ISSN: 2321-2152

IJMECE

International Journal of modern electronics and communication engineering

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IJMECE
International Journal of modern electronics and communication engineering
ISSN 2321-2152
www.ijmece.com
Vol 13, Issue 2, 2025

Smart DC Fast Charging for EVs: Simulation-Based Study of CC-CV Charging Strategies.

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Abstract—

As the demand for electric vehicles (EVs) rises due to environmental concerns, there has to be a quick transition to these eco-friendly automobiles. The availability and effectiveness of charging stations play a significant role in this transformation, since faster charging times are essential. Fast charging stations that employ DC (Direct Current) current are proposed here as a possible option. Using a MATLAB/Simulink model, this research aims to examine how electric cars behave while charging when connected to a DC fast charging station. The model incorporates a three-phase power supply, control algorithms, a buck converter, and an AC/DC converter to efficiently charge the batteries of electric vehicles. Several control mechanisms and design approaches are explored in the simulation, which is executed in compliance with the DC level-3 charging standards. The findings demonstrate that ConstantCurrent (CC) charging occurs while the EV battery's State of Charge (SOC) is below 80% and that Constant Voltage (CV) charging takes over when the SOC is over 80%. This procedure ensures that batteries are not overcharged, which significantly reduces their lifespan. The results provide insight on the potential future integration of DC fast charging devices into the power grid and their significance for the charging infrastructure. The widespread adoption of electric cars will be accelerated by this invention, which will maintain batteries healthy and charging efficiency at its peak. CC&CVcharging, MATLAB/Simulink, DC fast charging, and related terms.

INTRODUCTION

There are a variety of battery charging technologies that may be used to charge the batteries of electric vehicles. Trickle charge, AC charge, and DC charge are the three distinct kinds of charging. • CHARGE with choke Charging an electric car at home using a regular 220V outlet is one of the most sluggish methods. Please contact your electrical provider before doing this, and only in extreme emergencies. • Charging You may also use the public charging option. It enables you to charge the system more quickly with the wall box placed at your location. • DC charging Currently, the majority of electric vehicles (EVs) charge their batteries using regular household AC chargers. Nevertheless, DC fast chargers are swiftly replacing other options due to the increasing number of EVs on the road. Due to their many advantages, these quick chargers are sometimes referred to as Level 3 electric car chargers. By linking DC fast charging stations to solar PV producing, it is feasible to integrate efficient charging with renewable energy. This link reduces reliance on the grid while also encouraging environmentally friendly charging practices. Direct current fast chargers (DCFC) are a godsend for electric cars that need maximum range enhancement in a hurry. They are able to provide the fastest charging speeds for EVs, allowing drivers to quickly replenish their batteries and continue driving. METHOD FOR CONTROL The DC rapid charging technique with constant current and voltage is shown in the schematic design in Figure 1. In the beginning, we used a 3-phase AC supply with a 415 VAC input and linked it to an AC-to-DC converter using the appropriate parameter values in our design. The gate-pulsesto three-phase rectifier undergoes a change from ABC to dq0. The output from the after-rectifier DC is linked. on the requirement for algorithms that maintain a consistent current and voltage, to a Buck-Boost converter. It is determined using the M-function block in MATLAB which charging method is necessary for a certain battery. In that block, we wrote an algorithm to pick between CC and CV depending on battery voltage and available current. Due to concerns about overcharging and safety, we opted to charge the battery using a constant voltage algorithm after it reached 80% of its state of charge; however, we could adjust the threshold at which we switch from CC to CV if necessary.

