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Constant Current Fuzzy Logic Controller for Grid Connected Electric Vehicle Charging

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ABSTRACT

The increase in demand for clean sources of energy is getting more attention in recent time. Electric vehicle (EV) is an important area to fulfill this demand. However, one of the major obstacles in the growth of EV is the longer charging time. Therefore, there is a definite need for the reduction of charging time in EVs. Constant current charging of EV can help to solve this problem. That's why, the role of DC-DC converter is very important. DC-DC converters are commonly utilized in electronic devices such as mobile phones, computers etc. This paper presents the possibility of grid connected constant current charging of EV with buck DC-DC converter through fuzzy logic control (FLC). FLC is easy to implement without the requirement of intensive mathematical modelling. The complete model of the considered system has been developed in MATLAB/Simulink. The achieved simulation results show the viability and capability of the proposed scheme.

Keywords: DC-DC converter, fuzzy logic controller, electric vehicle

I.INTRODUCTION

ELECTRIC vehicles (EVs) have taken a significant leap forward by advances in motor drives, power converters, batteries, and energy management systems [1]–[4]. However, due to the limitation of current battery technologies, the driving miles are relatively short that restricts the wide application of EVs [5]–[7]. In terms of motor drives, high-performance permanent-magnet (PM) machines are widely used while rareearth materials are needed in large quantities, limiting the wide application of EVs [8], [9].Briaud et al. (1997) indicated that at least 25 percent of the 600,000 bridges in the US, or about 150,000 bridges, are affected by bridge approach settlement. Similar statistics were shown by other studies. The Stark et al. (1995) study reported that 27 percent of the 1181 bridges in Illinois had significant differential bridge approach movement and that adjacent states such as Iowa, Wisconsin, Michigan, Ohio, Indiana, Missouri, and Kentucky exhibited similar percentages. Ha et al. (2002) reported that 24.5 percent of the Texas DOT bridges indicated a bump. Another study conducted by Luna et al. (2003) for Missouri DOT (MoDOT) reported that 17 percent of the bridges exhibited bridge approach settlement and an additional 15 percent required remediation.

In order to overcome these issues, a photovoltaic (PV) panel and a switched reluctance motor (SRM) are introduced to pro-vide power supply and motor drive, respectively. First, by adding the PV panel on top of the EV, a sustainable energy source is achieved. Nowadays, a typical passenger car has a sur-face enough to install a 250-W PV panel [10]. Second, a SRM needs no rare-earth PMs and is also robust so that it receives increasing attention in EV applications [11]–[16]. While PV panels have low-power density for traction drives, they can be used to charge batteries most of time.

Generally, the PV-fed EV has a similar structure to the hybrid electrical vehicle (HEV), whose internal combustion engine (ICE) is replaced by the PV panel. The PV-fed EV system is illustrated in Fig. 1. Its key components include an off-board charging station, a PV, batteries, and power converters [17]– [19]. In order to decrease the energy conversion processes, one approach is to redesign the motor to include some onboard charging functions [20]–[22]. For instance, paper [22] designs a 20-kW split-phase PM motor for EV charging, but it suffers from high harmonic contents in the

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back electromotive force (EMF). Another solution is based on a traditional SRM. Paper [23] achieves onboard charging and power factor correction in a 2.3-kW SRM by employing machine windings as the input filter

In order to achieve low-cost and flexible energy flow modes, a low-cost tri port converter is proposed in this paper to coordinate the PV panel, SRM, and battery. Six operational modes are developed to support flexible control of energy flow. The drastic decline in the fossil fuels [1], brings out the term E for Electric in place of Engine. Electric vehicles have become a vital coinage in Auto mobile industry. The heart of this vehicle [2] are motor and the power supply to the motor (battery). Various charging paradigms have paved their way for fast and efficient charging.

