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Design of Fast Charger For Electric Vehicle

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Abstract: Depleting fossil fuels and pressing global warming challenges are wreaking havoc towards the sustainable future of mankind. To cater these alarming issues, renewable energy sources and alternate means of energy harnessing have been investigated rigorously for last several decades. Similarly, transportation sector has also seen paramount reforms with electric vehicles now seen as potential competitors to conventional internal combustion vehicles (ICEV). The major challenge electric vehicles face today includes slothful battery charging rates and less electric driving range. The range can be extended by proper selection of electric motors. Ultrafast DC charging is concurrently pondered upon to ramp up the sluggish battery charging rates. Fast chargers technology has been helpful in greatly reducing the battery charging time. Different types of charging technologies and methods have been employed. This projects mainly focus on the combining the different technologies and designing a Fast charger for EV's.
Even with the advancement of the high technology nowadays, the popularity of electric vehicle is still limited and unable to make it a common usage. The main reason is due to the limitation of the battery pack which is bulky, heavy, slow charging, short lifespan and toxicity hazardous. Among these problems, slow charging speed becomes the main consideration when purchasing an electric vehicle. Hence, different charging methods have to be studied thoroughly to seek for the best solution to overcome these problems. In today's competitive battery charging method, a lot of charger manufacturers claim that they can amazingly short charge times of 30 minutes or less.
In this project, different charging method such as Constant Voltage charging, Constant Current charging, Pulsed charge etc, have been studied and compared to optimize the charging time suitable for different kind of battery pack.

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I. INTRODUCTION

With the increasing usage of internal combustion engine (ICE) vehicles or conventional vehicles i.e., vehicles that use crude oil and its byproducts as fuel source, the demand for crude oil is getting increased day by day. Crude oil is being depleted at a rate of 4 billion tons per year . If this depletion carries at the same rate, crude oil reserved at present in world will be finished within a few years .Moreover, average CO_2 emissions from conventional vehicle (4.7 metric tons per year), plays a significant role towards the global warming . Owing to these major factors, the demand for electric vehicles (EVs), hybrid electric vehicles (HEVs) and plug-in hybrid electric vehicles (PHEVs) is getting increased day by day.
HEVs attracted the consumers as the CO_2 emissions for HEVs are 25% less compared to the conventional vehicle . HEVs are also more efficient with efficiency around 75% compared to where conventional vehicles are only 15% . Further, the running cost of HEVs is nearly 50% less compared to that of conventional vehicle. HEVs are also a better alternative for storage of grid energy, and they have the potential to transfer power to grid to alleviate the peak power demand, frequency regulation and also support renewable energy generation . However, the sales of HEVs are not growing in the rate as expected due to some of its major drawbacks. Cost of HEV is more compared to conventional vehicle. The reason for high cost of HEVs is high-tech energy sources used in the vehicle, batteries costs up to 50% of the total cost of an HEV. HEVs are limited by its range and speed, and also high charging time for batteries. At the same time, charging station infrastructure is also a major constraint for PHEVs. Main Energy sources for HEVs are ICE, fuel cells, super capacitors, batteries. I-ion battery is commonly used in HEVs as well as EVs due to its several advantages over its counterparts (fuel cell, ultra-capacitors, Pb-acid, Ni-Cd, Ni-MH).A comparison study of different energy sources is a part of the present work as discussed in Section II. At present scenario , charging time is a major constraint for HEVs. As the charging scheme decides the life cycle, efficiency, and charging time of the batteries, it is very important to design a good charger. Recently, an optimal charging scheme is proposed for the Li-ion battery .

II. LITERATURE SURVEY

Various charging schemes for batteries are present in the literature and practice. Details of some main charging schemes are presented in this section

A. Constant Voltage Charging Scheme:

In this method of charging, battery is charged with DC power supply till the battery voltage is reached to set-point voltage. Li-ion cells have 4.2+/-50mV as nominal set-point voltage and maximum allowable charging current is 1C. This method of charging is preferred for Pb-acid batteries as each individual cell equalize the charge among them. Major drawback of this method is battery does not get fully charged and time required for charging is more than 2 hours.

B. Constant Current Charging Scheme:

In this method of charging, battery is charged with uniformly constant current. If more number of cells are present in the battery this method of charging is not preferred to implement as some cells may get fully charged than others. This method is not efficient and also leads to over stress on the cells. Drawback of this method is maintaining low charge current leads to more charging time. To implement fast charging to Li-ion batteries using this method higher charging current is required. But when charging current is too high the travel rate of Li-ions exceeds the insertion rate of Li-ions into graphite layer. This leads deposition of some Li-ions on the electrode layer instead of getting inserted into the layers. This is called lithium plating. To overcome lithium plating enough settling time for Li-ions has to be provided to get inserted into vacant sites of graphite electrodes.

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C. Constant Current Constant Voltage charging:

The conventional charging technique employed for charging of Li-ion batteries is constant current constant voltage (CCCV) charging since it is easy to implement, efficient and has its own advantages. In this CCCV technique there are found different stages as shown in Fig.

1. Pre-charge mode:

In this mode of charging, deeply discharged cells (voltage below 3V) are charged with 10% of full charge current. This mode is important to avoid overheating of the cells until it is able to accept full charge current.