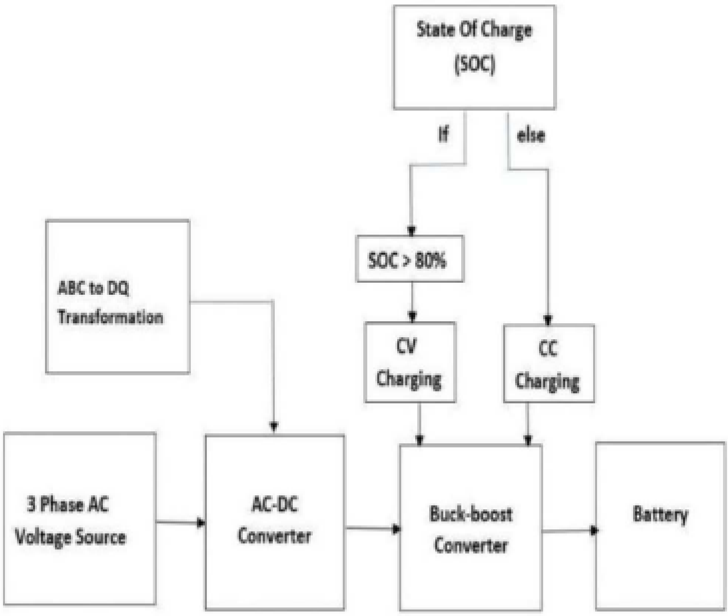

Fig.1 Block diagram for DC Fast charger

The quickest and most effective way to charge an electric vehicle (EV) is to use a public DC Fast station that has a power rating of 50kW or more. Direct current (DC) charging has several advantages over alternating current (AC). By bypassing the electric vehicle's on-board charger and conversion, it supplies DC power directly to the battery. Charging speeds may be significantly enhanced in this way. Charging time is dependent on many factors, including battery capacity and dispenser output. However, most DC fast chargers available today can fully charge a lot of EVs in little over an hour. DC quick charging is best used for long-distance trips, high mileage, or circumstances requiring large electric vehicle fleets. Thanks to the quick turnaround time, drivers can now charge their vehicles during the day or take a short break without having to wait for overnight or extended periods to completely charge them. In order to facilitate the building of a DC fast charger for electric cars, a Simulink model is now being developed. This model will accurately simulate charging in order to maximize the charger's efficiency. By providing a reliable and fast charging solution that utilizes DC fast charging, we want to assist electric car owners with their long-distance excursions, high-mileage needs, and fleet operations. The standard for quick charging (CCS) connections. Fast charging electric automobiles has never been easier than with these connections, which guarantee interoperability between various charging stations and vehicles. Although DC fast charging is now the most popular method, alternative charging methods are still the subject of continuing study. There are now ongoing efforts to improve the charging experience for electric car owners via the exploration and development of non-contact charging, which does away with the need for physical connections, and on-board solar charging, which makes use of solar panels incorporated into the vehicle. The need for efficient and sustainable charging infrastructure is expected to rise in response to the expanding electric vehicle industry. To fulfill this demand, it is crucial to deploy DC fast chargers, integrate them with renewable energy sources, and explore novel charging technologies.

SIMULATIONBLOCKS:

ThreePhasePowerSupplySub-system:

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ISSN 2321-2152

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Vol 13, Issue 2, 2025

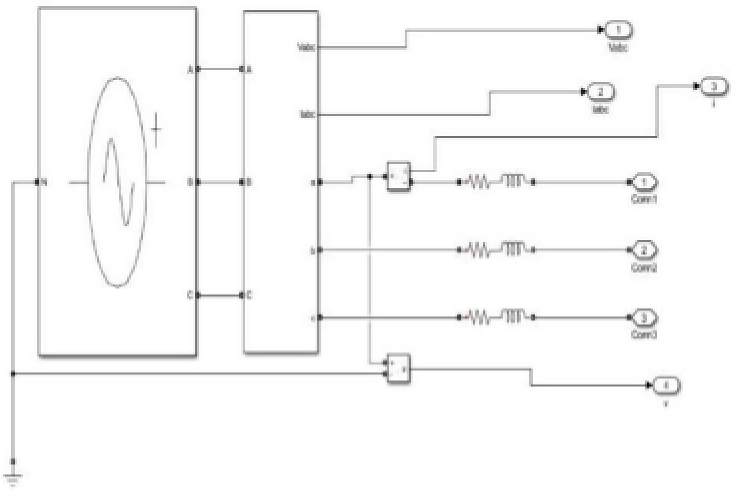

Fig. 1 Three phase power supply sub-system

Blocks Required:

1. 3 Phase Voltage Source
2. 3 Phase V-I Measurement
3. Series R-L Branch
4. Voltage Measurement
5. Current Measurement.

ABCtodq0transformations:

We transformed the three-phase voltages Va, Vab, and Vc into Vd and Vq in this block. Additionally, Id and Iq transformation is applied to Ia, Ib, and Ic. We revised our control technique after designing gainsofblock utilizing established equations.

