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Smart Hybrid Charging Station for Electrical Vehicles

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Abstract: The Indian vehicle market is at the exploratory stage of electrification. The transfiguration to electric mobility is an optimal strategy to reduce carbon footprint in the transport sector. Electric charging stations are an inevitable part of the electric vehicle ecosystem which supplies electric energy for the recharging of electric vehicles. This paper presents the design and expansion of an electric vehicle charging stations. The charging station is designed in a hybrid system with smart features. Energy to the charging ports is fed primarily by the solar energy and another source is assisting the system with electricity board. In the faulty environmental and electricity conditions there is a provision for battery backup. The terminal system is outlined into different charging ports according to the power consumption of electric vehicles.

Index Terms - E-Vehicle, Charging, Hybrid, Solar, Auto change over circuit, Renewable source

I.INTRODUCTION

Electric vehicles are meeting expressive growth because of the 'Going Green' direction as well as government initiatives. In the electric vehicle system, a charging station is an active requisite as it supplies electric energy for the recharging of electric vehicles. The recharging energy must be green energy such as renewable energy like solar, wind, tidal, etc. as the electric mobility system centers on the eco-friendly order. Nowadays India is experiencing a dense population and a high need for transportation. The Indian government is planning to sell only EVs by 2030 and for this mission, the government is really trying to push electric vehicles into the ecosystem by giving different subsidies, offers, and an ample amount of awareness.

Charging Stations [1] are already available in the commercial market. These charging stations are mainly of three types: Level 1(120 V), Level 2 (240V), DC Fast Charging (480V) [2][3]. However, all these charging stations either work completely on grid power or solar power. Both of them have certain advantages and limitations [4][5]. This topic already catches a lot of attention of the scientific community under the topic of EM [6, 7, 8, 9]. In this paper, the design and development of the solar system source and electricity board system source in combined have been discussed. Mainly charging station energy input focuses on the solar source as it is available in abundant amounts and it is one of the large and most powerful sources of renewable energy. When there is a lack of solar energy it automatically switches over to the source of electricity board with the help of the auto change over circuit. In rare cases like if both the sources are not available then there is a provision of battery backup which weighs up to the robustness and reliability of the system.

Literature Survey:

Many researchers have studied different methods for Electric Vehicle and is charging station to make it more robust and reliable. Furthermore, the huge research is carrying on improving backup quality of Electric Vehicle (EV) by advancing smart charging stations.

Soham Bhadra, Priyodeep Mukhopadhyay et al. estimated the design and development of a hybrid charging station for electric vehicles. The energy is fed to the system mainly from a solar source and in absence of solar energy, there is a grid system. The modifications are presented in this paper to establish the effectiveness of the Hybrid Charging Station [5].

Gamal Alkawsi, Yaahia Baahar et al. the paper includes studying and clarifying challenges faced by the electric vehicle system and proposing suitable solutions for these challenges. The paper discusses more V2G charging facilities and ESS which can form RCI with a microgrid plan for network charging [11].

G. R. Chandra Mouli, M Zeman et al. investigated the possibility of charging battery- electric vehicles at the workplace using renewable sources mainly solar energy as it is available in abundant amounts to make the system fully eco-friendly. It further disuses improving the efficiency of the electric vehicle system [12].

