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A REVIEW ON SUPERCHARGERS FOR ELECTRIC VEHICLES

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ABSTRACT

Electric vehicles are becoming more prevalent on the road. According to current adoption, the adoption of electric vehicles is likely to keep up with the need for quick charging. The supercharger network was introduced on September 24, 2012, with 6 supercharger stations. As of February 18, 2021, Tesla operates over 30,000 supercharges in 2,500 stations worldwide. Nowadays, superchargers are more commonly used in electric vehicles like Tesla cars. And also, the world is moving more and more towards electrified transportation as a result of the negative effects of petroleum-based transportation. By using a supercharger, it takes less time to charge and our work is done much faster compared to other chargers. Tesla superchargers are better and faster charging technology for electric cars.

Fast charging systems are being developed since standardised conductive connectors are not available when electric cars are initially mass produced. Supercharged electric cars have a shorter charging time and higher charging speeds than conventional ones. To shorten the charging period, larger power rates must be used.

Keywords: ***fast-charging; electric vehicle; high power charging; battery energy storage: Super high speed; design considerations; electric supercharger; switched reluctance motor***

Introduction

Negative repercussions from the dominance of petroleum-based forms of transportation are pushing the globe toward electric transportation. To be competitive with petroleum-based transportation, electric vehicle (EV) battery charging durations must decrease to the 5-10 minute range. In this article, we take a look at the literature around the topic of how EV fast-charging techniques affect battery systems, with a focus on heat management and the constraints this creates.[2]

As the world increasingly adopts EVs as a sustainable means of transportation, it is crucial that we find ways to charge them as quickly as filling the gasoline tank of an ICE car. To lessen their impact on the environment and the economy, automakers are developing electric, hybrid electric,

and plug-in hybrid electric cars. An electric vehicle's lithium ion battery may be charged to 80% capacity in 30 minutes, as shown by the Tesla Models.There's a 480 V DC plug. The supercharger is able to attain such rapid charging rates because it uses direct DC power to charge the battery instead of converting ac to DC. When using a supercharger, a vehicle's range may be extended by up to 200 miles in only 15 minutes. The battery life of the Tesla automobile is 375 miles per charge. Superchargers for Tesla vehicles can draw up to 250 kilowatts of electricity from a 480-volt, three-phase outlet. The supercharger's output varies from 0 kW up to 60 kW and then back down again. After the first 40 minutes, the Tesla supercharger will only charge at a slow rate. This is to keep the battery from getting too hot.[1]

Electric vehicles charging plugs:

There are different charging plugs are used for electric vehicles. In that there are some supercharger plugs are used for fast charging.

1.Combined charging system (ccs):

It is the plug 2–6 miles range is added per minute. And the charge duration to 80% in between 25-60 minutes.

Fig 1: ccs1 and ccs2 plugs

1. chaDeMO:
   It is the plug only 2 miles range is added per minute.and the charge duration to 80% in 60 minutes.

Fig 2: chaDeMO plug

3.Tesla:

It is the plug 5-9 miles range is added per minute. And the charge duration to 80% in between 20-40 minutes.

Fig 3: Tesla supercharger plug

The battery is a crucial part of any electrical vehicle. The low energy density, long charging time, short lifespan, and high cost of this technology severely restrict its practical uses. The battery's charging time and lifespan are both affected by the battery charger's design and how often it is used. There are two basic types of chargers used for electric vehicles:[5]

1.on board : by oneself The battery may be charged "on-board" during the day from a public power source and "at home" at night from a standard household socket (slow charger)

2.independent: it functions like a petrol station and provides quick battery charging. It is possible to reuse a full battery to recharge a depleted one.

There are downsides to the "stand-alone" approach:

There are two main issues with public battery charging There are two main issues with public battery charging stations:

(1) the expensive price, and

(2) the possibility of vandalism owing to their easy accessibility.

