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FLC Based On a Wide Input and Output Voltage Range Battery Charger Using Buck-Boost Power Factor Correction Converter

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Abstract: *For electric vehicle battery charging better converters needs to be used for reduced ripple in voltage and current. The conventional buck-boost converters are replaced with novel PFC converters for improving the power factor of the source. As the large capacity batteries need more power to charge which impacts the quality of the source. In this paper a novel interleaved boost cascaded by buck converter is integrated to single phase source to charge batteries with wide range of ratings. The converter is controlled by FIS to operate the switches of the converter so as to change the output voltage to specific value. The output voltage generation has wide range between 50V to 500V. The complete modeling and analysis is done is MATLAB software with results discussion for different operating conditions. A comparative analysis between PI and fuzzy controllers is also carried out with respect to time.*

Keywords: *Electric Vehicle, Conventional Buck-Boost Converter, PFC Converter, PI and Fuzzy Controller*.

1. Introduction

There has been a gradual but steady infiltration into mainstream transportation of electric cars because of electric vehicles' enormous beneficial influence on the environment. However, despite the fact that a lot of EVs are being produced, the number of EVs on the road is rather low. Lithium-ion batteries are the most often used sort of EV battery. Despite the fact that electric and plug-in hybrid cars are the most fuel efficient, they have not been extensively embraced. Batteries, pricing, and charging issues have all been cited as significant reasons for not implementing these cars on the grid. Another issue with PHEVs as compared to traditional fuel stations is the absence of suitable and appropriate charging infrastructure and regulatory support for energy storage solutions.

Hybrid cars employ lithium-ion batteries that are quicker and less efficient than those used in typical electric vehicles. In addition to battery life, plug-in electric and hybrid cars have a slew of additional drawbacks as compared to pure electric vehicles. For example, the HEV's fuel economy is much lower than that of an EV. Bi-directional AC-DC converters and DC-DC converters of the same origin are the most widely utilised power converters for these vehicles.[1]

Because PEVs are a relatively new technology, there aren't many charging stations around. In addition, PEV's bidirectional converters don't employ conventional architecture; instead, they're often unidirectional bridge rectifiers. As a result of the facts acquired, it can be concluded that EVs are more efficient than HEVs or PHEVs in nature due to their zero emissions, high efficiency, reduced noise, safety, and smooth operation, as well as their independence from petroleum fuel. During braking, the electric motor acts like a generator and recharges the battery as the kinetic energy is completely transformed to potential energy. This is the primary benefit of EVs. [2]

General configuration of an EV charging system

The fundamental DC of the AC power converters is used to create the EV battery chargers, which must be very powerful and effective. Unregulated or regulated rectifiers are used in AC-DC converters that use Buck / Boost or switch mode technology. In most cases, DC-AC converters are built around single-phase H-bridge inverters or three-phase inverters.

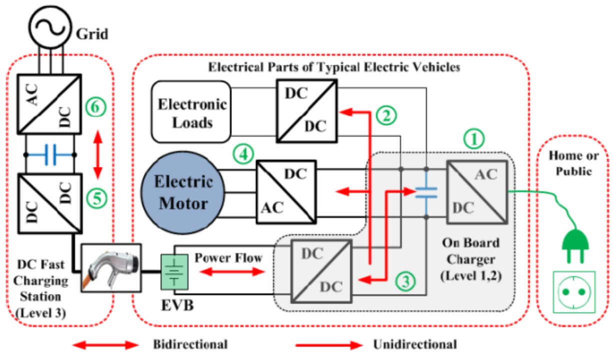

Figure 1 General topology of EV charging panel

There are many different ways to charge an electric vehicle, and this diagram displays the most common setup. Figure 1 depicts the many types of power converters that may be utilised to achieve the various effects shown (numbered from number 1 to number 6). EV batteries may be recharged with either an onboard or an offboard charger (levels 1, 2, and 3). EV battery chargers may be integrated into a vehicle, either as an on-board charger or an isolated outboard charger. The EV batteries and the grid may have a one-way or two-way power flow.
Modern commercial on-board chargers use unidirectional power flow because it is simple and reliable in both topology and function. Electric vehicle batteries may be used to generate electricity by controlling bidirectional charges. It's possible to think of an EV battery as a highly efficient distributed power source that may be used in a variety of ways. AC-DC converters and DC-DC converters are featured in all on/off board loaders, as seen in Figure 1. Nevertheless, the topologies and power ratings of the converters differ entirely within each category of chargers. [3]