II. Proposed System Description:

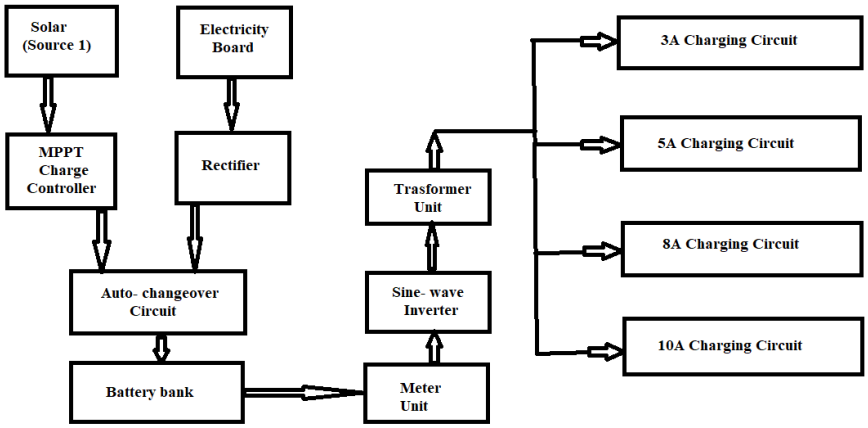

Fig 1: Block diagram of Smart Hybrid Charging Station

The block diagram of the main system is shown in fig.1. The system model consists of a solar source (panel), electricity board, MPPT, Rectifier, auto change over circuit, battery bank, inverter, and different ratings of charging circuits. In this paper, a smart hybrid charging system has been proposed where charging ports are fed with two sources primarily first is the solar source and the second is assisting the system with electricity board. For the future scope as according to the environmental conditions and availability of renewable sources, the system can use wind energy, tidal energy, etc. as the primary source.

In the proposed system, mainly input energy focuses on the solar source, and with the help of solar panels solar energy is harnessed. For the maximum solar output, MPPT charge controller is used which ultimately gives the controlled output. For uncontrolled environmental conditions, the system has set up an electricity board as the secondary source. For further AC to DC conversion rectifier is used. Auto change over circuit plays a vital role in an auto switch over between two sources. In rare cases such as if solar energy as well as electricity both, are not available then there is a provision of battery backup. For the next conversion of DC to AC form sine wave inverter is used. Further, this energy is given to the charging ports. The design of charging ports is outlined into 4 different charging ports according to power consumption of electric vehicles specifically as 3A,5A, 8A and10A.

For E.g. For light loads like 2 and 3 wheelers, there are 3A and 5A ports

and For heavy loads like 4 and 10 wheelers, there are 8A and 10A ports

III. Description of Individual System Model:

Solar Panel-

Solar panels harness non-conventional powerful solar energy and convert it into electricity. This process works by absorbing the energy of photons to generate charge pairs which are forced to flow through an external circuit path to obtain electrical energy. This effect of charge generation is called as photoelectric effect or PEE [10]. This energy is provided to the battery. PV solar panel generates DC energy. Here specifically monocrystalline type 12V, 10W solar panel is used.

MPPT Charge Controller-

MPPT type microcontroller based 12V, 5A solar charge controller, MPPT stands for Maximum power point tracker. It is basically used for regulating the output from the solar panel. The intensity of sunlight varies continuously so it is important to regulate the solar output. Various voltage boosters and current boosters are present in this Maximum Power Point Tracker circuit, which help to produce the desired output. The MPPT charge controller is more efficient than the Pulse Width Modulation charge controller. MPPT boosts the circuit when output from a solar panel is low and also regulates output when output is high.

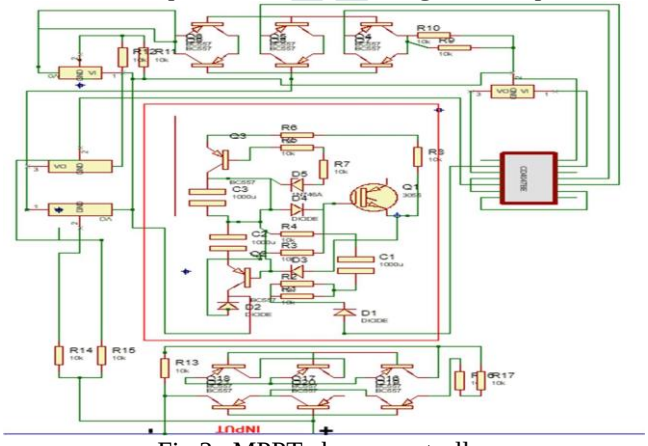

Fig.2. MPPT charge controller

Table 1-Components of MPPT charge controller

SR.NO	Name	Specification	Quantity
1	IGBT	3055,12v,10A	2
2	Filter capacitor	1025	2
3	Connector	3 pole pcb mounted connector	2
4	Command IC	4060,12v,14pins	1
5	Voltage regulator	7805	4
6	Switching transistors	557 switching and amp. Transistor	12
7	Buzzer	5V, DC	1

Transformer-

The system has center tap copper winding 12V, 5A transformer, which transfers electric energy from one alternating current circuit to one or more other circuit. The system uses center tapped transformer, when alternating current is supplied to primary winding of transformer it creates a magnetic flux in the core and when secondary winding is brought near an alternating magnetic flux is also induced in the secondary winding as the flux flows through iron core and changes its direction with each and every cycle of alternating current.