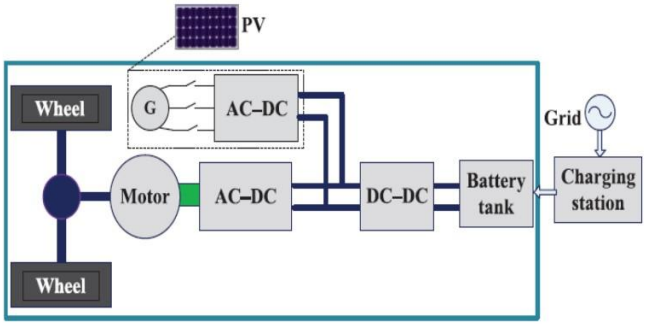


Figure 1:Shows PV-fed HEV

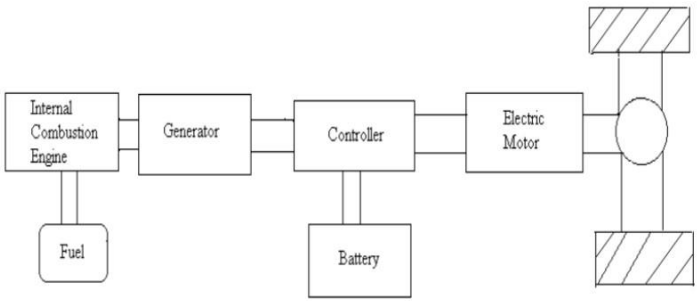
II. ELECTRICAL VEHICLES

Global warming, carbon footprint, environmental pollution and shortage of fossil energy hassled to the wide application of Electric Vehicles in many countries. With the rapid development of the EV industry, planning of ways to charge EVs is gaining widespread attention [1].Moreover, apart from private vehicles, modes of public transport like Auto-Rickshaw are also being developed using PV in developing countries [2]. Charging of an EV plays a very important role in the EV industry. We use EV to decrease the carbon footprint due to vehicles run by petroleum products. But charging of an EV also needs electricity.

There's no meaning of using an EV if the charging of EV is done altogether by conventional power plants that use fossil fuels or nuclear energy for producing electricity. Anticipation is to make future charging stations powered by on-site PV systems [3]. But due to intermittency of solar power, we need to connect it with grid as well to create a reliable supply source. Charging deadlines are the key determinant of the overall carbon footprint of the charging service. The later the deadlines are, the more solar energy would be available for EV charging, reducing the use of conventional energy and the associated carbon footprint. This method can be used to charge an EV to travel for longer distances but with charging wait time associated with it. To further reduce the wait time, the concept of PV-based Battery Switch Stations was proposed [4].

HYBRID ELECTRIC VEHICLE

The Hybrid Electric Vehicle (HEV) (Chan 2001, JoergAbthoff 1998) is a concept vehicle, the driveline of which consists of both an internal combustion engine (ICE) and an electrical machine drive system. The two main topologies available are parallel and series HEV.



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Figure 2 : Shows the Hybrid Electric Vehicle

III. SYSTEM & SPECIFICATIONS

The complete simulation diagram of the EV charging system is developed in MATLAB/Simulink as presented in Fig. 1. In this figure, voltage source is modeled as a three phase source and the transformer as a Star-Delta connection. A three-level bridge inverter is used for AC to DC conversion. The adjustment of the DC bus voltage and reactive current of the grid are done by the control system, DC regulator, as shown in Fig. 2. This comprises of a DC voltage control and a current control. A d-q transformation process is employed with phase loop. The current reference Id is the output of the DC voltage regulator. The magnitude and voltage phase generated by the current regulator is used to regulate the converter as presented in [16].

Figure 3 shows DC-DC buck converter system with output Vo. The converter allows the lowering of input voltage magnitude to a desirable level in order to charge the EV. The input of the DC-DC buck converter is connected to the output of the grid supply and the output of the converter is connected to the battery.
The duty cycle of the buck converter, which is the ratio of two voltages, can be determined as:

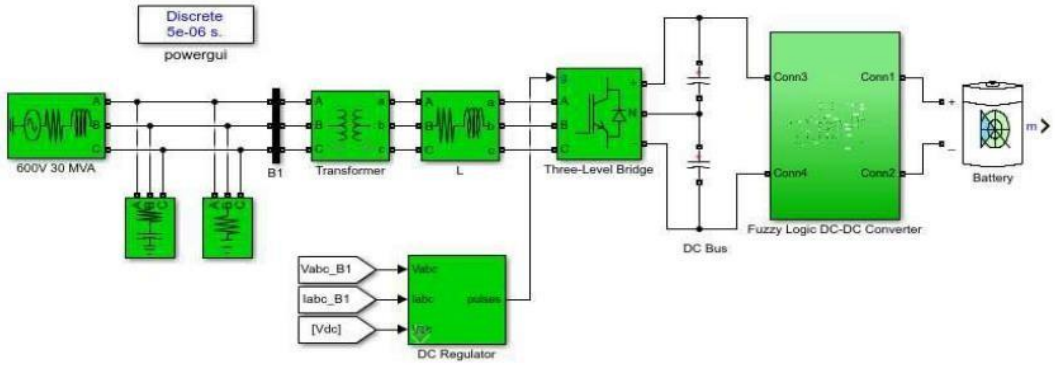


Figure 3: Shows the EV Charging system Developed in MATLAB/SIMLINK

FUZZY LOGIC CONTROLLER

Controllers are primarily employed to bridge the gap between the measured output parameter and the reference value. The fuzzy logic controller in this paper is based on the bang-bang control [15],[12]. Bangbang control system automatically turns on/off in order to keep the measured output close to the reference value. It is basically known as a two-step controller.
Fig. 4 shows the design for the control system where the fuzzy controller is implemented as a current regulator. The difference between the reference and the actual voltage measurement serves as the input for the fuzzy controller. This determines the reference current to charge the EV battery.

