FAST CHARGING OF ELECTRIC BICYCLE

V. Srikanth[1], M. Navya Jyothi[2], CH. Rasagna[3], Dr K. Suneeta[4], S. Rathna Kumar[5]
[1,2,3]PG Student,[4]Professor,[5]Assistant Professor
[1,2,3,4,5]Department of Electrical and Electronic Engineering,
[1,2,3,4,5]J.B.Institute of Engineering and Technology, Hyderabad.

Abstract: To compete with gas stations, electrical vehicle charging stations should be able to charge batteries as fast as possible. Therefore, we come up with a solution to solve the charging time weakness. In this technique, battery reduced a significant amount of time needed during charging without reduces the performance and lifespan of the battery. To achieve this technique we are using more number of batteries (more than one). When the vehicle is in use the batteries are connected as per the requirement (series or parallel). At the time of charging the vehicle, we are disconnecting the batteries from the circuit and charging the batteries individually. So the number of batteries is more the lesser time to charge.

Keywords – Electric bicycles, Electric Power-Assisted Cycles, Light Hybrid Vehicles.

I. INTRODUCTION

Nowadays, fast chargers for batteries are required for many applications such as electrical vehicles (EVs), cell phones, laptops, and tablets. In electrical vehicle charging stations (EVCSs), fast charging needs high power converters to inject high currents during constant current mode. This leads to high voltage drop on the internal resistance and polarization parameters at the end of the constant current charging process. Also, high charging current may reduce the lifetime of batteries, so the charging process must be precisely controlled.

Many Electrical vehicles use Li-ion Batteries. So it is necessary to investigate the charging technique for LIBs. Different charging techniques are proposed in literature to charge the LIB [1][2][3][4][5]. Researchers in [5] claimed that negative pulse charging can increase the charging performance of batteries. [2] and [6] proved that if the internal resistance of LIBs is estimated and compensated, the CC-CV technique can charge the LIBs faster. To improve the cycling performance of batteries and reduce the temperature of batteries during charging, [3] introduced a multistage charging technique. However, this technique does not significantly reduce the charging time.

In order to further improve the charging speed, the effects of battery's internal resistance and polarization parameters also need to be considered [7]. However, the polarization and internal resistance parameters are functions of temperature, age, of the batteries [7]. So, accurate online battery parameter estimation is necessary to further increase the speed of battery charging.

In this, we are using the rectifier circuit to charge the batteries individually. Suppose if the electric bicycle is in use the batteries are connected in series or parallel connection as for the requirement.

When the electric bicycle is in charging mode the batteries are disconnected from the controller. Then the batteries are individually connected to the rectifier circuits and the batteries are charged individually by this we can obtain constant current and constant voltage. This charges the batteries as fast as possible and reduces the time for a full charge of the batteries.

The multiple batteries charging by using rectifier circuit figure is shown in below.

