

### 2N7000

2n7000 is a uni-polar N-Channel Enhancement mode MOSFET which comes with terminals called drain source and gate.In this transistor, the input voltage applied at the gate terminal is used to control the conductivity between source and drain.The conducting path between source and drain is called channel whose length can be controlled by the input voltage at the gate terminal.As it is an enhancement mode MOSFET, it is assumed as OFF i.e. it doesn't conduct under normal operating condition when Vgs=0. It will start conducting when some input voltage is applied at the gate terminal.2n7000 is a 60 V device and comes in TO-92 enclosure. It is a voltage controlled device which is widely used in place of other BJT(Bipolar junction transistors)

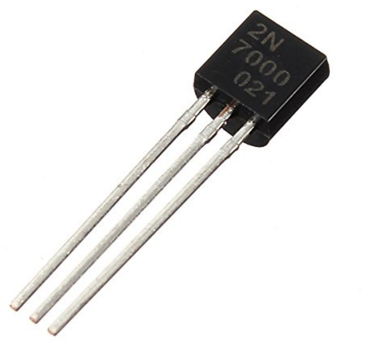


Figure 3.14: 2N7000 Mosfet

### SIM800L-GSM Module

SIM800L is a miniature cellular module which allows for GPRS transmission, sending and receiving SMS and making and receiving voice calls. Low cost and small footprint and quad band frequency support make this module perfect solution for any project that require long range connectivity.


Figure 3.15: GSM module

### 0.96 inch I2C/IIC 128x32-OLED Display

OLED (Organic Light Emitting Diodes) is a flat light emitting technology, made by placing a series of organic thin films between two conductors. When electrical current is applied, a bright light is emitted. OLEDs are emissive displays that do not require a backlight and so are thinner and more efficient than LCD displays (which do require a white backlight). The a ‘OLED’ stands for Organic Light-Emitting Diode - a technology that uses

LEDs in which the light is produced by organic molecules. These organic LEDs are used to create world's best display panels. Or OLED (Organic Light-Emitting Diode) is a self light-emitting technology composed of a thin, multi-layered organic film placed between an anode and cathode. The OLED display is used to provide real time charging status to the user. It uses I2C for communication with the NANO. The R6 and R7 pullup resistors are already soldered Once done, the module is ready for I2C communication.


Figure 3.16: OLED display

### 3.6.2 Software Overview

#### Platformio

A user-friendly and extensible integrated development environment with a set of professional development instruments, providing modern and powerful features to speed up yet simplify the creation and delivery of embedded products. Features:

- A lightweight but powerful cross-platform source code editor
- smart code completions based on variable types, function definitions, and library dependencies
- Multi-projects workflow with easy navigation around project codebase, multiple panes, and themes support

Figure 3.17: PlatformIO logo

## 3.7 Experimentation

The proposed system stresses on the need to follow J1772 protocol, which is the international standard for EVSE charging systems.

### 3.7.1 Setting Up the charger- Not charging

When the charger is plugged-in and not connected.The Charger enters its state A.This is indicated by the switching on of the ”device on” led on the case and the ”charger not connected” output on the display.At this state there is no live charge at the end of the charging cable.

Figure 3.18: An EVSE Charger

The charge controller on being turned is automatically set to state A.There is a 12v dc on the pilot pin of the charger as per J1772 standard which indicates the absence of a connection the the electric car.

### 3.7.2 Charger Connected Car Not Ready-Not Charging

When the charger is connected to the car a voltage drop is induced by the car. which is detected by a voltage comparatoe and the micro controller sets the charger to State B. This is indicated by the turning on of the ”charger Connected” Led on the case and A charger connected Message on the display.

Figure 3.19: State B-Car Connected

In this state the car is yet not ready to be charged so there is no live charge at the end of the charger.

### 3.7.3 Car Connected - Charging

When the car is ready to charge.It induces a further voltage drop across the pilot pin, Which is detected by the voltage comparator and lets the micro-controller know that the car is ready to charge. The charger now enters State C.

On entering State C, The Micro-controller turns on a DPST relay which provides both live and neutral line at the end of the charger which is used to charge the car.The charging state is indicated by turning on the ”charging” LED on the case. The Display also display ”charging” and a timer is shown on screen to keep track of the time charged.


