SOLAR POWERED PORTABLE ELECTRICAL VEHICLE CHARGING STATION

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Abstract - *Electrical vehicles (EV) are actually need of the hour in this drastically degrading environment.*

By 2030, the Government of India plans to have only EV in India. Fast charging of EVs and Charging Infrastructure is required to make EVs widely acceptable as the charging time is the key barrier standing in the way of widespread acceptance of EV. Thus, important enabler of the transformation will be – Smart Infrastructure for charging the EV. This will empower futuristic vision of the Nation.

One of the important aspects of this transformation is having an approving charging infrastructure. The present power system could face huge instabilities with wide spread of EVs. This project named 'Solar Powered Portable Electrical Vehicle charging station' uses hybrid power system. The solar energy is converted to electrical and used to charge the lead acid battery, which in turn charges the battery of the EVs connected to this station. When the energy from solar panels is not sufficient to meet the demands, electricity from power grid is utilized. Electric Vehicle battery charger is a business of imminent potential. Currently its worth is of billions of dollars, and supports millions of vehicles worldwide and is expected to grow exponentially in coming years. In such a scenario, it is crucial to provide public charging service. In order to make this more user-friendly a set of facilities are attached along with this station like user authentication, LCD display, audio interaction, WIFI connectivity, cloud storage and thingspeak platform. They could be installed at: Hotels, clubs, Retail stores, railway stations, Shopping malls, Universities, Colleges, Airports etc.

Key Words: *Dual power supply charging station, ESP32 MCU, cloud storage, user-friendly facilities, RFID, Smart infrastructure.*

1. INTRODUCTION

The widespread introduction of electric vehicles (EVs) is a major goal amongst policy makers because of their potential to significantly reduce the CO2-emissions of the transportation sector and thus the reliance on fossil fuels for transportation. Especially interesting fields of application for EVs are urban areas, where benefits such as virtually no local exhaust and noise emissions by far outweigh their currently limited available range. Hence, many cities such as Amsterdam introduce strong incentive programs to support the introduction of EVs. However, EVs are expensive due to high battery costs and limited in their usability compared to conventional vehicles.

Commercial success for EVs will require installing charging infrastructure that is accessible, easy to use, and relatively inexpensive—whether at home or in public locations. The form this infrastructure will take is still uncertain, with a range of charging technologies currently available and more expected to emerge over the next five years. The current range of equipment spans slower alternating current (AC) chargers best suited to home or office locations and short trips (Level 1-2 in this paper), and much faster direct current fast chargers (DCFC) for rapid refuelling in public locations, best suited for recharging on longer journeys (Level 3-5). The time taken to add 100 miles of range varies from 26 hours for the slowest AC charger, to six minutes for the fastest DCFC charger—still far slower than the 300 miles-per-minute enjoyed by a 30 mile-per-gallon ICE.

The vehicle battery charging station using hybrid power system developed in this work provides a unique service to the traveller who wishes to travel for a long distance using electric vehicle. For such users in between over the highways there should be an electric charging station to recharge their vehicle. The vehicle battery charging station can be quickly and easily installed outside any business premises.

1.1 Basic assumptions

The design of RF ID based Solar Powered Portable Electrical Vehicle charging station relies on the following assumptions:

- Maximum solar energy is used for charging the lead acid battery inside the vehicle battery charger to keep it charged fully all the time
- The charging current is up to 1 amp @ 48vDC
- A single solar panel of size 635 x 550 x 38 mm, 37WP capable of supplying up to 5 amp is used.
- Provision to charge maximum 1 vehicle is provided.

2. METHODOLOGY

The proposed protype uses AC supply from grid. Transformer is used to step down(220v/54v) the voltage from the distribution grid voltage level to EVs battery voltage levels. AC/DC converter transforms the ac power into dc power and forms a dc bus. EVs are connected to the DC bus for charging via DC-DC converters.

The DC bus makes it possible to connect Renewable Energy Sources (RESs) generation systems directly through a simple DC-DC converter, that is DC supply from solar panel is passed via solar charge converter and DC-DC converter to be stored in Lead Acid (PbA) battery through a suitable battery charger.

The prototype focuses on building an electric charging station which fills in the cavity that acts as obstruction in the penetration EVs globally. Thus, few user-friendly facilities are added and enabled with microcontroller unit to enhance the overall consumer experience.