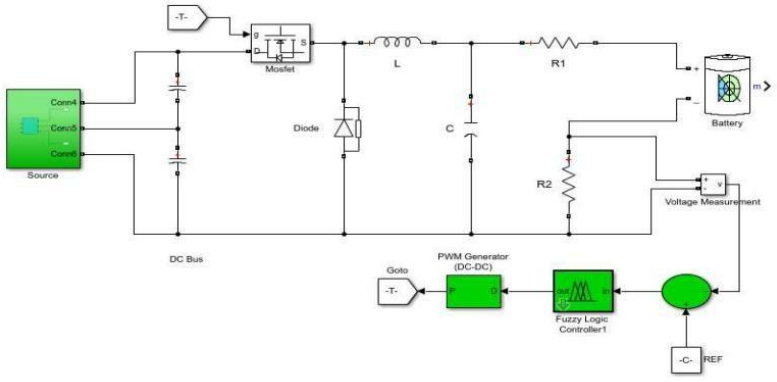


Figure 4:Shows the Fuzzy logic controller with DC-DC converter.

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Centroid defuzzification or center of gravity (COG) approach was employed between the input and output membership functions (MF). This is center of gravity where all points intersect. This procedure produces an output value based on the COG of the fuzzy set. The overall control is obtained from smaller division of membership function's total area.

IV. RESULTS AND DISCUSSION

The values of the parameters used for simulation are presented in TABLE I. DC fast charging mode with $400V$, $120A$ and $48kW$ are used for simulation. The complete simulation block diagram is presented in Fig.

1.Fig. 8 shows the result for the $120A$ constant current (CC) Charging for the 12 kWh EV battery. The fuzzy logic controller maintains a constant current for charging of the EV battery. This result shows the applicability of the fuzzy logic controller for fast DC charging of EV.

Furthermore, there is a steady rise in battery state of charge (SOC) from 50% while maintaining a constant DC bus voltage as shown in Fig. 10 and Fig. 11 respectively. Fig. 12 shows the transient behaviour of DC bus voltage when battery is connected for charging. The small settling time of around 0.2 second can be observed before reaching the final value of 800V.

Table 1 : Table of Design Parameters

Parameters	Values
DC bus voltage	800 V
Inductance	21µH
Grid voltage	600 V
Transformer	600/240 V
Grid frequency	60 Hz
Battery SOC	50 %
Battery nominal voltage	300 V
Battery time constant	2 sec
Battery capacity	12 kWh
Short circuit level	30 MVA
X/R ratio	8
EV charging current	120 A

V. FUTURE SCOPE

In this paper, the complete model of EV charging system with the utilization of fuzzy logic controller is presented. The complete simulation model has been developed in MATLAB/Simulink. The achieved simulation results show how easy FLC can be used in EV charging without the requirement for any tuning like with PI controller. In perspective of this work, experimental validation of the proposed scheme can be Performed.

REFERENCES:

[1] M. Tesanovic and S. Vadgama, "Short paper: Vehicle emission control in Smart Cities," in 2014 IEEE World Forum on Internet of Things (WF-IoT), 2014, pp. 163-164.
[2] P. Goli and W. Shireen, "PV Integrated Smart Charging of PHEVs Based on DC Link Voltage Sensing," IEEE Transactions on Smart Grid, vol. 5, pp. 1421-1428, 2014.
[3] Z. S. R. Bhatti, M. Abdul Aziz, K. Pui Yee "A Comprehensive Overview of Electric Vehicle Charging using Renewable Energy," International Journal of Power Electronics and Drive System (IJPEDS)" vol. Vol. 7, No. 1, p. pp. 114~123, 2016.
[4] V. Tikka, H. Makkonen, J. Lassila, and J. Partanen, "Case study: Smartcharging plug-in hybrid vehicle test environment with vehicle-to-grid ability," in 2014 16th European Conference on Power Electronics and Applications, 2014, pp. 1-10.
[5] L. Dickerman and J. Harrison, "A New Car, a New Grid," IEEE Power and Energy Magazine, vol. 8, pp. 55-61, 2010.

[6] R. Shi, S. Semsar, and P. W. Lehn, "Constant Current Fast Charging of Electric Vehicles via a DC Grid Using a Dual-Inverter Drive," IEEE Transactions on Industrial Electronics, vol. 64, pp. 6940-6949, 2017.
[7] D. Sbordone, I. Bertini, B. Di Pietra, M. C. Falvo, A. Genovese, and L.Martirano, "EV fast charging stations and energy storage technologies: A real implementation in the smart micro grid paradigm," Electric Power Systems Research, vol. 120, pp. 96-108, 2015/03/01/ 2015.
[8] L. Tan, B. Wu, S. Rivera, and V. Yaramasu, "Comprehensive DC Power Balance Management in HighPower Three-Level DC–DC Converter for Electric Vehicle Fast Charging," IEEE Transactions on Power Electronics, vol. 31, pp. 89-100, 2016.

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