Figure 3.20: State C-car charging

### 3.7.4 User Interaction Interfaces

Information regarding the charging states and Charging period is given to the user in 3 ways

- On-case LED
- On-case Display
- via SMS

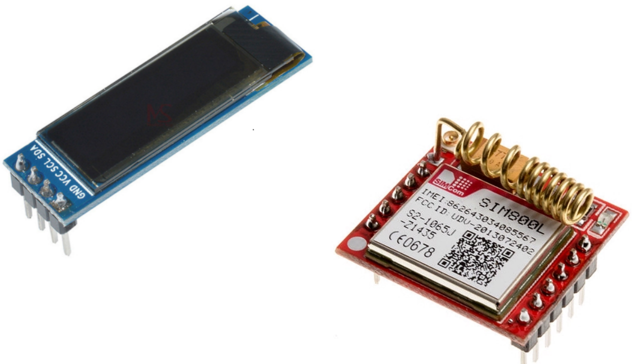


Figure 3.21: Display Elements

The on-case LEDs provide details regarding the various Charging states and let the user know if the car is charging.
The on-case Display information regarding the time elapsed while charging in addition to information regarding various states of charging

A GSM module is interfaced along with the charge controller to send information to the User's Phone number when the car begins charging and when the car stops charging.A detailed information of the time charged is also provided to the user in the latter message.

# Chapter 4

# RESULTS AND ANALYSIS

## 4.1 Circuit Implementation

Circuit implementation of the charge controller and simulation circuit

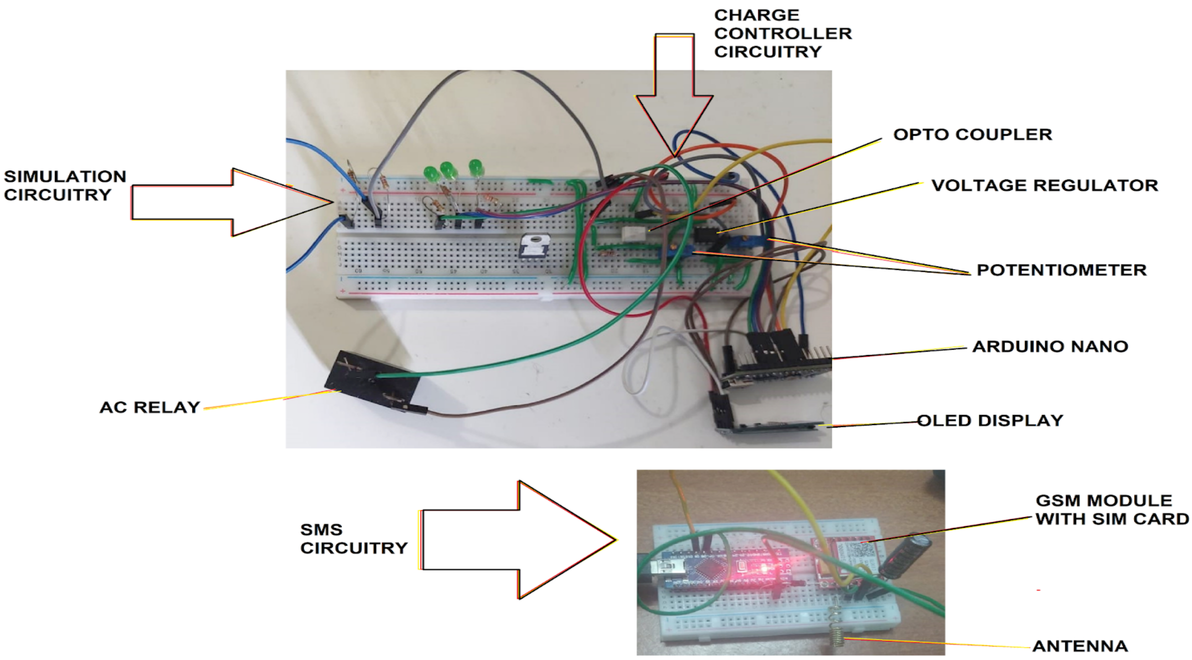


Figure 4.1: The final Circuit Implemetation

## 4.2 State A detection

The experimental setup for detecting state A of J1772 standard was made and the following results were obtained