Rectifier-

An electric device that converts alternating current (AC), which periodically reverses its direction, to direct current (DC) it is called as rectifier. The output coming from transformer is given to the rectifier. Then rectifier converts AC current to DC current. The whole process is known as rectification.

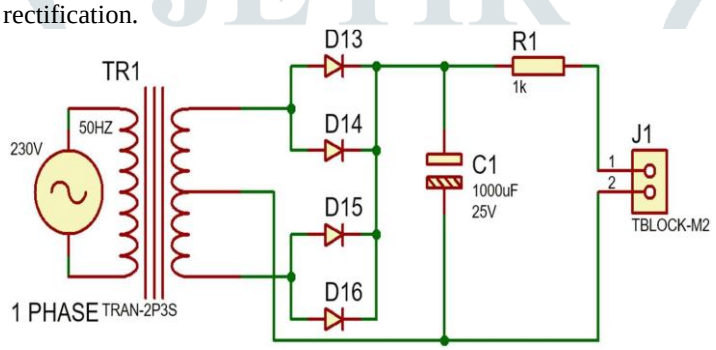

Fig.3.-Rectifier circuit

Table 2 -Components of rectifier circuit

SR.NO	Name	Specification	Quantity
1	Diode	10A,12V	4
2	Filter capacitor	1025	1
3	Connector	3 pole PCB mounted connector	1

Auto Changeover Circuit-

The circuit is used for automatic switchover between two sources. The system is consisting of two sources solar source and an electricity board which makes the system hybrid. The auto changeover circuit is designed by using a relay. Furthermore, it is designed in such a way that by default it gives preference to the renewable source i.e. solar energy. This helps to achieve energy conservation. When the renewable source is not available due to some technical and environmental factors then it switches towards a non-renewable source i.e. conventional source. So auto changeover circuit helps for choosing one source from two available sources.

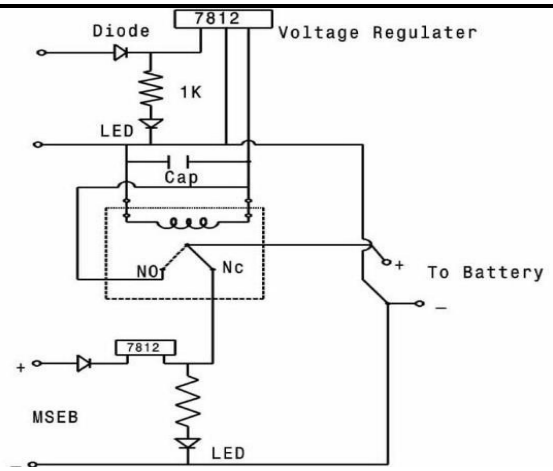

Fig. 4-Auto Changeover Circuit

Battery Bank-

The battery bank is specifically used for storage of the energy. The system has a12V,9AH high power lead- acid battery which is used as backup when both sources are not available. It is also used for the storage of energy obtained from solar source and electricity boards. The system has a forward-biased diode in the auto changeover circuit for protection from the backflow of the current coming from the battery.

Inverter unit (Sine wave) –

The inverter is used for converting DC to 230V AC and this 230V AC step down with the help of a step-down transformer and giving proper 12V supply to the output circuitry. (220V, 50Hz, 1 phase). Here pure sine wave (220 V, 50Hz, 1phase AC) inverter circuit is used. It is used to convert DC to AC. When the charging process is on condition, in that condition battery storage will reduced so it cannot take 12V constant supply at customer end. So that's reason it is converted the output voltage of battery DC to AC. Step up transformer is connected to this inverter circuit for to step up 12 V to 220 V.

