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Utilization of Renewable Energy using V2H Technology

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Abstract: *In recent years, the electric vehicle (EV) sector is growing day by day. Electric vehicles have various advantages as they are more powerful, does not emit pollutant gases like CO2, CO. It is possible to use solar energy to charge EV's. EV's can act as mobile power reservoirs. This paper analyses the capability of electric vehicles, in Vehicle to Home (V2H) scenarios, for which the vehicle acts as a residential battery storage system and/or a backup generator during a grid outage or more frequent short duration distribution system fault, similar to a stand-alone emergency generator. This paper also proposes the use renewable energy like solar energy to charge batteries of EV. During the S2V operation mode the batteries are charged from the solar with constant current. During the S2H operation mode the power is supplied back to the home. In the vehicle to home (V2H) operation mode the energy from EV's batteries can be used to supply home loads during power outages and/or in emergency condition. The smart IOT based system, app is composed for monitoring battery charging state and switching modes to control system, where the relays control the switching action to adjust power supply modes.*

Keywords: Electric Vehicle, V2H, Solar Energy, IOT, Renewable Energy

I. INTRODUCTION

Nowadays the automobile world and the automobile industries are going through a transition process influenced by climate change and increasing need for independence from oil that is the main carrier source in the transport sector. Hence, the major automobile manufacturers began launching electric vehicles. Electric vehicles have attracted the attention of the transport sector and the people, mainly due to the advantages that the electrical vehicles are most economical and they do not emit harmful pollutant gases. But electrical vehicles require energy to charge and currently energy used to charge electrical vehicles is generally comes from power plants like nuclear power plants, thermal power plants which are operated by coal. So electrical vehicles are not completely eco-friendly. We have to design a system in which energy from renewable sources like solar energy, wind energy can used to charge electric vehicles so that electric vehicles become completely eco-friendly.

This paper will talk about such a system, in which electric vehicles are charged from rooftop solar power plant. This rooftop solar power plant system is onetime investment and it can be used for long period of time. The owner of electric vehicle can charge their vehicle from solar energy. After SOC of vehicle's battery become 100 percent there is possibility, that owner can use solar energy to fulfil household load demand. Another advantage of this system is that, owner can use this system as a bi directional system. Owner can use energy stored in the batteries of electric vehicle to power the particular load for several days, if there is emergency or power from main grid is not available. Therefore, the system is capable of operating in three different mode that are solar to vehicle (charging mode), solar to home (after SOC 100%) and Vehicle to home mode (discharging mode). The hole system is controllable by user's smartphone or laptop. For this controlling purpose IOT cloud system is used. User can monitor State of charge of battery like how much battery is charged. He can shift the mode as per requirement.

This type of systems can become very useful in upcoming time. The detailed specification, working of system's prototype model is explained in the below part of this paper.

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II. BLOCK DIAGRAM

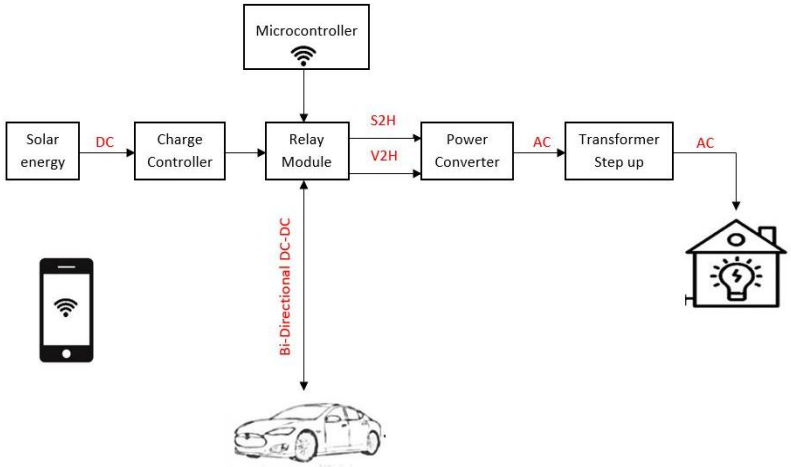

Figure 2.0

- **Solar Energy:** Solar energy will be generated by the solar plant which is mounted on top of roof. The capacity of solar plant should be sufficient to charge vehicle at normal speed and to power the home.
- **Charge Controller:** The voltage generated by the solar panel is variable due to variable intensity of the sun. So constant voltage is required for charging the vehicle battery. This controller helps to keep voltage constant generated by solar panel.
- **Relay Module:** Relay module act as a switch. This block is Actuator. With the help of this block, we can transfer the load using mobile application as per the user's requirement. Switching between different mode is possible with the help of relay module using microcontroller.
- **Microcontroller:** With the help of this block, we will able to control the different modes of operation using relay module and android application. Also, we can monitor the battery percentage of vehicles battery
- **Power Converter:** The voltage generated by solar panel and the voltage stored in battery of EV is in the DC form. Voltage required for house utilities is Alternating current. So, this block is required to convert DC to AC.
- **Transformer:** The voltage from power converter block is AC. To attain required voltage level for house appliances a transformer is used. This transformer can step up voltage as per requirement.