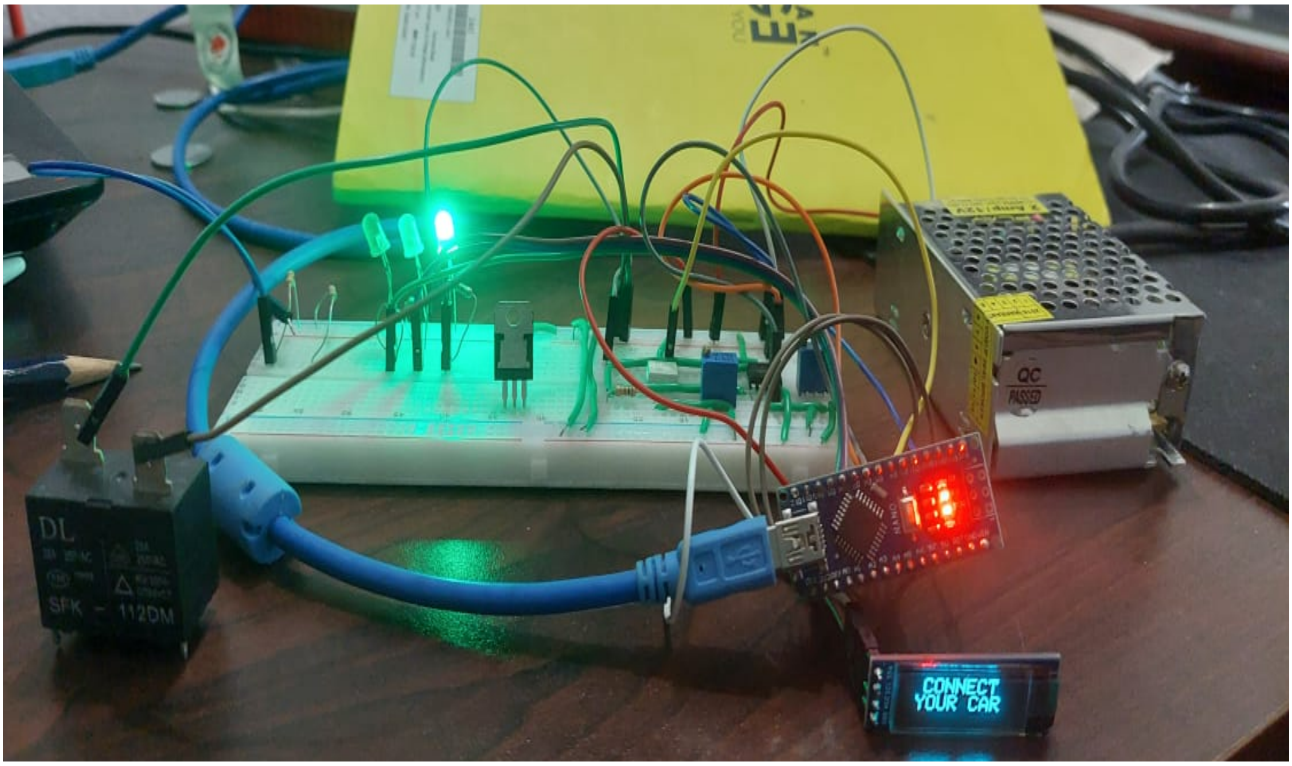


Figure 4.2: State A detection

## 4.3 State B detection

The experimental setup for detecting state B of J1772 standard was made and the following results were obtained