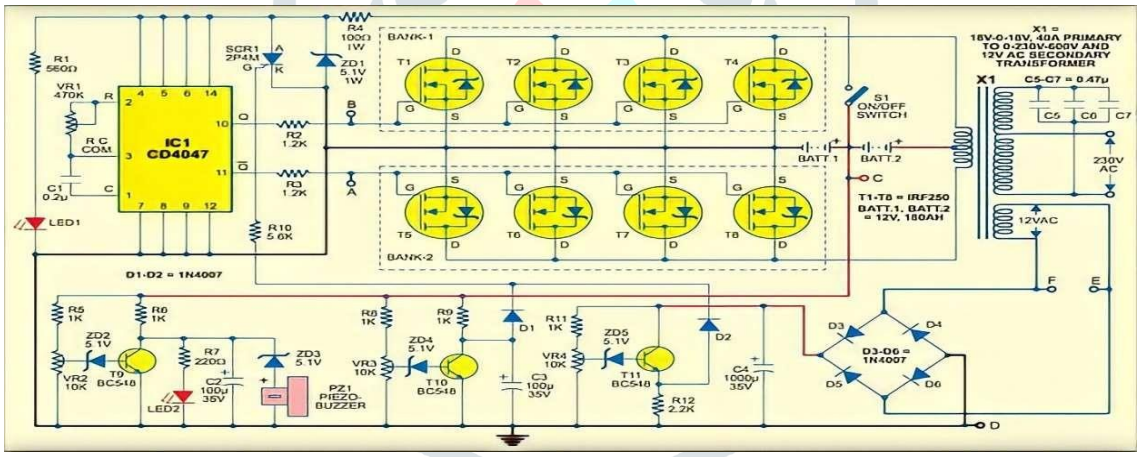

Fig.5.-Sine wave inverter circuit

3A Circuit:

Here figure 6 shows 3A charging circuit. For operating this circuit, 12V, 3A supply is given from step down transformer which is parallelly connected to other charging circuit. This circuit is called as transistor-based circuit because in that circuit we not used any microcontroller. To convert AC to DC we designed center tapped full wave rectifier this converted dc supply given to the filter capacitor to filter or give proper 12V supply and also other voltage regulators used for regulate voltage, by using this circuit system get proper 12V,3A output to charge electric vehicle battery having rating 3A charging current.

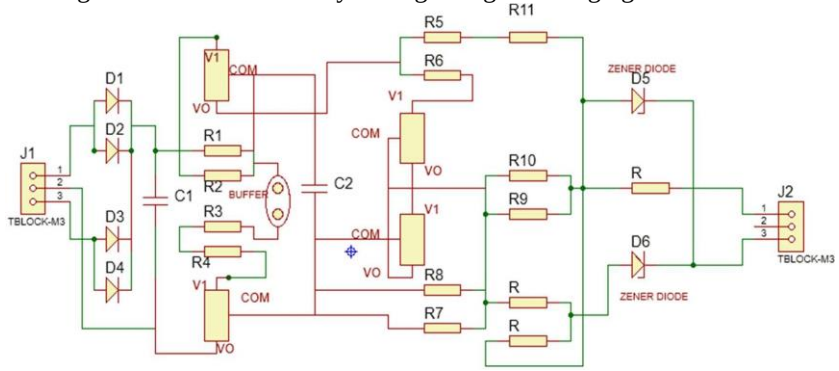

Fig .6. 3A charging circuit

Table 3-Components of 3A charging circuit

SR.NO	Name	Specification	Quantity
1	Diode	3A,12V	4
2	Voltage regulator	7812,12V	4
3	Connector	3 pole pcb mounted connector	2
4	Capacitor	100 Microfarad	2
5	Resistor	1 Ohm	14
6	Buffer	-	1
7	Zener diode	3A,12V	2
8	Step down Transformer	12V,3A centre tapped copper winding	1

5A Circuit:

Here figure 7 shows 5A charging circuit. For operating this circuit, 12V, 5A supply is given from step down transformer which is parallelly connected to other charging circuit. This circuit is called as transistor-based circuit because in that circuit microcontroller is not used.

To convert AC to DC center tapped full wave rectifier is designed this converted dc supply given to the filter capacitor to filter or give proper 12V supply and also other voltage regulators used for regulate voltage, IC used for controlling purpose. By using this circuit, system get proper 12V,5A output to charge electric vehicle battery having rating 5A charging current.