2. Constant current mode:

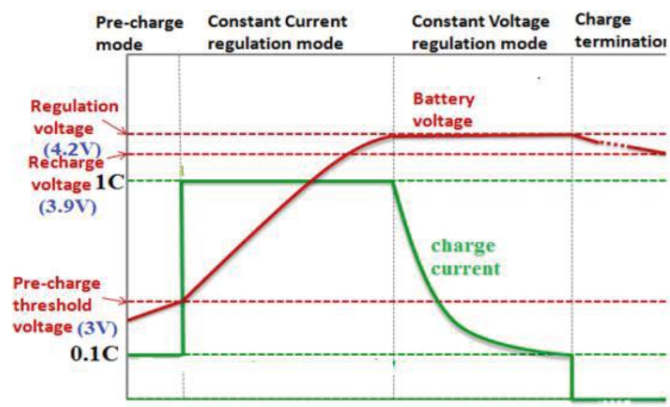
In this mode of charging, normally battery is below 1C rate until the battery reaches 4.2 V. If high charging current rates are implemented, cell voltage rises more rapidly and constant current stage become shorter but overall charging time doesn't reduce.

3. Constant voltage mode:

In this mode of charging, battery is charged at constant voltage of 4.2 V. Constant current mode is not extended till 100 SoC because to avoid overheating, stress on the cells. Even though battery reaches 4.2 V it does not indicate that battery is fully charged so it has to be further charged in constant voltage mode. During this stage, current drops till 0.1C while charging is terminated.

4. Charge termination mode:

Normally charge termination is done by minimum charge current method or timer method. In minimum current method, charge current is always monitored and as it reaches a value in range of 0.02C - 0.07C charging is terminated Despite its advantages, the drawback of this conventional charging to lithium ion batteries is it takes long time (at least more than 2 hours) to charge the battery completely.



III. WORKING

- The 230 V AC power the readily available Source is Coverted to 12 V DC using Step Down Transformer and Bridge Rectifier Circuit or Directly a DC source can be used.

  12 V DC is used as an input to Buck Converter.

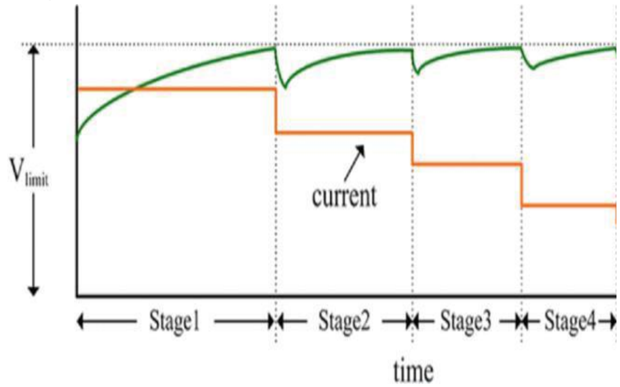
  The DSP TMS320F28335 is used as controller

  A current sensor ACS712 (20A rating) is used to measure current. The measured current is used to calculate SoC by Arduino UNO platform. The SoC is estimated using equation , where 'Q' is the amount of charge present in the battery and 'Qmax' is maximum charge that can be injected into battery .

  Reference current generated from Arduino UNO will be in form of digital signal i.e, as '5'or '0'. An analog signal of 1.5 V magnitude is given as 1 kHz pulse with 30% duty cycle. So, a low pass RC filter is used to obtain average value of that signal.Current sensed using ACS712 sensor and obtained reference current from low pass RC filter are given as analog signals to DSP TMS320F28335. PI controller is implemented in DSP TMS320F28335. The output of the PI controller and sequence generator are used to generate PWM pulses of 20 kHz.

IV. METHODOLOGY

A. Diagram:



Components

1. Rectifier : a convention OBC (on board charging system) has bridge rectifier to convert Ac voltage to Dc.

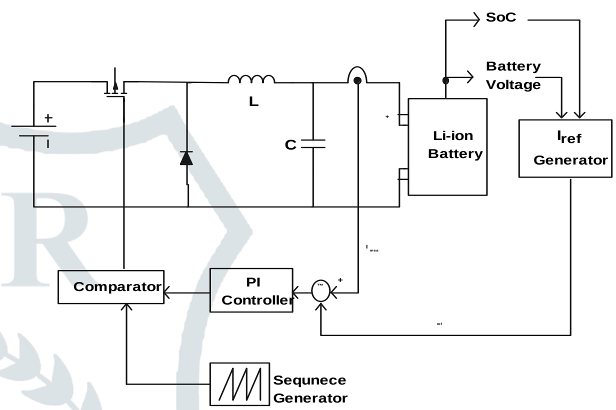
2. Ripple Monitoring : Ripple monitoring circuit may generate information indicative of falling component in power supply.

3. Control Circuit : Control circuit is component of computer central processing unit , that directs the operation of processor.

4. Voltage Regulator : A circuit that create and maintain a fixed output voltage irrespective of changes to the input or load condition.

5. Current Sensor : It measures current flow using magnetic field to detect the current and generate the proportional output.

DESIGN OF SYSTEM



Charging circuit to implement five level charging scheme.

V. ADVANTAGES

- Reduce the battery charging time.
- Faster operation
- Battery life is not affected.

- Reduced size
- Energy saving
- Low cost
- Quick charge
- Bettery temperature under permissible limit

VI. CONCLUSION

In this project, it is expected to reduce the conventional battery charging time required to charger a Li-ion battery in EV's.

VII. FUTURE SCOPE

Future work might be:

- To further reduce the charging time to as minimal as possible.
- To reduce the cost of the charger and make it more robust.
- To design a potable charger which can be used for any battery type irrespective of its ratings.

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