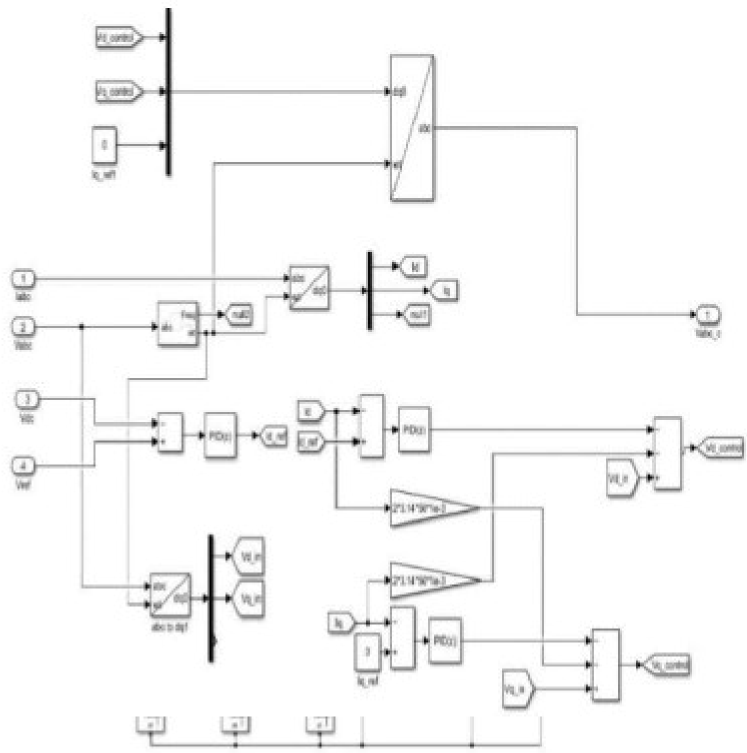

Fig.3 ABC to dq0 transformations

Math-functionblockforswitchingCCtoCValgorithm:

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There are two distinct ways in which DC fast chargers function. 1. When the battery's state-of-charge (SOC) is less than 80%, the DC fast charger will continue to charge the battery at a steady current. The charging current is around 125 A, and the voltage required to charge the battery is 400 V. For a battery state of charge (SOC) greater than 80%:

MATLAB Function

```
function ref = fcn(CV, CC,T, SOC)
persistent ref1 n
if isempty(ref1)
    ref1 = 0 ;
end
if isempty(n)
    n = 0 ;
end
if (T>n*0.000002) % sample time is 0.02s
    n=n+1;
    if SOC < 80.0
        ref1 = CC ;
    elseif SOC > 80.0
        ref1 = CV ;
    end
end
ref = ref1;
```