Few other facilities attached are, for example, the RF ID reader and card enables easy authentication of every user. LCD display shows the charging time selected and the amount of money deducted/ left. Voice recorded memory chip enables recorded audio instructions to the user. With help of WIFI mod all the data is stored in thingspeak platform, which can be analysed and processed for further advancement.

3. MAJOR SUBSYTEMS

1) Hybrid Source Management Module
2) Station Management Module
3) Charging Point
4) Vehicle Side Subsystem
5) User Management Module

3.1HYBRID SOURCE MANAGEMENT MODULE

The hybrid source management module consists of two sources i.e., solar panel source and an electric grid source. The power drawn from the power grid is converted from AC to DC and the noise from both of the sources in the supply is reduced using a DC-DC converter. This power is then stored in a battery. In this project, we used a lead-acid battery of 48V rating.

3.2STATION MANAGEMENT MODULE

The station management module consists of the ESP 32 microcontroller. Various peripherals such as the keyboard for input, LCD display for output and a voice memory chip for an audio output is connected to it. The module is given a 12 V input from the battery and the charging of the vehicle is monitored through the charging regulator. A charging point is connected to the charging regulator.

3.3CHARGING POINT

To charge the lead acid battery of the car, a battery charger is required which can increase the charge of the battery. For this project, a 12V, 2A battery charger is used which can be used to charge the battery of the electric vehicle.

3.4VEHICLE SIDE SUBSYSTEM

The vehicle side subsystem is used to verify the results of the charging system. The vehicle side subsystem consists of an ESP32 microcontroller, a 48 V power supply, an LCD display and a voltage sensor. The 48V is given through the lead acid battery which is used to run the vehicle. The voltage level is detected by using voltage sensor which is then sent to the ESP and the output is then displayed through the LCD display.

3.5USER MANAGEMENT MODULE

The ensure that the user of the charging station is verified and receives timely updates about the charging condition of the vehicle, a user management module is used. It consists of an RFID sensor unit for user verification and a server on Thinkspeak cloud platform to retrieve the data about the various details of the battery.

4. SIGNIFICANT COMPONENTS

4.1 SOLAR PANEL (PHOTOVOLTAIC (PV) MODULE):

A solar panel (Photovoltaic (PV) module) is a device that produces a flow of electricity under sunlight. This electricity is accustomed charge batteries and, with the help of an inverter, it can power normal household electrical devices or loads.

Solar cells can either be monocrystalline (cut from one silicon source) or polycrystalline (from multiple sources). Let's look at the differences between the two options. Amongst the few types available Monolithic Solar Panels are used for this project.

Fig 01: Monocrystalline solar panels

Monocrystalline solar panels contain cells that are cut from one crystalline silicon ingot. The composition of those cells is purer because each cell is formed from one piece of silicon[4].

Solar panel specifications

- Total number of panels- 3 nos
- Maximum Power (Pmax) = 5 Watts * 3 = 15 Watts
- Maximum Power Voltage = 18 Volts * 3= 54Volts
- Open Circuit Voltage (Voc) = 18 Volts
- Short Circuit Current (Isc) = 1 Amp
- Temp coefficient of ISC = 0.08x102 A/C°
- Cells - 36
- Cell Technology - Monocrystalline Cell Shape – Rectangular

Therefore, the intensity of each solar panel = 5 watts

4.2 DC – DC CONVERTER:

DC-DC converters are also known as Choppers. Here we will have a look at Buck Boost converter which can operate as a DC-DC Step-Down converter or a DC-DC Step-Up converter depending upon the duty cycle (D)[3].

In this project the dc output from solar panels which bear voltage in the range of 46V to 54V is fed into the input of the Buck Boost converter, which produces a constant DC voltage of 48V.

When the sunlight is sufficient or more than necessary then voltage produced by PV solar panels is approx. 54 V for the given specifications of the PV modules.in that case the DC-DC converter bucks the input, that is lowers the input value to give constant 48V output.

Similarly, when it's a cloudy day or when there's no sunlight (at night) the voltage produced by PV solar panels is approx. 46 V for again for given specifications.in such case the DC-DC converter boosts the input, that is apprehends the input value to give constant 48V output. The DC-dc converter uses PID converter to provide constant sensitive output. the simulation of DC-DC Buck Boost converter is shown below, done using MATLAB along with the circuit diagram.