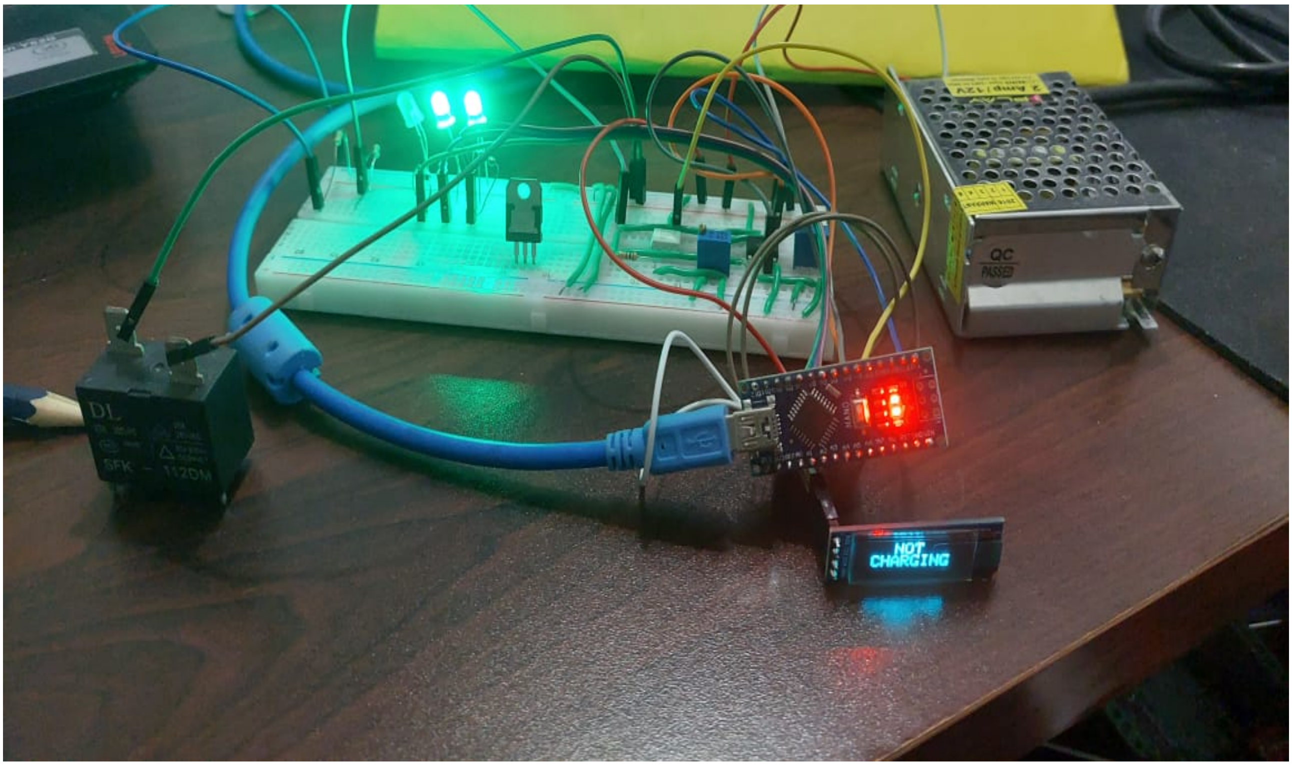


Figure 4.3: State B detection

## 4.4 State C detection

The experimental setup for detecting state C of J1772 standard was made and the following results were obtained