The whole system is controllable and monitorable by smartphone or laptop by the user.

III. SYSTEM'S COMPONENTS AND SPECIFICATION

3.1 Inverter

Household appliances runs on AC supply. The power stored in the battery of electrical vehicle is in DC form. Hence, if have to operate household appliances by using energy form electrical vehicle's battery, it is necessary to convert DC power into AC. This can be done by using inverter circuit between power from battery and load. In the prototype model we have small inverter circuit that is capable for inverting 12V DC into 230 VAC.

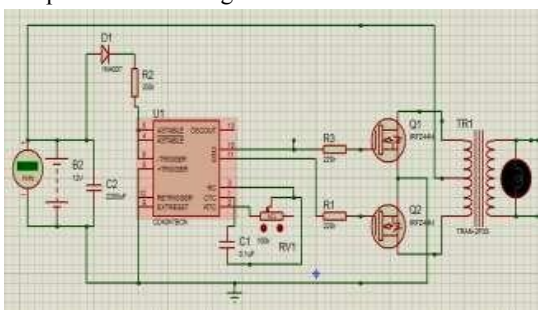

Figure 3.0

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The above figure 2.0 shows the circuit diagram of inverter circuit used in the prototype model. The inverter circuit consist of three major parts that are inverter oscillator, MOSFET and transformer. Most of the inverter industries using IC SG3525, because this IC SG3525 chip has fixed frequency pulse width modulation voltage regulator control circuit, with different output for single ended or push-pull application. The IC SG3525 is an electrical inverter or switching regulator on a single chip with all the functions necessary for the production of a regulating power supply. Moreover, for high power inverter this IC can be used as control element.

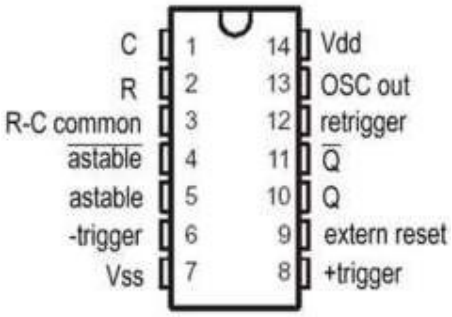

Figure 3.1

For the implementation of this project IC CD4047 is used. The pinout diagram of IC CD4047 is shown in the figure 3.1. This IC have the following features and specifications. This IC have high voltage type (20V rating) and low power consumption. Due to which the circuit consume less power. This IC have special CMOS oscillator arrangement and requires one external resistor and capacitor astable or monostable (one-shot) operation. Due which this IC introduce less error in the circuit. This IC is more flexible and it gives the complemented buffered and true output. To obtain PWM signal this IC is used in astable mode in this circuit. This IC produce two complimentary output signals at pin no. 10 and 11 which have 50% duty cycle. The time difference between these two signals is around 0.01seconds. The astable mode works by charging a external capacitor through a external resistor as in every astable multi-vibrators. Variable resistor of 100K is connected as a external resistor for adjusting the output frequency to exact 50Hz.

The time period of the oscillation for IC CD4047 is given by the following equation……

$T=4.4*R*C$ .....(1)

Where R is external resistor and C is capacitor, whose value is known to us.

To obtain output frequency f = 50H

$F=1/T$… .....(2)

Therefore, from equation 1 and 2

$F=1/4.4*R*C$

As we have used external capacitor of Value…..

C = 0. l uF

Hence, to get F = 50Hz.

50=1/4.4*R*0.1*10 ^ -6

Therefore,

R = 1 / (4.4*50*0.1*10 ^ -6)

R = 45.45 K ohm

As per this calculation to obtain output frequency of 50Hz, the external resistor of 45.5K ohm is required. We have used variableresistorandadjustedoutputfrequencyequalto50Hz using CRO. This signal is connected to the MOSFET's IRFZ44N which drive the inverter transformer.

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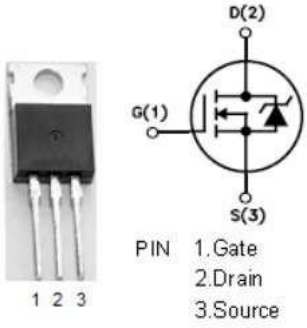

Figure 3.2

Figure 3.2 shows the symbol of IRFZ44N MOSFET. This MOSFET is N-channel enhancement mode standard level MOSFET in a plastic envelope. This MOSFET have very low on-state resistance and internal arrangement of integral Zener diode which gives ESD protection up to 2kV. The drain to source voltage of this IRFZ44N is 55volt, drain current is 49Amps and total power dissipation is of 110watts. The 230Volt ac supply is available at the output side of transformer. The transformer is selected as per the required load. Transformer have to step up the voltage. Here the 36VA Centre tapped transformer is used, where the transformer can be loaded up to 36watts and it can also withstand up to 50watts.