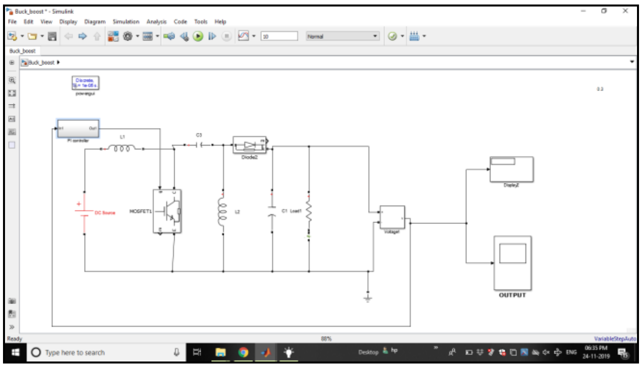

Fig 02: Block diagram of DC-DC Buck Boost Converter

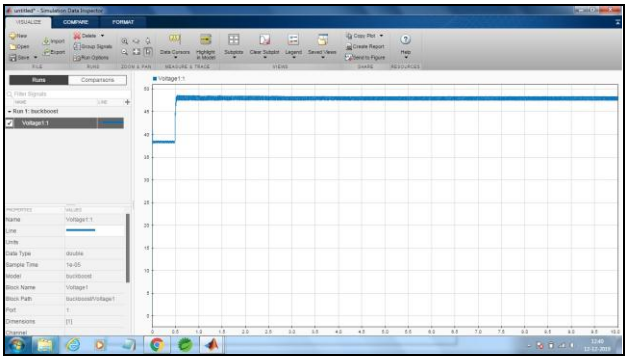

Fig 03: Simulation of DC-DC Buck Boost converter using MATLAB

4.3 RECTIFIER

An electrical device that is used to convert alternating current into direct current is called as rectifier. Every electronics system which is made of embedded systems-based circuit or project consists of micro-controller as major component [2].

The power from the grid is of AC form, at the customer end it is of magnitude 220V -230V. Now when the EV is connected to the charging station, the power conversion of suitable form happens like this. First an AC transformer steps down the voltage from 220V to 54V keeping the frequency and power same. Then this 54V is converted from its AC form to DC form with the help of a Bridge rectifier. The output of bridge rectifier is 54V variable DC, which is then sent to DC-DC converter to obtain stable, constant DC.

4.4 BATTERY

The Lead Acid battery which uses sponge lead and lead peroxide for the conversion of the energy into electric power, such style of battery is termed a lead acid battery. The lead acid battery is most generally employed in the power stations and substations because it's higher cell voltage and lower cost.

Some general specifications of the standard Lead Acid Battery
Nominal cell voltage: 2.1 V
Charge/discharge efficiency: 50–95%
Charge temperature interval: Min. −35 °C, max. 45 °C
Self-discharge rate: 3–20%/month
Specific energy: 35–40 Wh/kg
Energy density: 80–90 Wh/L
Specific power: 180 W/kg
In this project we aim at using 4 nos of 12V, 1Ah capacity.so that makes the total capacity as:
If connected in series: 4*12=48 V, 1Ah capacity.
If connected in Parallel: 12V, 4Ah capacity.
Since the optimum voltage to be fed in to the battery is 48 V we'll choose series connection of the Lead Acid batteries for the project.

4.5 RADIO-FREQUENCY (RF):

Radio frequency Identification (RFID) is termed as wireless identification technology that uses radio waves to spot the presence of RFID tags. Just like Universal Product Code reader, RFID technology is employed for identification of individuals, object etc. presence.

RFID based system has two basic elements:

1. RFID Tag: RFID tag has microchip with radio antenna mounted on the substrate which carries 12 Byte unique Identification number.
2. RFID Reader- It reads unique ID from RFID tags. Whenever RFID tags comes in range of the RFID reader, it detects the unique ID on from the RFID tad and communicates it serially to the microcontroller or PC. RFID reader has transceiver and an antenna mounted upon it. It is mostly fixed in stationary position.

4.6 LCD DISPLAY:

A liquid-crystal display (LCD) is a smooth panel display, electronic video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly.

LCDs are utilized in a good range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, and signage.

In this project the LCD shown in the above figure is used .it is of configuration 16 X 2.