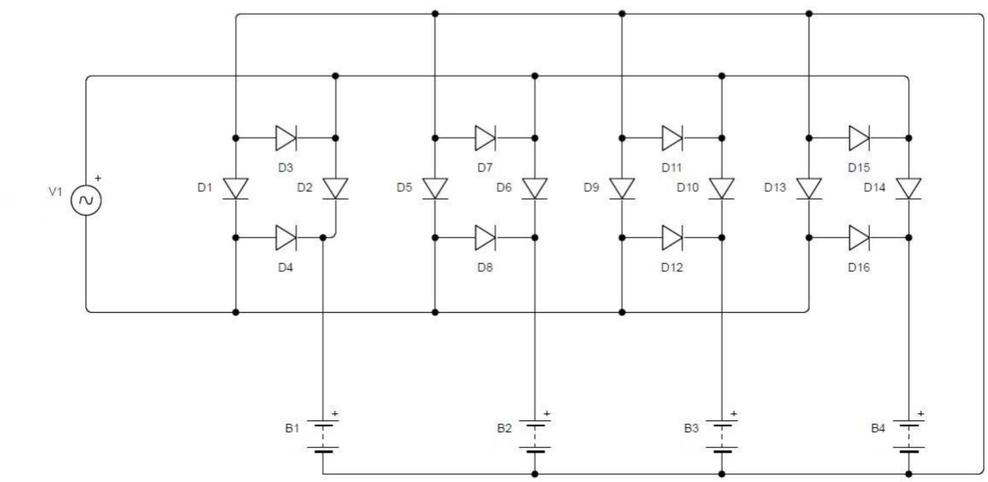

Fig. 1. Multiple Batteries charging using Rectifier Circuit Here v1 is the applied alternating voltage source

D1-D16 diodes
B1-B4 DC batteries

II. MAIN METHODS

When choosing a concept for designing an EPAC, one needs to be aware of the different approaches that are possible. In order to be able to list them in some order the approach taken in this paper is to separate them into three main domains – Electrical Engineering Domain, Mechanical Engineering Domain and System Level Design Domain. The main questions in each domain are [8], [9]:

- Electrical Engineering Domain –What type of electric machine to use? What motor drive control algorithm to implement? , What power converters need to be designed? What will the primary energy storage be (possibly a hybrid one)? How to charge the battery or what type of BMS system to implement?
- Mechanical Domain – Where to place the electric motor? What gears should we use in order to combine human and machine torque?
- System Level Design – What kind of power topology to use? Should it assist only (pedelec) or can it be driven with pure electric power (ebike)? Should there be any energy regeneration in the bike?

The paper reviews the possible solutions to the above posed questions.

III. PROPOSED CLASSIFICATION

A. System Level Design

Looking at the system level EPACs are a light hybrid electric vehicle that combines human and electric power. There are two main ways to design such a vehicle - in a serial or parallel way. The parallel case shown in Figure 1 is the more popular way of designing such a vehicle. In this case, human torque is combined in the mechanical domain with the torque from the motor via gears . In the serial configuration, shown in Figure 2 the human and electrical machine torque are coupled in the electrical domain. The double conversion of human power has the positive effect that optimal cadence can be achieved at all slopes, while lowering the overall efficiency. When implementing the serial hybrid approach, special care must be taken to ensure a natural feeling during cycling, minimizing the index of perceived exertion. The problem of optimal control for serial ebikes is the main topic.

In this initial system level design phase one more question must be addressed – Should the system include regenerative braking? And should the bicycle be able to run on pure electric energy, without pedaling input from the cyclist (ebike) or the cyclist needs to apply power at all times in order to operate it (pedelec, PAS)?

Regarding the first question some theoretical considerations predict that around 35% of the energy can be recovered, in the case of an ideal recovery system in a certain hilly city test track [11]. Other studies argue that efficiency is less than 10% , while some real data showed that it is around 16%. As the added cost to implement such a system is mostly a control algorithm that is a worthwhile investment from a design perspective .

Regarding the second posed question, it should be noted that the law in some countries answers this question unilaterally [3], [5]. Most of the sold EPACs in Europe are of the pedelec type, and it seems to be the more popular choice [5].