Figure 3.3

The rating of the transformer shown in Figure 3.3 has Primary 12-0-12 V, 3Amps and Secondary 230V. The output at the pin 10 &11 of CD4047 has two complimentary square pulses, and these pulses given to the upper and lower side of the center tapped transformer 12-0-12 / 230V transformer. At the secondary side of the transformer AC voltage of 230V is obtained, which is employed to power the house appliances. The above implemented circuit is tested by using 9W LED lamp as a load.

3.2 NodeMCU

Nodemcu used in the prototype is esp8266 which has total 30 pins. In which 17 pins are GPIO pins which are called general purpose input output pins were digital input output is connected. Remaining pins contains one analog pin,3.3voltagepin,groundpin,etc.Themoduleisself-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your wifi network. It is also multitasking module which can connect to IoT cloud to access the module from anywhere from the world. Fig 3.4 shows the esp module used in the prototype.

Figure3.4

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The module has been connected with one voltage sensor to measure voltage of the battery and connected with the relay to switch modes according to user interface. It requires a 5-volt input for working and which is provided by the battery. The module uses Arduino ide software to edit changes and upload code in it. Hence, the module is multitasking module. Given below in figure 3.5 is the voltage sensor which is connected to nodemcu.

Figure 3.5

A voltage sensor is a sensor used to calculate and monitor the amount of voltage in a circuit. Voltage sensor measures the AC voltage or DC voltage level in any circuit. The sensor module works on the voltage divider principle. Voltage divider is a circuit which has two resistors connected in series. We are using the voltage sensor to measure the battery voltage level in the circuit. The voltage sensor module is of 0-25 DC voltage sensing device. It is a sensor module that reduces the input voltage by the factor of 5 and generates a corresponding analog output voltage with respect to step down voltage factor. This voltage measurement circuit is small, portable and easy to handle. It is used to detect under and over-voltage faults in electrical circuits.

An input voltage of battery is connected to the circuit. The applied voltage is passed between the two resistors and division takes place in direct accordance with the resistances. The output analog voltage is taken from the second resistor and then it is measured. The equation of the output voltage is Vout= Vin*R2/R1+R2 The equation shows that the output voltage is directly proportional to the input voltage and has the ratio of R2 resistor to the sum of R1 and R2 resistors. Resistances value R1 is 30KΩ and R2 is 7.5KΩ.

3.3 Relay

A relay is an electrically operated switch. Current flowing from the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. One electrical circuit is controlled by relay by opening contacts and another circuit by closing contacts. Relay has two contacts normally open and normally close, each works at a time. In each case, applying electrical current to the contacts will change their state.

Figure 3.6

The relay helps to on off the switch electrically instead of manually. As it is connected to nodemcu it works according to the code inserted in nodemcu. There are conditions mentioned in the code for when the relay will be switch on and off. The relay shown in figure 3.6 is used in the prototype. It is called as two channel relay which has specification of 12 volt and 10 ampere. It works for both AC and DC supply.

3.4 Battery

Battery used in the prototype is 12 volt, 5 ampere hour capacity. The home load connected is a 9 watt bulb, 230 volt and 5mA. The discharging time of battery using load is 7 hours. As battery is also charged by using solar panel of ratings 20 watt and 12 volt its charging time is 4 hours at maximum output current of solar panel.

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IV. Working Of The Prototype

Figure, shows the detailed block diagram of the prototype and general view of V2H system. Nodemcu, dc-ac converter, PV panel, battery, buck boost converter and relays are the components used in the prototype. The PV panel is situated on the roof. The buck boost converter provides constant power supply from PV panel. The Nodemcu is the bridge between relays and cloud. The buck boost converter and battery have dc output which is converted into ac by dc-ac converter. According to the control algorithm the Arduino cloud is used to deliver and receive the status of battery and the controllers in the prototype. The home satisfies its power requirements from rooftop solar PV module and utility grid. However, when both the power sources could not be able to feed the power to the home load then V2H delivers power to the home load.

The prototype has the user access to switch mode which they want to operate it. There are 3 modes in this prototype V2H, S2H, S2V. User can operate these three modes from their mobile application or web application, which has cloud interface in it.