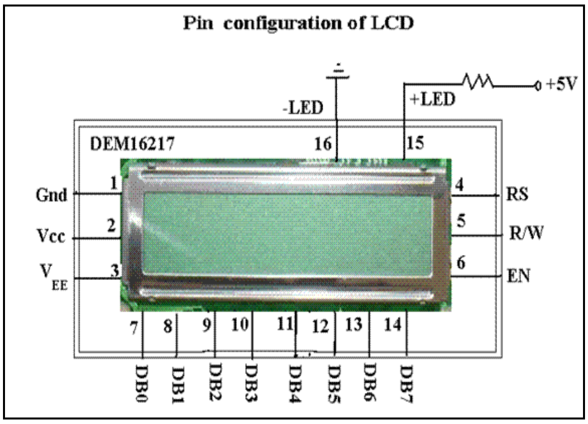

Fig 04: LCD

It basically facilitates monitoring and shows various selected parameters such as

- Voltage of solar panels
- Time left/selected for charge
- Balance left/ deducted from the user account

4.7 ESP 32 - NODE MCU

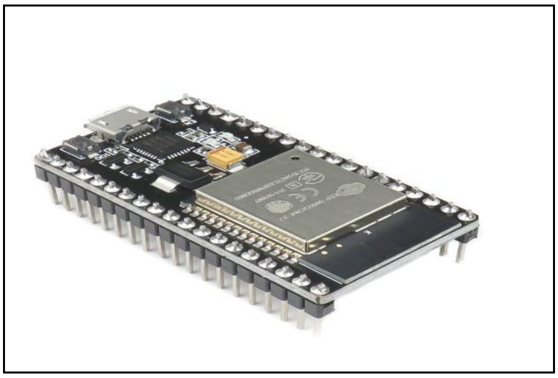

Fig 05: ESP 32

The ESP WROOM 32 is a great, generic module that has WIFI-BLUETOOTH-LOW ENERGY as its prominent features. It targets a wide variety of applications, ranging from low-power sensor networks to the most demanding tasks, such as audio encoding, MP3 streaming and decoding.

At the core of this module is a ESP32S chip, which is meant to be scalable and adaptive. There are 2 CPU cores which will be individually controlled or powered, and therefore the clock frequency is adjustable from 80 MHz to 240 MHz . The main use of the Node MCU in this project is to transfer the data over WIFI and store it in cloud for storage and analysis.

Its another important task here is to convert the Analog data to digital data that can be displayed on LCD.

4.8 I2C

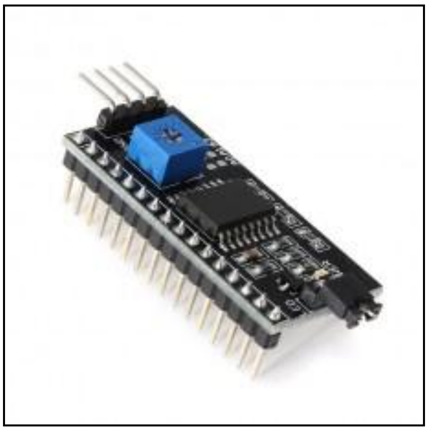

Fig 06: I2C Module

I2C combines the best features of serial peripheral interface (SPI)and universal asynchronous receivers - transmitters (UARTs). With I2C, you'll be able to connect multiple slaves to one master (like SPI) and you'll have multiple masters controlling single, or multiple slaves. This is used because here in this project we have more than one displaying text to a single LCD.

4.9 CLOUD COMPUTING (THING SPEAK)

The data visualization and storing will be done in MathWorks's Thingspeak platform.

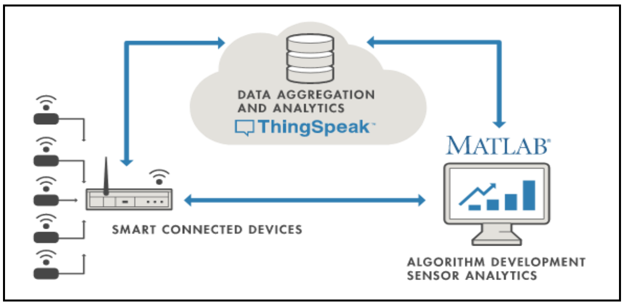

Fig 07: use of Thinkspeak

The data collected over thingspeak can be viewed on PC or mobile application. this project aims at collecting

1. user end credentials for authentication
2. Time selected for charging the vehicle
3. Frequency of usage/charging etc.