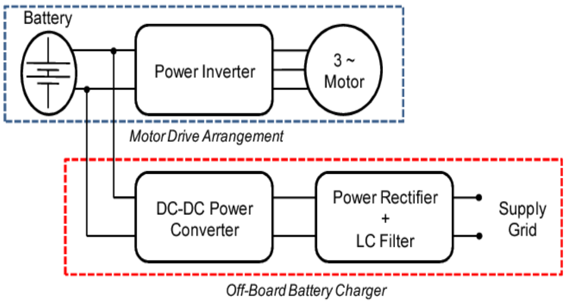

Fig 4: electric drive motor with off- board battery charger

The structure of an electric vehicle that allows for external battery charging It is more expensive to implement such a design since it calls for two power converters: one for driving the vehicle, and another for recharging the batteries. One possible remedy to this severe drawback is to include the rapid charger's power electronics within the car. Further, if the electric vehicle's motor drive's power components are put to use, it may be possible to lower the charger's overall size and expense.[4]

The suggested battery charger includes components like a power rectifier and an LC filter that may be conveniently installed next to the motor, such as a propulsion drive power inverter. Harmonic pollution and the consequences of the charger's low power factor are two ways in which the expanding usage of electric vehicles may impact the electric distribution system. Therefore, a battery charger with power factor adjustment is required while charging from an AC outlet.

Fast charging power electronics:

The fast-charging power electronics of a plug-in hybrid electric vehicle include three stages: an input filter for input harmonic reduction (which also aids in power factor reduction), an AC-DC rectifier, and a DC-DC converter that transfers power to the battery (PHEV). Another benefit of DC charging is that it does not need an external AC-DC rectifier or DC-DC converter since it is included into the onboard charger for AC charging. The size of the in-car charging equipment is limited by available cabin space. The quantity of energy that can be converted and sent to the battery by the onboard converter is often low due to the converter's compact size (3–6 kW).[7]

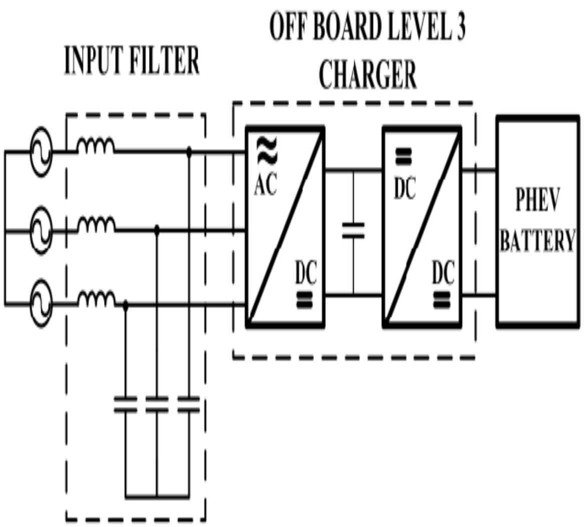

Fig 5: *off-board fast charger*

Because of the AC-DC conversion process through rectification, the EV charging station appears as a DC load to the electric distribution system, which might have a detrimental impact on grid power quality. It is the job of the input filter to eliminate power factor-robbing harmonics before they enter the distribution system. The following formula represents total harmonic distortion (THD) in terms of the ratio of harmonic input currents to the fundamental component of the total input current.

$$THD = \frac{\sqrt{\sum_{h=2}^{\infty} (I_h)^2}}{I_1} \quad (1)$$

Where, Ih = harmonic input current

L1=fundamental component of the total input current

DPF=cosϕ1 (2)

Where, φ1 = phase shift between the fundamental input current and the input voltage

The above equation gives displacement power factor(DPF)

It is possible to adjust the charging system's energy factor at the input filter and during the AC-DC rectifier. The grid power is transformed into a DC bus through the AC-DC conversion process. A common DC bus is being developed for EV charging stations so that all of the chargers may use the same power source. A common AC bus can power several chargers, but each one will need its own AC-DC rectifier. Renewable energy services and on-site energy storage are simplified by a centrally located DC bus.

Power electronic converters:

The power electronic converter can securely charge an electric vehicle's battery in 5–10 minutes, has isolation to protect drivers, allows for power to flow in both directions, uses soft switching to minimise switching losses, and achieves resonance to maximise efficiency. Pulse charging is an exciting new quick charging technology for electric vehicle batteries. High-power pulse charging necessitates the creation and optimization of cutting-edge converters. Pulse charging controls are also necessary since they can keep track of the battery's condition and make adjustments for optimal charging. The DC bus and the grid will be affected by the large current pulses. [6]

