Review On Design And Analysis Of Regulated Charging System For Electric Vehicle

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Abstract- *Reservoirs of conventional fuels are depleting due to overuse. So the concept of electric vehicle(EVs) over conventional vehicle comes into exist in 21st century. But along with these electric vehicles, setting up charging stations is also a greater need. Due to lack of sufficient charging stations in India, Indian automobile industry becomes ineffective to launch new electric vehicles.To overcome this problem, it is necessary to focus on charging system of electric vehicles. This paper is a review of Designing and analysis of a Regulated charging system for electric vehicle, but this design is a low power rated for a E-Rickshaw, E-Bike, E-Cycle and other DIY electric vehicle.*

Keywords- Electric Vehicle, Boost Converter, Rectifier, Filter.

I. INTRODUCTION

Internal Combustion Engine(ICE) of vehicle causes environmental problems. To surpass this condition, rapid growth of EVs in the market is increased. Use of EVs reduces air pollution and emission of greenhouse gases. [1],[2]In spite of inadequacies associated with EVs like limited driving range, short lifecycle of the battery, high cost of battery, high charging time, scarcity of electricity required for charging are still gaining acceptance. [3] Subsequently, the penetration of EVs in the market is eternally accelerating. Currently India is one of the top energy consumers in the world. It is the world's third largest producer as well as third largest consumer of electricity. 76% of the vehicles in the country are comprised by two-wheelers. Modifying India's EV Policy to suit the current demands of its auto-industry i.e. concentrating more on the production of electric-two wheelers can be favorable[4].

The main motive of this work to review the recent literatures related to current scenario for charging the EV through various sources and give an alternative solution as a domestic level regulated charging system for EV. This work gives an insight of EV charging infrastructure which are commercially available in market for mainly 2 and 3 wheelers with their technical specification.

II. EV CHARGING INFRASTRUCTURE

After entering commercial markets in the first half of the decade, electric car sales have soared. Only about 17 000 electric cars were on the world's roads in 2010. By 2019, that number had swelled to 7.2 million. Nine countries had more than 100 000 electric cars on the road. At least 20 countries reached market shares above 1%. [5]

The infrastructure for electric-vehicle charging continues to expand. In 2019, there were about 7.3 million chargers worldwide, of which about 6.5 million were private, light-duty vehicle slow chargers in homes, multi-dwelling buildings and workplaces. [5] The market share of electric cars is around 2% in China, while the share in India is a meagre 0.06%. [6]

Electric mobility market of India differs from those of the countries having higher levels of penetration of electric vehicles and mature market conditions. The difference is primarily due to various aspects such as geographical area, public policy, social norms as well as economy. Heterogeneous development in urban areas, large population, low availability of public infrastructure and low affordability pose several barriers to mass scale adoption of e-vehicles. [7] At the present stage few companies are focuses on E-Rickshaw, E-Bike and E-Cycle. With support of the Government, electric vehicles have started penetrating in the Indian market. However, availability of adequate Charging Infrastructure is one of the key requirements for accelerated adoption of electric vehicles in India. Government of India has set up some objectives related to it.

- To enable faster adoption of electric vehicles in India by ensuring safe, reliable, accessible and affordable Charging Infrastructure and eco-system
- To proactively support creation of EV Charging Infrastructure in the initial phase and eventually create market for EV Charging business. [8]

Table no- 1 Current available chargers for E-Bike

Sr No.	Name of Company	Voltage rating	Current rating
1	Hero[9]	48V	2.7A
2	Lzen electronics India[10]	48V 60V	3.5A 3A
3	Powertron [11]	60V	3A
4	Amptek [12] [13]	60V 48V	2.7A 2.7A

All these popular chargers ranges between 1000 to 3000 Rupee. Commercial Companies like Delta Electronics India, Mass-Tech, Exicom, ABB India, EVQpoint, BrightBlu, Magenta Group, RRT Electro Power (P) make the electric vehicle chargers. Above these only two companies mainly focused on e-Rickshaw, e-bikes and e-Cycles. [14]