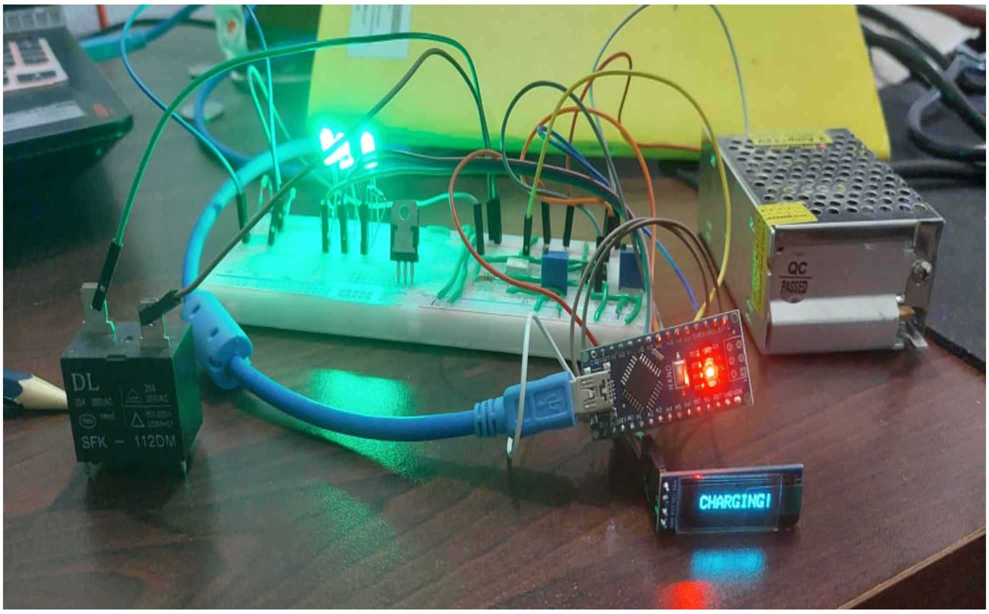


Figure 4.4: State C detection

## 4.5 CASE DESIGN

A Case for the Charged controlled was 3D printed with the following parameters

Case: Length = 24cm Breadth = 18cm Height = 5cm

Display: Length = 8cm Breadth = 3cm

Material-ABS


Figure 4.5: Case

# Chapter 5

# CONCLUSION

## 5.1 Conclusion

At the end of financial year 2019, almost 83 percent of the electric vehicles sold across India but sales of EVs i fell 20 per cent in the financial year 2020-21 to 2,36,802 units.Despite the low environmental impact and high energy efficiency, electric vehicles(EV) have not been widely accepted by people to date. The lack of charging infrastructure is one of the reasons. Cost of EV charging stations varies from Rs. 1 Lakh to Rs. 40 Lakhs depending on the types of chargers and investment one is willing to make.Considering all the above complications ,In this project we have developed a level 2 AC charger for electric vehicles.

This project presents the design of charge controller for electric vehicle applications. The proposed system is verified with the simulation and also the prototype is designed to charge an electric vehicle having a capacity of 48V 20Ah battery. The prototype is tested for different charging conditions and the results are tabulated.

In addition to, the thesis project presented the importance of AC charging to encourage people to adopt electric vehicle over traditional gasoline cars. The future work on the electric vehicle charge controller type 2 AC, 30 Amps charger compliant with SAE J1772 standards can be Implementation of safety features such as diode check and other features mentioned in the

J1772 standard. Perform Authentication before charging to identify the user and make payments automated.Creating an online database and a mobile application for the charge controller to improve the user interaction .Design and build a PCB.

## 5.2 Future Scope

EVs have three unique abilities which make them an excellent asset in the grid: the flexibility to vary their charging power, the capability to quickly ramp up/down the charging power and the ability to both charge and discharge. However, this potential is presently unused. Currently, EV charging is an uncontrolled process where the EV charges at a fixed power once connected to a charger and charges till the battery is full. With the use of smart charging, the EV charging power and direction can be continuously controlled (dynamic charging) Smart charging of EVs can provide several benefits to the EV owner and to the providers of the EV charging infrastructure:

- Reduce the cost of EV charging based on energy prices
- Provide new revenue streams like vehicle-to-grid
- Increase the use of solar energy for charging of EV in the day and wind in the night . EV battery can be a storage for renewables, so an extra storage is not required
- Reduce distribution system losses
- Reducing the peak demand on the grid due to EV charging by demand side management. This delays/negates the need for infrastructure upgrade in the distribution network
- Use the EV's fast ramp up/down potential to provide regulation services to the grid and for ancillary services like reactive power compensation and voltage control

- Implementing multiplexing of EV chargers and using a single charger for several EVs. This will drastically reduce cost of EV charging infrastructure.

The traditional approach to smart charging is to consider one or few of these applications in an optimization to reap direct or indirect economic benefits. While this method is simpler, it does not utilize the complete potential of smart charging and makes the benefits economically uninteresting. In the future, integration of several smart charging applications in a single framework will be the key. The benefits will then add up and the net gain will become economically attractive for large-scale implementation . In this project the type 2 AC EV charger, the EV and charger operate in a MASTER and SLAVE manner, respectively. A PWM pulse on the control pilot (CP) can be continuously adjusted on the EV charger to control the maximum charging power. Using the PWM limit as a constraint, the EV (master) determines the actual charging currenting. It is the duty of the EV charger (Slave) to deliver the requested current. Thus, by controlling the CP, variable power, dynamic, smart charging can be implemented

# Bibliography

[1] Y. Wu, "Design and implementation of ac conductive charging system for electrical vehicles," *IEEE Access*, pp. 282–288, 2019.