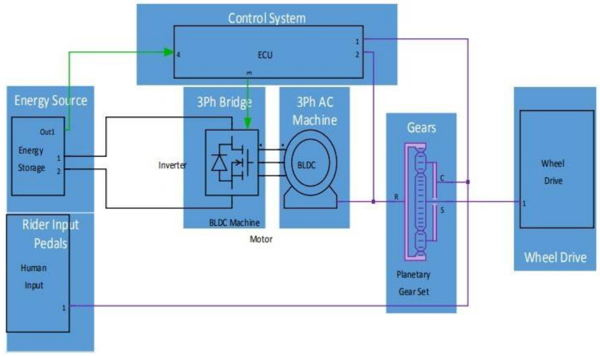

Fig. 2. Parallel Configuration of an electric bicycle

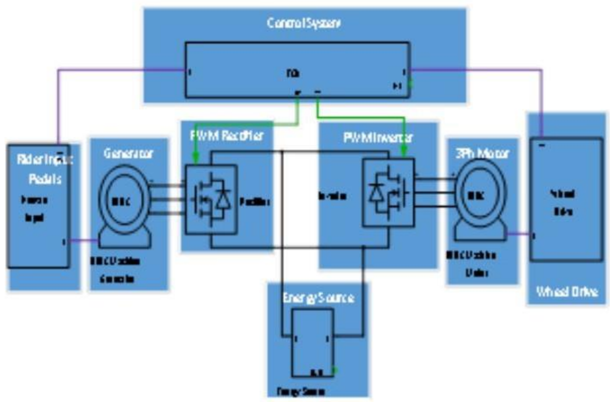

Fig. 3. Serial Configuration of an electric bicycle

B. Electrical Engineering Domain

In Figure 2 and 3 it is assumed that the energy source is a chemical battery and the drive is achieved with a brushless dc motor – both of which could be changed with other alternatives and the choice lies in the electrical engineering domain.

The most common topology for the energy storage is a chemical energy source. The VRLA battery is the cheaper choice, popular in China. The Li-Ion battery is becoming the standard when obtaining conversion kits or buying a new ebike in Europe. There are some experiments about adding alternative energy sources, such as a fuel cell or a super capacitor to either replace the battery, or supplement it. As the standard bike is not expected to achieve spectacular accelerations, and the energy pulses that need to be absorbed when implementing regenerative braking are not large, the benefit of adding a high specific power device, as the supercapacitor, seems counterintuitive. On the other hand, using hydrogen can lower the range anxiety, offering greater ranges utilizing cheap fuel and rapid charging, which is not possible without swapping the batteries. There are some commercially available fuel cell bikes from Pragma Industries in France and Linde H2 Bike in Germany.

The brushed dc motor, while very popular in early implementations of EPACs, has been gradually replaced by the BLDC (mostly with trapezoidal back emf) for almost all conversion kits or ebikes. The main reason for this is its optimal performance in terms of reliability, power density and naturally smaller dimensions. The other types of ac motors, namely the induction machine, synchronous and switched reluctance motors have not yet gained popularity. The induction machine, although cheaper and more reliable, has the disadvantages of lower torque density and lower efficiency. Thus its application in small electric vehicles, such as an ebike, is not very popular. One example using IM. The potential volatility in the price of rare earth magnets has spurred interest in the switched reluctance motor. In its classical form it offers better fault tolerance, cost and easer sensorless control, while its disadvantages are lower efficiency, torque density, noise and larger torque ripple in comparison to the brushless motor. A more detailed comparison for advanced various types of motors and their applications for electric vehicles.

In order to correctly commutate the BLDC motor with trapezoidal back-emf the position of the rotor must be known. This can be done by deducing it from the measured back-emf or some other non-direct method (called sensorless control). The other available method is to measure it directly by a rotary sensor such as Hall sensors or an encoder. The latter approach is more common in ebikes, with motors having adopted the integrated Hall sensor approach. When using Hall sensors there are two different switching control schemes - a two-phase 120° conduction or a three-phase 180° conduction scheme. The former achieves higher maximum torque, while the latter has the advantage of better operation in the constant power region. Both schemes can be improved by phase advancing the pulses, compared to the feedback signal from the hall sensors at higher speeds . The main reason to use an encoder as the feedback mechanism is the possibility to implement more sophisticated control algorithm such as Direct Torque Control. The use of such control mechanisms allows for tighter control of the obtained torque or speed command, less ripple and better drive dynamics. Out of these reducing the ripple torque is the most important aspect as it directly relates to driving comfort.

C. Proposed Classification

Figure 4 shows the proposed classification of electric bicycles by summing all the presented information and categorizing it according to the specific domain that it is applicable to.