2. Methodology

2.1 Fuzzy Logic Controller

In order to create a shunt active filter control method, the DC side capacitor voltage must be monitored and compared to a reference value. There are two inputs to fuzzy processing: an error and an error change. A fuzzy controller uses a set of language rules to regulate its actions. Since no mathematical model is necessary, it may be used with erroneous inputs. [3]

2.2 Fuzzification

In fuzzy logic control, instead of numerical variables, linguistic variables are employed. These mistakes may be classified as either positive, medium, large, negative, or zero when compared to the reference and output signals, with the exception of zero, which is always positive. Using a triangle membership function, fuzziness is being implemented. Numerical variables are transformed into linguistic variables using fuzzification. [4]

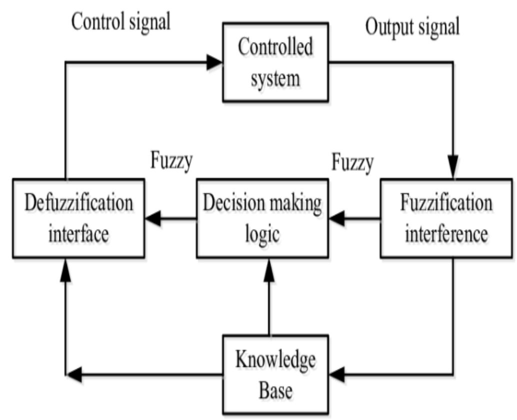

Figure 2 Block diagram of Fuzzy Logic Controller

3. Result Analysis

With the above modules the modeling is done in Simulink of MATLAB software as shown in figure 6 below.

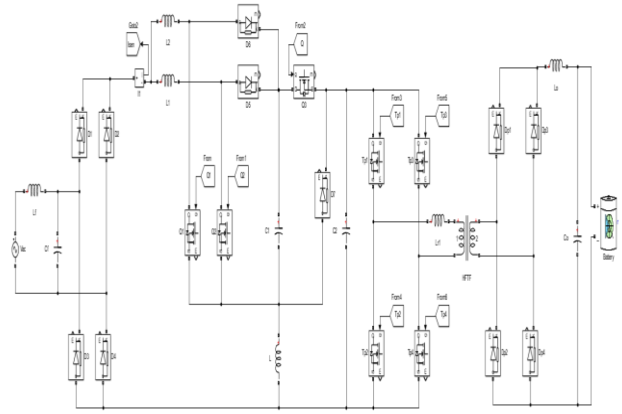
Fig. 3 Simulation modeling of proposed circuit topology

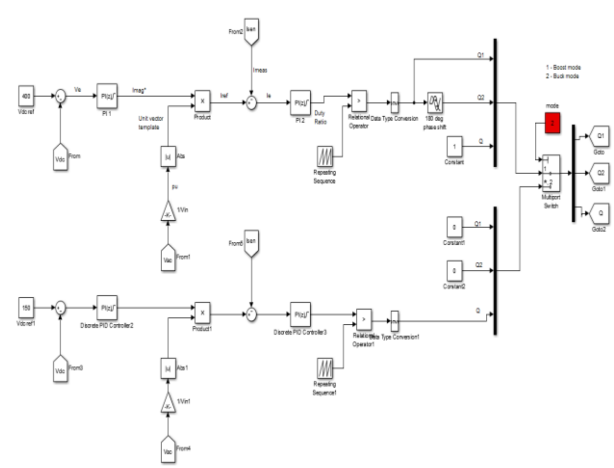
Fig. 4 modeling of control scheme with PI controller

The above figure is modeling of proposed control structure with PI controller generating pulses for the MOSFET switches. The FIS controller updated to the control scheme is shown in below figure.

The simulation is run for 1 sec and measurements of different elements is shown below operating the circuit in buck and boost conditions. The below is the input voltage and current of the single phase source.