III. MODELLING

Block Diagram

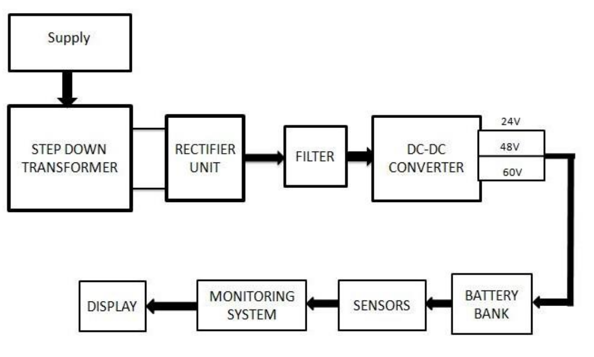

Fig.1 Block dia. of regulated charging system

Transformer-

A transformer is a static (or stationary) piece of apparatus by means of which electric power in one circuit is transformed into electric power of the same frequency in another circuit. It can raise or lower the voltage in a circuit but with a corresponding decrease or increase in current. The physical basis of a transformer is mutual induction between two circuits linked by a common magnetic flux. [15]

$$V_1 I_1 = V_2 I_2 \quad \text{Or} \quad \frac{I_2}{I_1} = \frac{V_1}{V_2} = \frac{1}{K}$$

In this system the transformer is used for a two main reasons, to provide isolation and to drop the voltage to the desired amount. Let’s take an example, if you have 230V AC available and you need 12V. If you didn’t use a transformer, you rectify it to about 312V then have to find a way of losing 300V at your load current and you have no isolation either. You can use an Isolation transformer which also named as UPS transformer. According to your application you can use any rating of transformers which are commercially available. Ex. 6-0-6, 9-0-9, 12-0-12, 24-0-24. These transformers will step-down your input A.C. and fed to the rectifier circuit.

Rectifier and filter:

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification, since it "straightens" the direction of current. Rectifier circuits may be single-phase or multi-phase. Most low power rectifiers for domestic equipment are single-phase, but three-phase rectification is very important for industrial applications and for the transmission of energy as DC (HVDC). [16]

There are two types of full wave rectifier i.e. Center tapped and Bridge configurations are available. Bridge rectifier having more advantages than center tapped configuration, which are transformer utilization factor is more, it can be used in application allowing floating output terminal, the need of a center tapped transformer is eliminated, The PIV (Peak Inverse Voltage) is one half of that of center tapped rectifier. [17]. Fig. no. 2 represents the input and output waveform of full wave rectifier.

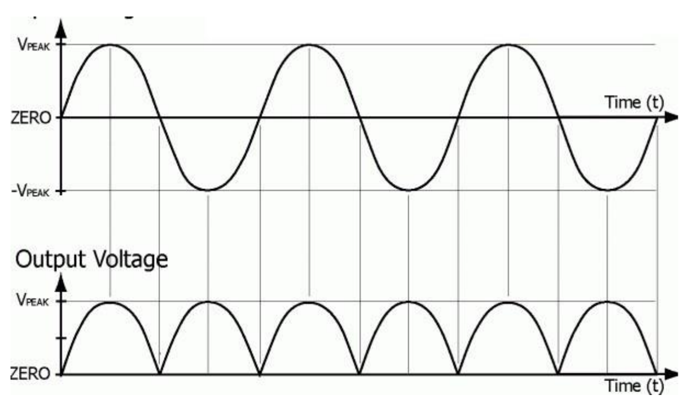

Fig. 2 input and output waveform of full wave rectifier

Table No. 2 Parameters of full wave rectifier [18]

Parameters	Values
$V_{average}$	$2V_m/\pi$
V_{rms}	$V_m/\sqrt{2}$
Ripple factor	0.482
Maximum Efficiency	81.2%

The average and RMS no-load outputvoltages of an ideal single-phase full-waverectifier is shown in table 1. From fig.1, we can see the output of the rectifier is not pure DC it's a pulsating DC, for getting a pure DC output we have to add a filter at the end of the rectifier. There are various filter circuits used for the rectifier like a series inductor filter, Shunt Capacitance filter, R-C filter, π filter. For a bridge rectifier configuration Shunt Capacitance (C filter) is mostly used to get a low ripple in the output.