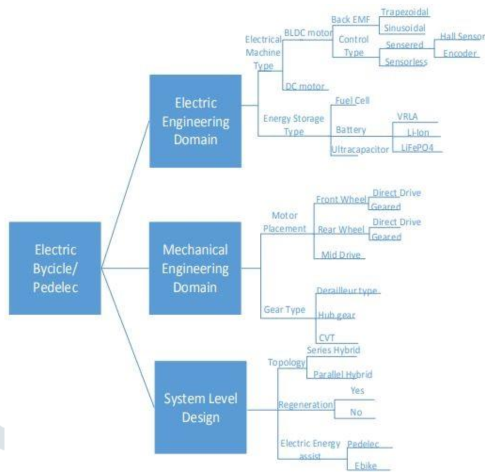

Fig. 4. Proposed Classification

The proposed classification allows the designer of an electric bike to quickly evaluate his options and look for additional information before commencing the actual design.

IV. CONCLUSION

In this paper, a new controller (rectifier) for the fast charging of the batteries is obtained with the constant current and constant voltage. This technique is applied when we use more than one battery. The proposed technique can control the average current which is applied to each cell of the converter. Finally, the experimental results validated the fast charging of batteries with the CC-CV charging.

ACKNOWLEDGMENTS

This work is supported by “J.B Institute of Engineering and technology” and we also gratefully thank our staff for giving advice and supporting for us.

REFERENCES

[1] D. Aggeler et al., "Ultra-fast DC-charge infrastructures for EV-mobility and future smart grids," 2010 IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT Europe), Gothenburg, 2010, pp. 1-8.

[2] T. C. Huang, R. H. Peng, T. W. Tsai, K. H. Chen and C. L. Wey, "Fast Charging and High Efficiency Switching-Based Charger With Continuous Built-In Resistance Detection and Automatic Energy Deliver Control for Portable Electronics," in IEEE Journal of Solid-State Circuits, vol. 49, no. 7, pp. 1580-1594, July 2014.

[3] Y. H. Liu and Y. F. Luo, "Search for an Optimal Rapid-Charging Pattern for Li-Ion Batteries Using the Taguchi Approach," in IEEE Transactions on Industrial Electronics, vol. 57, no. 12, pp. 3963-3971, Dec. 2010.

[4] IYun-Sung Kim, Soon-Sang Hwang, Min-Hee Jeon, Byung-Dug Baeg and Byoung- Kuk Lee, "Development of a 3kW fast battery charger with various charging modes and parallel operation," 2012 IEEE Vehicle Power and Propulsion Conference, Seoul, 2012, pp. 1211-1216.

[5] H. I. Hsieh, C. Y. Tsai and G. C. Hsieh, "Photovoltaic Burp Charge System on Energy-Saving Configuration by Smart Charge Management," in IEEE Transactions on Power Electronics, vol. 29, no. 4, pp. 1777-1790, April 2014.

[6] C. H. Lin, C. Y. Hsieh and K. H. Chen, "A Li-Ion Battery Charger With Smooth Control Circuit and Built-In Resistance Compensator for Achieving Stable and Fast Charging," in IEEE Transactions on Circuits and Systems I: Regular Papers, vol. 57, no. 2, pp. 506-517, Feb. 2010.

[7] J. Jiang, Q. Liu, C. Zhang and W. Zhang, "Evaluation of Acceptable Charging Current of Power Li-Ion Batteries Based on Polarization Characteristics," in IEEE Transactions on Industrial Electronics, vol. 61, no. 12, pp. 6844-6851, Dec. 2014.

[8] A. Muetze and Y. C. Tan, “Electric bicycles - A performance evaluation,” IEEE Ind. Appl. Mag., vol. 13, no. 4, pp. 12–21, 2007.

[9] W. C. Morchin, “Battery-powered electric bicycles,” in Northcon/94 Conference Record, 1994, pp. 269–274.