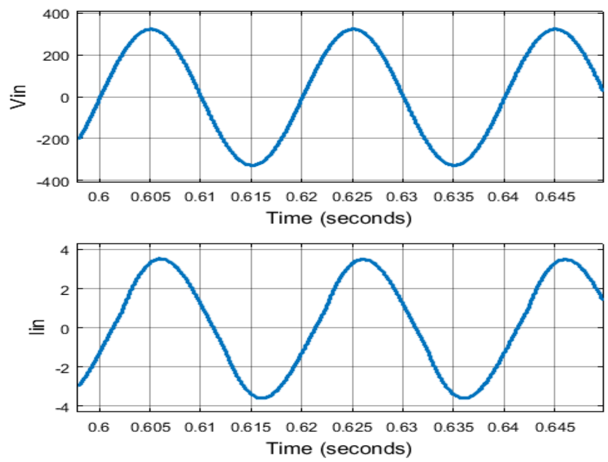

Fig. 5 Input voltage and current

At first the circuit is run in buck operating condition with reference voltage at 70V considered as charging voltage for 48V 30Ah battery. The below are the results for the buck mode operating.

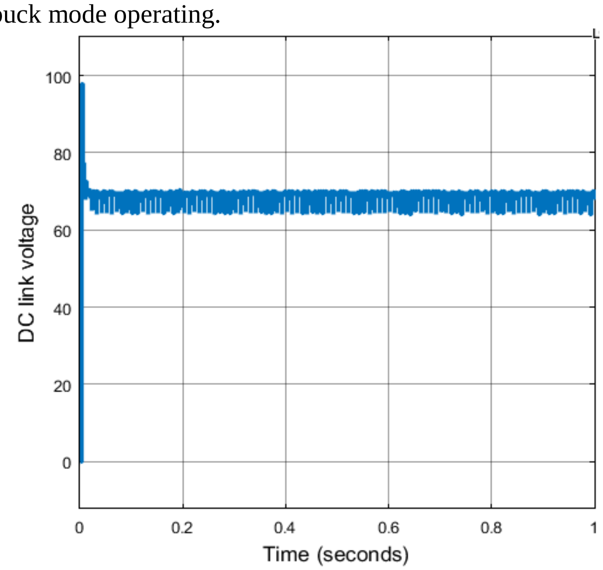

Fig. 6 DC output voltage during buck operation

The above is the DC link voltage measurement outputs of the interleaved boost cascaded by buck converter in buck operating condition and below are the characteristics of low rating battery.

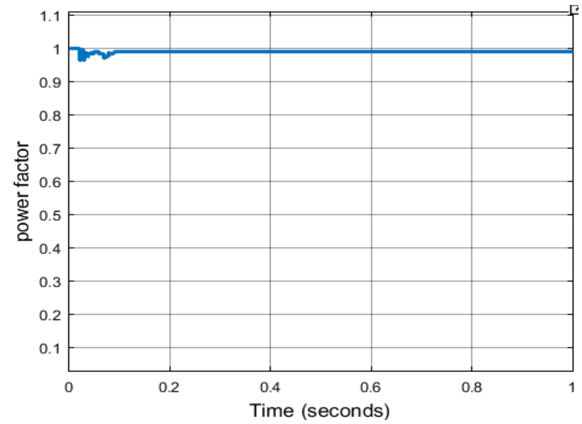

Fig. 7 Power factor of source during boost or buck modes with PI controller

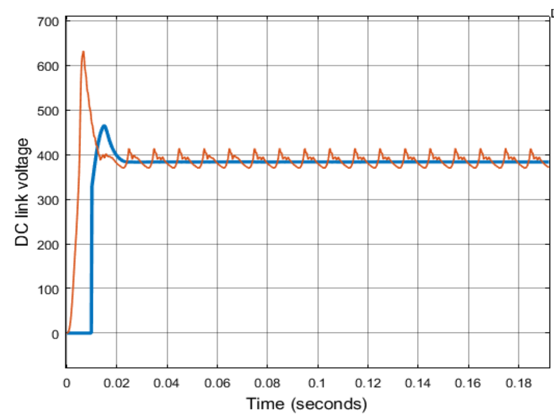

Fig. 8 DC link voltage comparison with PI and FIS controller in boost mode.

4. Conclusion

With the above results it is clear that the proposed interleaved boost cascaded by buck DC-DC converter can be operated for low voltage at 70V and also at high voltage of 400V. The same circuit can charge the low rating battery with 48V 30Ah and also charges high rating battery with 400V 90Ah rating. The results show that the input power factor is also maintained near to unity when the circuit is charging the battery. Ripples and less peak overshoot as compared to PI controller.

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