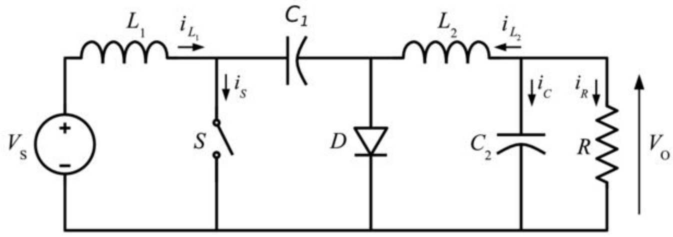

Fig 6: Cuk converter

An example of a negative-output DC-to-DC converter is the Cuk converter. It uses a buck-boost converter architecture but with the output polarity flipped. Depending on the duty cycle setting, the voltage will increase or decrease. The Cuk converter swaps out the inductor for a capacitor to accomplish the same task. As a filter, the input inductor reduces the amount of harmonic distortion in the power supply. However, if constructed correctly, the converter provides ripple-free output, increasing its usefulness in many contexts. The Cuk converter's easy installation of transformer isolation, which reduces input current at start-up and under overload, makes it a good choice for PFC applications.[8]

Charging types and levels

Conduction and induction charging are two ways for charging electric vehicles.

Wireless induction charging takes place between a transmitter and a receiver. During conduction, charging is performed by connecting a high-power wire from the source to the EV. Wireless charging requires more research, and not all EVs support it. Therefore, charging EVs using conduction charging is less costly and more efficient.

Conduction charging is classified into three levels based on the kind of connection, power rating, and source type. Table 2 shows the charging levels most typically utilised by EV chargers.[10]

Battery model for electric vehicles

Electro chemical characteristics of battery:

When a battery is first made available, its maximum capacity is set. True battery capacity, however, is not fixed but rather changes with power input. Therefore, the SOC estimation error and the anticipated driving range error both rise due to this factor. Discharge capacity decreases as discharge current rises. The chemical reaction rate is lower than the power input, so this happens. It can be seen from the battery's discharge capacity curve that the battery's capacity decreases as it is discharged more quickly. Capacity offset is the performance metric universally acknowledged by all forms of energy storage. in proportion to the increase in current or power. To power its electric discharge, a battery undergoes a chemical reaction in which lithium ions move from the anode electrode to the cathode electrode. During the charging process, the ions move in the opposite direction. The anode and cathode values in a cell-balanced battery are both equal. EV batteries have a function called cell balancing.[9]

Equivalent structure of battery :

There are several components that contribute to the same battery design. It's quite hard to achieve accurate modelling. It is possible for SOC estimation inaccuracies to be brought on by incorrectly configured battery models. However, a simple SOC prediction method based on the similar battery model has benefits, such as real-time SOC estimate. To improve the precision of SOC estimations in operational contexts in real time, we present a comparable model-based estimating approach utilising ECM and EIM. The battery may be represented as an electric equivalent circuit. According to studies in electrochemistry and electric response, batteries have a voltage source, Voc, and an internal resistance, Rin, in their equivalent circuit. Rin is the terminal voltage and voltage drop reaction to internal resistance while charging and draining. To more accurately predict the voltage and current response, a multi-RC model of the battery's equivalent circuit was employed.[5]

Charging strategy improvement:

Having your driving range diminished is almost inevitable. However, efficient charging is feasible if the charger is a suitable reflection of the battery's capabilities. In fast charging mode, an electric vehicle's usable energy loss is more obvious. This section places a premium on enhancement by suggesting the CPCV charging method. Supercharged engines have a smaller volume of displacement, which lowers frictional and heat losses. Because more fuel is expended in the same amount of time due to the increased mass taken per stroke, a supercharged engine's braking power improves by around 30-45 percent. It's a breeze for a fast motor.[11]

Conclusion:

This study introduced fast-charging methods, discussed their difficulties (such as heat control and limited consequences on battery systems), and suggested future research directions. It is clear that in the next decades, a transportation system based on petroleum will not be able to meet the needs of the planet, thus innovative technologies that will move the globe toward sustainable electric transportation are urgently needed. Therefore, the usage of electric cars may help decrease pollution and pave the way for innovations like superchargers. Superchargers have several downsides, such as requiring a certain kind of high-capacity battery and posing some heat management challenges, but they hold great promise for the future if these obstacles are overcome. hence, this study suggests the rapid charging methods for electric cars.

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