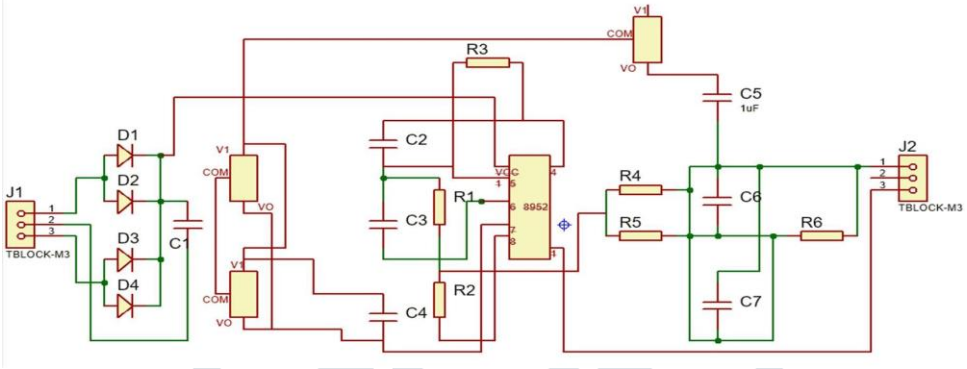

Fig.7. 5A charging circuit

Table 4-Components of 5 A charging Circuit

SR.NO	Name	Specification	Quantity
1	Diode	5A,12V	4
2	Voltage regulator	7812,12V	3
3	Connector	3 pole pcb mounted connector	2
4	Capacitor	1000 Microfarad	7
5	Resistor	1 Ohm	6
6	IC	8952 digital Microcontroller	1
7	Step down Transformer	12V,5A centre tapped copper winding	1

10A Circuit:

The figure 8 shows 10A charging circuit. For operating this circuit, 12V, 10A supply is given from step down transformer which is parallelly connected to other charging circuit. This circuit is microcontroller-based circuit because circuit has Arduino UNO board with in build ATMEGA328P-PU IC microcontroller.

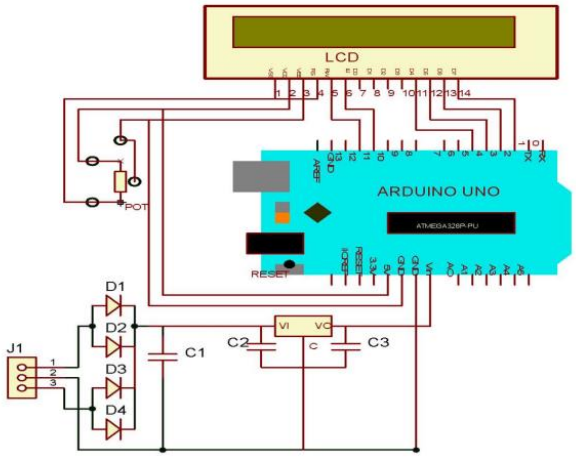

Fig.8. 10A Charging circuit

IV. Results and Discussion:

For generation of energy, system has two input sources one is solar source and another is the electricity board and calculations of the system are as follows:

Table 5-Input side generation side calculation

SR.NO	Name	Input Voltage (Vin)	Input Current (Iin)	Output Voltage (Vout)	Output Current (Iout)
1	Step down Transformer	230	3	11.40	2.97
2	Rectifier circuit	12	3	12	2.46
3	MPPT Charge controller Circuit	12	2	12	1.99
4	Auto changeover Circuit (MSEB)	12	3	10.12	2.87
5	Auto changeover Circuit (SOLAR)	12	3	9.40	2.98

In above table, input and output values of voltage and current are measured from step down transformer, rectifier circuit, MPPT charge controller circuit, auto change over circuit (here it takes input from Maharashtra State Electricity Board) and auto change over circuit (here it takes input from solar source) respectively which are the main units of energy generation system.