[2] T. Bohn and H. Chaudhry, "Overview of sae standards for plug-in electric vehicle," *International Conference on Emerging Frontiers in Electrical and Electronic Technologies (ICEFEET)*, pp. 1–7, 2020.

[3] A. Gaurav and A. Gaur, "Modelling of hybrid electric vehicle charger and study the simulation results," *IEEE Access*, pp. 1–6, 2020.

# Appendix A

# DATASHEET

## A.1 Arduino Nano

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328P released in 2008. It offers the same connectivity and specs of the Arduino Uno board in a smaller form factor

### A.1.1 Features

- he ATmega328 is a single-chip microcontroller created by Atmel. It has a Harvard architecture 8-bit RISC processor core.
- Flash memory of Arduino Nano is 32Kb
- SRAM memory of this Microcontroller board is 8kb.
- It has an EEPROM memory of 1kb.
- It has 22 input/output pins in total.
- Arduino Nano has 8 analogue pins.
- It has 6 PWM pins among the digital pins
- It has a crystal oscillator of 16MHz
- It's operating voltage varies from 5V to 12V.

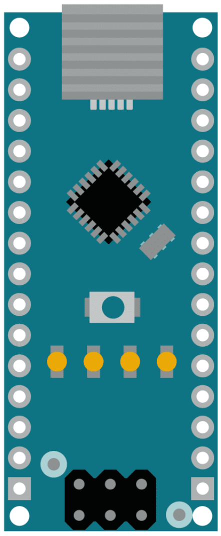


Figure A.1: Arduino Nano Pin Diagram

## A.2 4N35 Opto-coupler

Each optocoupler consists of gallium arsenide infrared LED and a silicon NPN phototransistor.

### A.2.1 Features

- Forward Diode Voltage:0.8 V
- Minimum current:0.30ma
- Max Collector-Emitter voltage is 30V
- Isolation test voltage 5000 VRMS
- Interfaces with common logic families
- Input-output coupling capacitance ¡ 0.5 pF

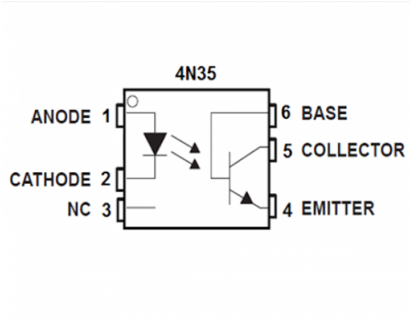


Figure A.2: 4N35 Opto-coupler pin Out

## A.3 LM393-Comparator

The LM193-N series consists of two independent precision voltage comparators with an offset voltage specification as low as 2.0 mV max for two comparators which were designed specifically to operate from a single power supply over a wide range of voltages

### A.3.1 Features

- Voltage Range: 2.0 V to 36 V
- Single or Dual Supplies: ±1.0 V to ±18 V
- Very Low Supply Current Drain (0.4 mA) —Independent of Supply Voltage
- Low Input Biasing Current: 25 nA
- Low Input Offset Current: ±5 nA
- Maximum Offset voltage: ±3 mV
- Differential Input Voltage Range Equal to the Power Supply Voltage
- Input Common-Mode Voltage Range Includes Ground

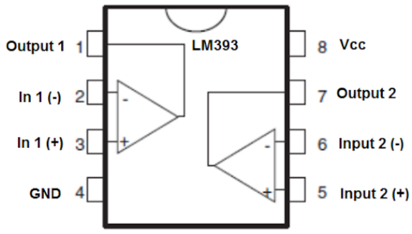


Figure A.3: LM393 pinout

## A.4 SIM800L-GSM Module

SIM800L is a miniature cellular module which allows for GPRS transmission, sending and receiving SMS and making and receiving voice calls.