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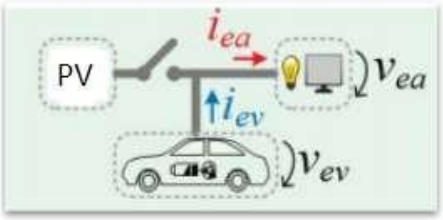
VI. Operating Modes

The operation of the system in the proposed strategy is categorized into three modes: Mode–I: (Vehicle to home), Mode–II: (Solar to home), Mode–III: (Solar to vehicle)

Mode–I: (Vehicle to Home):



This is the most pleasing operating mode of the system, where power is supplied by the vehicle battery to home load. This mode is used in emergency conditions when there is power cutoff in the area. User has the access to switch this mode through mobile or web application.

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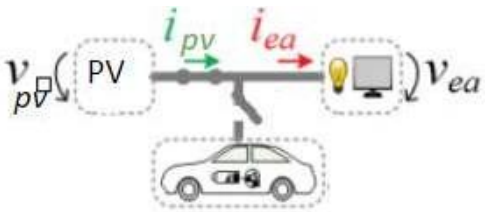
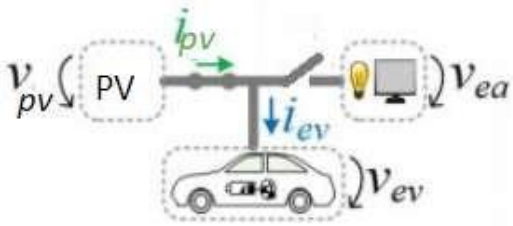
Mode–II: (Solar to Home):



In this mode, power is supplied by the solar to home load. This mode is used when battery is full charged and we have excess power remained. User has the access to switch this mode through mobile or web application.

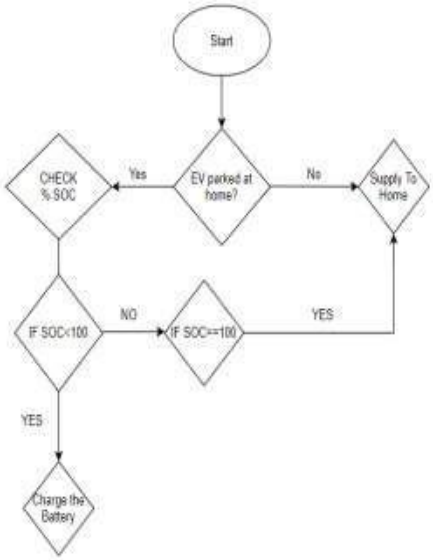
Mode–III: (Solar to Vehicle)

In this mode, the vehicle is charged through solar. This mode is default connected to charge the vehicle.



There are two buttons on the screen, if the user presses the button 1 to ON condition, then V2H mode will operate in these other modes will be OFF. In the backend when user press the button the nodemcu gets HIGH command from the cloud interface, therefore nodemcu pass signal to relay1 to turn ON the V2H mode. If user want to turn OFF the V2H mode then the user can press the same button 1. If user press button 2 then S2H mode gets turn ON where in backend nodemcu gets HIGH command from the cloud interface and nodemcu pass signal to relay2 to turn ON the S2H mode and other modes will be OFF. If user want to turn OFF the S2H mode then the user can press the same button 2. The S2Vmode don't have any button but it is default mode, whenever the other two modes are OFF it will be ON and keep charging the vehicle battery, only when the battery gets 100% full charge then it shifts automatically to S2H mode to protect battery from over charging, in backend button 2 operation gets executed.

VII. Interfacing Of Cloud With Microcontroller



Flowchart

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Cloud is the advanced platform used by each and every one to make communications easier with the machines. As it helps to operate any machine from any corner of the world. The prototype also has interface of Arduino IoT cloud where it helps user to access the system through their own mobile itself. The two figures given below are the mobile and web application of Arduino IoT cloud.

The application consists graph and two buttons, the graph gives the information regarding live battery percentage with time. And the button 1 is used to switch the mode to v2h followed by button 2 which switch mode to s2h. This is the beginning of the cloud in the prototype, as it will be also handle by voice commands and time intervals.

The interface of cloud with prototype is done with the help of esp8266. It requires coding which is uploaded in esp module, after adding Arduino cloud key in the code it gets connected with cloud application and becomes capable to handle prototype through cloud.

This paper proposed the use of EV as a vehicle as well as power source for the home during power outages. In addition to the utility grid, the vehicle is charged from solar PV panels. The PV charging is applied to reduce the home billing and prevent more stress on the grid. Three operation modes S2V, S2H, V2H was developed. The smart system includes battery monitoring and adjusting the power supply modes. Hardware in the setup was experimentally validated by means of a prototype of the system. The obtained results are in accordance with the proposed strategy. These results can be the references for future researches of V2H and V2G modes.

VIII. Interfacing Of Cloud With Microcontroller

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