Experimental Results:

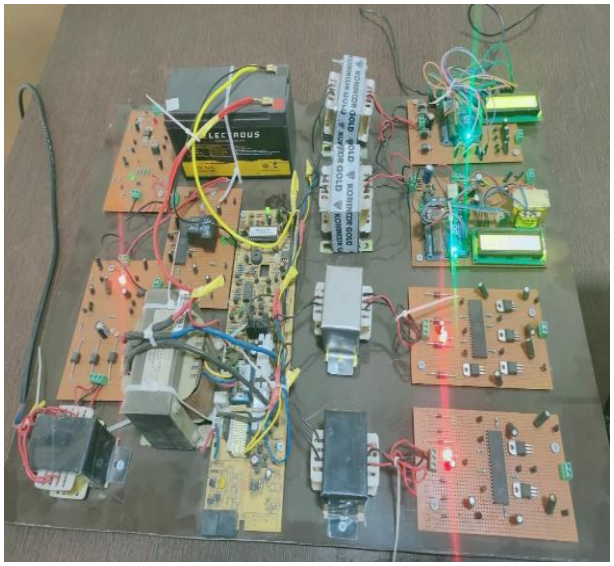

Photo 1. Hardware Model

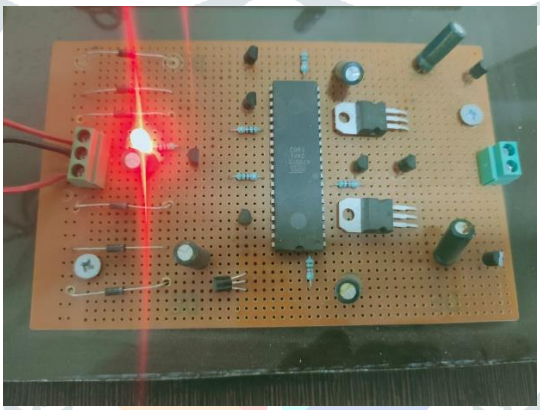

Photo 2. 3A Charging Circuit

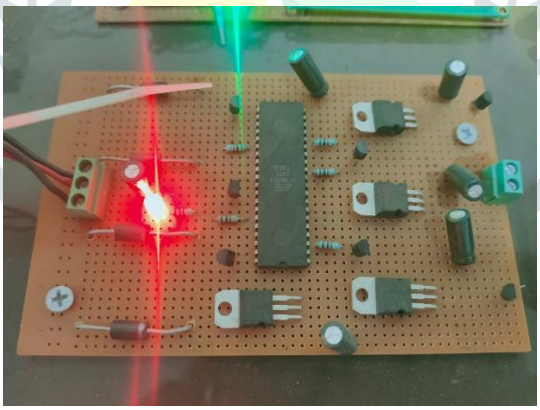

Photo 3. 5A Charging Circuit

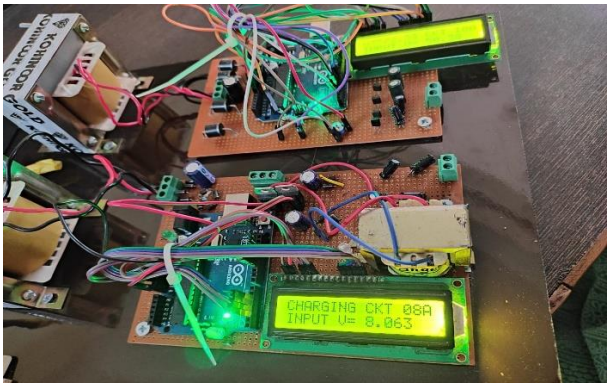

Photo 5. 8A and 10 A Charging Circuit

Above photo1 shows the prototype model of whole smart hybrid charging station for electric vehicles. Photo 2 is 3A circuit which works on 12 V input voltage. Photo3 is 5A circuit which is similar to 3A circuit in design and in working method. Photo 4 shows 8A and 10A circuits with display boards which works on Arduino system and also takes 12 V as input voltage.

V. Conclusion:

In this work design and expansion of the charging station for electric vehicles is discussed. Charging station is in the hybrid system with the combination of the solar source and electricity board. Primarily energy is fed to the charging ports from solar source and in faulty conditions there is automatic switch over towards electricity board with the help of auto change over circuit. The results are drawn from different charging ports with effective outputs. The advanced design of hybrid charging station can be implemented in the real life as an eco-friendly as well as energy efficient approach for charging of electric vehicles.

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