### A.4.1 Features

- Supply voltage: 3.8V - 4.2V
- Recommended supply voltage: 4V
- Module size: 25 x 23 mm
- Interface: UART (max. 2.8V) and AT commands
- SIM card socket: microSIM (bottom side)
- Supported frequencies: Quad Band (850 / 950 / 1800 /1900 MHz)
- Antenna connector: IPX
- Working temperature range: -40 do + 85 ° C

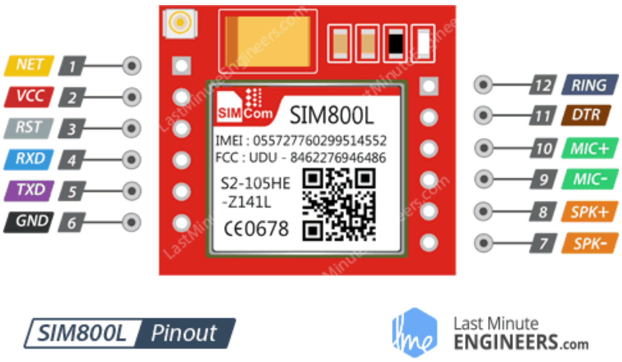


Figure A.4: GSM Module pinout

## A.5 0.96 inch I2C/IIC 128x32-OLED Display

SIM800L is a miniature cellular module which allows for GPRS transmission, sending and receiving SMS and making and receiving voice calls.

### A.5.1 Features

- OLED Driver IC: SSD1306
- Operating Voltage: 3.3-5V
- Resolution: 128 x 32
- Text Color: Blue
- Work perfectly well without the need of back light.
- 128*32 high resolution, ultra wide viewing angle
- The display is self-illuminating
- Interface: I2C