All of this data can be analysed to draw study various aspects like the frequency of a particular customer, time he/she usually selects for charging, money spent, type/ company of automobile etc.

4.10. SOLAR CHARGE CONTROLLER

A solar charge controller is basically a voltage or current controller used to charge the battery and keep electric cells from overcharging [1].

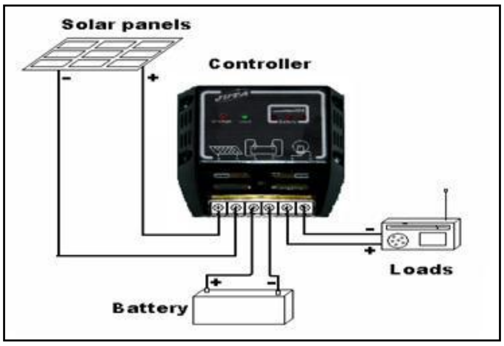

Fig 08: Solar charge controller

It directs the voltage and current hailing from the solar panels setting off to the electrical cell. Generally, 12V boards/panels put call at the ballpark of 16 to 20V, so if there's no regulation the electrical cells will damage from overcharging.

4.11 BATTERY CHARGER:

When the Lead Acid battery discharges, it is charged again Like every device which needs its charger to gain back the lost charge, lead acid battery requires on of its kind to recharge. this is what battery charger is meant for.

Fig 09: A Solar battery charger

A simple 12V, 2A battery charger is shown in the above figure.

4.12 TRANSFORMER:

A transformer is defined as a passive device that transfers power from one circuit to secondary through the method of electromagnetic induction. It is most typically utilized increase ('step up') or decrease ('step down') voltage levels between circuits[5].

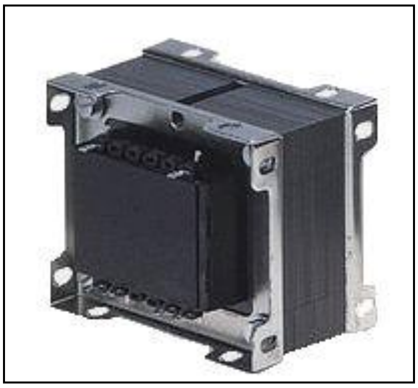

Fig 10: Voltage transformer

The power supply from the grid at the consumer end is in terms of 220V-230V, to convert this voltage to usable form , it is stepped down to 54V.using a small voltage transformer as above.

4.13 PUSH BUTTON/ KEYBOARD

Push-Buttons are normally-open tactile switches. Push buttons allow us to power the circuit or make any particular connection only we press the button. Simply, it completes the circuit connected when pressed and breaks when released. A push button is additionally used for triggering of the SCR by gate terminal.

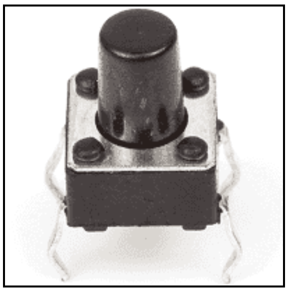

Fig. 11: A push button

A push button as shown above is used to take inputs from the consumer, while selecting the time and amount for charging the vehicles, based on the instructions displayed in the LCD.

5. CONCLUSION

The charging station prototype is implemented with a hybrid power supply to charge electric vehicles efficiently, keeping in mind the need to switch to renewable sources for energy supply. With the recent advancement of the sustainable transportation industry, this will be used to charge vehicles in an eco-friendly way. The proposed prototype can charge an electric scooter at the least. Since this is just a prototype, it may to be able to charge the e-scooter within desirable time.

In order to speed up the charging time necessary changes has to be made with respect to the battery capacity. Battery of higher ampere -hour specifications must be used. The current has few limitations, like it is not that efficient during cloudy and rainy days, there is loss of solar energy in the transfer of power, loss of solar energy in the transfer of power and the charging current is up to 1 amp @ 48vDC.

Futuristic approach or advancement could be- being able to charge a variety of EVs; use of solar tracking system for max output from solar panels; increase in the range of journey over one charge thus to establish the real time charging station.

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