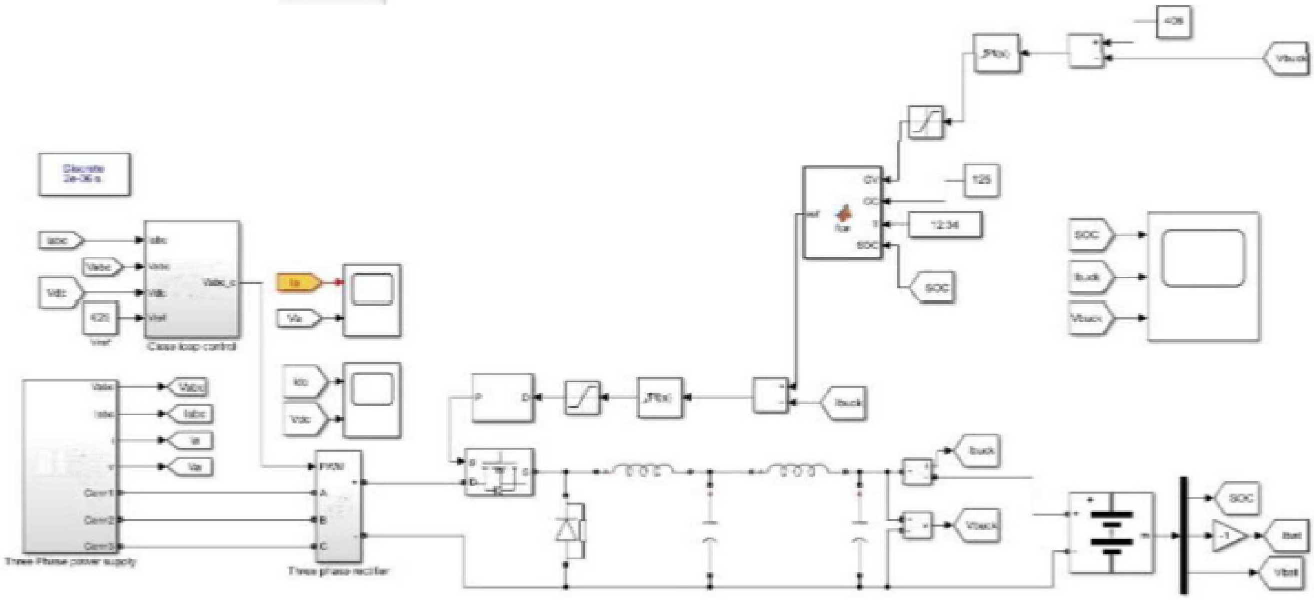

Fig.5 DC Fast Charger Model

***SIMULATION RESULTS*:**

Following the effective implementation of the aforementioned battery management approach for DC fast charging of electric vehicles, we obtained the following outcomes: 1. The Algorithm for Constant Current: Algorithms that ensure a consistent current flow charge the battery more quickly by supplying a higher current value that is proportional to the battery's capacity. After 80% of the system-on-chip (SoC) batteries have been charged using constant voltage algorithms, our design mandates that the remaining 20% be charged using different methods to prevent the battery from being overcharged and potentially damaged.

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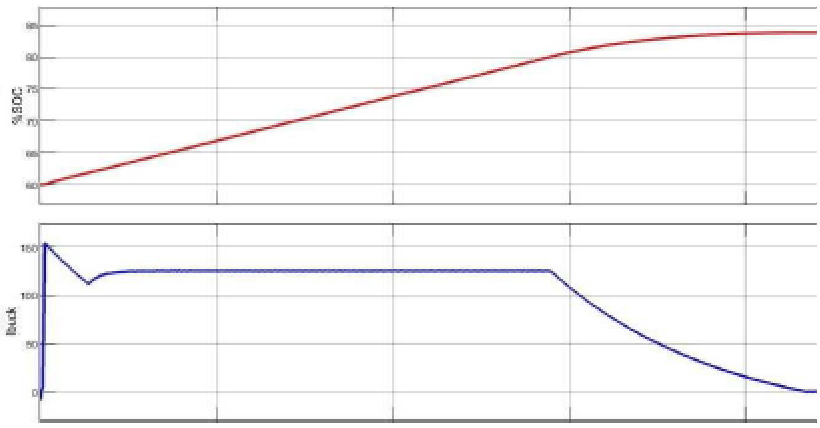

Fig.5 Output waveform during constant current algorithm

2. CONSTANT VOLTAGE ALGORITHM:

A constant voltage algorithm allows the battery to charge more quickly by supplying a lower current value in relation to the battery's capacity. Also, we made sure to include a threshold for when to use CV algorithms to charge the battery; otherwise, it may overcharge and harm itself, thus our design calls for disconnecting the battery from the power source when the SoC battery has been charged to 100%.

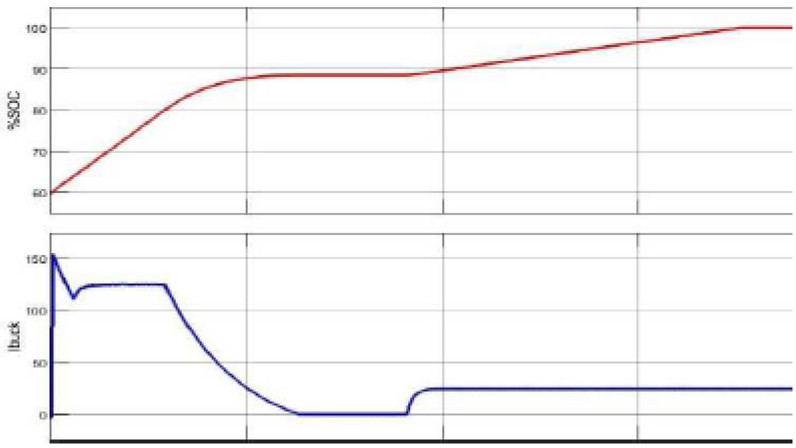

Fig.6 Output waveform during constant voltage algorithm

CONCLUSION:

The main objective of this suggested endeavor is to build DC fast charging algorithms since a DC charger may charge a battery to the same capacity in one to two hours instead of four to five hours with an AC charger. That being the case, charging times for EVs may be cut. When developing a system on chip (SoC), continuous current algorithms with a conditional threshold are one option; when the SoC is ready, constant voltage algorithms for charging batteries will be automatically applied. Using this system's Constant Current (CC) charging technology, electric vehicle batteries may be charged to 80% capacity economically and fast. The DC fast charger will charge the battery to full capacity using the Constant Voltage (CV) charging method when the State of Charge (SOC) reaches 80%. These chargers protect the batteries from being overcharged and also extend their life. The suggested research aims to find a technique to decrease charging time. Although DC fast charging reduces charging times for consumers, it is more expensive up front and has a greater failure or damage probability than AC charging. Consequently, the hardware implementation of this requires extra safety precautions. One possible way to encourage more people to use electric vehicles is to put the aforementioned technology at charging stations.

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