# Appendix B

# CODE SEGMENTS

```
#include <SPI.h>
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
#include <SoftwareSerial.h>
SoftwareSerial sim800l(2, 3);

#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 32 // OLED display height, in pixels


#define OLED_RESET   6 // Reset pin # (or -1 if sharing Arduino reset pin)
#define SCREEN_ADDRESS 0x3C ///< See datasheet for Address; 0x3D for 128x64, 0x3C for 128x32
Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);

#define LOGO_HEIGHT 16
#define LOGO_WIDTH  16

const int PilotPin = 3;
const int ChargeRequestPin = 4;
const int VehicleDetectPin = 5;
const int PowerRelay = 12;
bool VehicleDetected = false;
bool ChargeRequested = false;

int k,l;

int t; //check charge duration flag


void displayResult();

const int led1 = 7;
const int led2 = 8;
```

```
const int led3 = 9;

unsigned long start, finished, elapsed;    //create unsigned long integer variables for start
    finished elapsed
float h, m, s, ms;

void setup() {

    Serial.begin(9600);
    sim800l.begin(9600);
    delay(1000);
  // SSD1306_SWITCHCAPVCC = generate display voltage from 3.3V internally
  if(!display.begin(SSD1306_SWITCHCAPVCC, SCREEN_ADDRESS)) {
    Serial.println(F("SSD1306 allocation failed"));
    //for(;;); // Don't proceed, loop forever
  }

  // Clear the buffer
  display.clearDisplay();

  // put your setup code here, to run once:
  pinMode(PilotPin, OUTPUT);
  pinMode(11, OUTPUT);
  TCCR2A = _BV(COM2A1) | _BV(COM2B1) | _BV(WGM21) | _BV(WGM20);
  TCCR2B = _BV(CS22);
  OCR2A = 180;
  OCR2B = 50;
  pinMode(ChargeRequestPin, INPUT_PULLUP);
  pinMode(VehicleDetectPin, INPUT_PULLUP);
  pinMode(PowerRelay, OUTPUT);
  pinMode(led1, OUTPUT);
  pinMode(led2, OUTPUT);
  pinMode(led3, OUTPUT);

  digitalWrite(PowerRelay, LOW);
  analogWrite(PilotPin, 255);
  digitalWrite(led1, HIGH);
   Serial.begin(9600);
  Serial.println("Started");

}

void loop() {
  // put your main code here, to run repeatedly:

  CheckStatus();

  Serial.println(k);
```

```
Serial.println(l);

if(VehicleDetected == true){
  digitalWrite(led2, HIGH);
  analogWrite(PilotPin, 64);
  Serial.println("State B");
  l++;

}

else{
  digitalWrite(led2, LOW);
  analogWrite(PilotPin, 255);
  Serial.println("State A");
  k++;
display.setTextSize(2);
display.setTextColor(WHITE);
display.clearDisplay();
display.setCursor(20,0);
display.println("CONNECT");
display.println(" YOUR CAR");
display.display();
t=0;
}

 if(VehicleDetected == true && ChargeRequested == true){
  delay(1000);
  CheckStatus();
 if(VehicleDetected == true && ChargeRequested == true){
  digitalWrite(led3, HIGH);
  digitalWrite(PowerRelay, HIGH);
  Serial.println("State C");

  if(t==0){
   start = millis();                          //start = current millis
       display.clearDisplay();
   display.setTextSize(2);
display.setTextColor(WHITE);
display.setCursor(20, 10);
// Display static text
display.println("CHARGING!");
display.display();
  }
  finished = millis();
  displayResult();
  t=1;
```

```
    //display

   }
   else{
    digitalWrite(led3, LOW);
    digitalWrite(PowerRelay, LOW);

   display.clearDisplay();
   display.setTextSize(2);
  display.setTextColor(WHITE);
  display.setCursor(40,0);
  // Display static text
  display.println("NOT");
  display.println(" CHARGING");
  display.display();
   t=0;
   }

   }
   else{
    digitalWrite(led3, LOW);
    digitalWrite(PowerRelay, LOW);


   }
   }
void CheckStatus(){
  Serial.println("checking status");
   VehicleDetected = !(digitalRead(VehicleDetectPin));

    if(pulseIn(ChargeRequestPin, HIGH, 5000) > 0){
    ChargeRequested = false;
  }else{
      ChargeRequested = true;
  }

}

void displayResult()                           //create a function called displayResult
{
  display.setTextSize(1);                      //set display params
  display.setTextColor(WHITE);                 //set display params
  display.setCursor(0,0);                      //set display params
  display.clearDisplay();                       //clear display & buffer
  unsigned long over;                           //create unsigned long integer variable over
  elapsed = finished - start;                   //elapsed time is finished minus start
  h = int(elapsed / 3600000);                   //h is the integer created by dividing elapsed by
      360000
```

```
  over = elapsed % 3600000;                 //over is created by elapsed modulo 360000
  m = int(over / 60000);                    //m is the integer created by dividing over (seconds
      over 60) by 60000
  over = over % 60000;                      //new over is over modulo 60000
  s = int(over / 1000);                     //seconds is the integer created by dividing over by
      1000
  ms = over % 1000;                         //ms is created by new over modulo 1000
  display.print("Charging!:       ");             //send a title for elapsed to display buffer
  //display.println(elapsed);                 //send the raw elapsed time (miliseconds) to display
      buffer
  display.println("Duration: ");           //send title for h,m,s,ms to display buffer
  display.print(h, 0);                      //send value to display buffer, no decimals
  display.print("h ");
  display.print(m, 0);                      //send value to display buffer, no decimals
  display.print("m ");
  display.print(s, 0);                      //send value to display buffer, no decimals
  display.print("s ");
  display.print(ms, 0);                     //send value to display buffer, no decimals
  display.println("ms");
  display.println();                        //send blank line to display buffer
  display.display();                        //show buffer data on display
  SendSMS();
}

void SendSMS()
{
  Serial.println("Sending SMS...");          //Show this message on serial monitor
  sim800l.print("AT+CMGF=1\r");              //Set the module to SMS mode
  delay(100);
  sim800l.print("AT+CMGS=\"+*********\"\r"); //Your phone number don't forget to include your
      country code, example +212123456789"
  delay(500);
  updateSerial();
  sim800l.print("Car unplugged,");//This is the text to send to the phone number, don't make it
      too long or you have to modify the SoftwareSerial buffer
  sim800l.print("Elapsed:");
  sim800l.print(h, 0);
  sim800l.print("h ");
  sim800l.print(m, 0);
  sim800l.print("m ");
  sim800l.print(s, 0);
  sim800l.print("s ");
  delay(500);
  updateSerial();
  sim800l.print((char)26);// (required according to the datasheet)
  delay(500);
  sim800l.println();
  Serial.println("Text Sent.");
```

```
  delay(500);

}

void updateSerial()
{
  delay(500);
  while(Serial.available())
  {
    sim800l.write(Serial.read());//Forward what Serial received to Software Serial Port
  }
  while(sim800l.available())
  {
    Serial.write(sim800l.read());//Forward what Software Serial received to Serial Port
  }
}
```