C = 0.7 * I /(ΔV * F)
C = capacitance in farads, I = current in amps,
ΔV = peak-to-peak ripple voltage,
F= ripple freq in Hz

Note that ripple frequency in a full-wave rectifier is double line frequency. For half-wave rectification, the ripple frequency is the line frequency. [19]

DC-DC Converter:

The DC/DC converters are widely used in regulated switch mode DC power supplies. In these converters the average DC output voltage must be controlled to be equated to the desired value although the input voltage is changing. From the energy point of view, output voltage regulation inthe DC/DC converter is achieved by constantly adjusting the amount of energy absorbed from the source and that injected into the load, which is in turn controlled by the relative durations of the absorption and injection intervals. These two basic processes of energy absorption and injection constitute a switching cycle. [20]

Table no. 1 represents the voltage levels for EV's chargers which are available in commercial market. So the desired values of the voltage are either 48 or 60 volt. In this system we use a boost converter to boost the output of the rectifier to get the desired voltage level. The DC/DC boost converter only needs four external components: Inductor, Electronic switch, Diode and output capacitor.

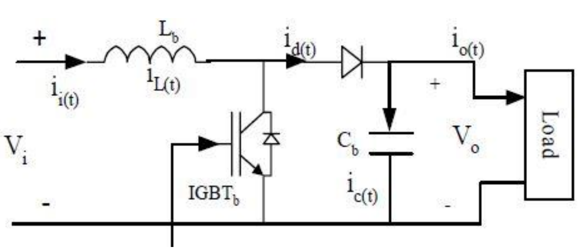

Fig. No.3 Circuit diagram of Boost Converter [20]

Formulas for calculating the values of boost converter:[21]

$$D(Duty\ Ratio) = 1 - \frac{V_{in(min)} \times \eta}{V_{out}}$$

$$C(Capacitor) = \frac{I_{(out)max} \times D}{f_s \times \Delta V_{out}}$$

$$L(Inductor) \frac{V_{in} \times (V_{out} - V_{in})}{\Delta I_L \times f_0 \times V_{out}}$$

$$\Delta I_L = (0.2\ to\ 0.4) \times I_{(out)max} \times \frac{V_{out}}{V_{in}}$$

Monitoring System:

The monitoring system will monitor the whole charging process of EV i.e. output of boost converter, charging current and a gate pulse to the IGBT. In fig. no. 1, we can see the sensor's output is fed to the monitoring system, these sensors are anything which transfers the real time data of a battery while charging process is on. Ex. Voltage sensors, Current Sensors, Temperature Sensors etc.

The one most important thing a monitoring system can do is to calculate the charging time of the battery and show on the display, and cut down the supply after charging is done with the indication of battery is fully charged.

The Monitoring system can be made by use of Microcontroller, Microprocessor, IoT and Arduino, but at this rating Arduino will be a good option as a microcontroller and microprocessor are too complex.

IV. CONCLUSION

The recent concern related to environmental pollution has initiated promotion of electric vehicles. The driving range anxiety related with the EVs has initiated establishment of charging infrastructure across the world. This area witnessed a number of research work in past few years. We hope that over the course of the next decade technological advancements and policy changes will help ease the transition from traditional fuel-powered vehicles. All the research work concludes that the availability of adequate charging infrastructure is one of the key requirements for adoption of electric vehicle.

This research paper represents a design of a domestic level regulated charging system which include important formulas and easy methods which is an alternative solution for commercial chargers available in the markets.

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