Fast and Integrated Chargers for Lithium Ion Batteries

M Sabarimuthu¹, N Senthilnathan², M Arun Kumar³, M S Kamaleh⁴, V Jayaprakash⁵, R Srinivasan⁶
¹,⁴AP, Department of Electrical and Electronics Engineering, Kongu Engineering College Perundurai, India
² Professor, Department of Electrical and Electronics Engineering, Kongu Engineering College Perundurai, India
³ Assistant Professor, Department of EECE, GITAM University, Bengaluru campus, Bengaluru.
⁵,⁶UG Scholar, Department of Electrical and Electronics Engineering, Kongu Engineering College, Perundurai, India

Abstract. Electric vehicles were introduced in the year of 1908, where they have larger battery for power supply. Now- a- days the technique for charging e-bikes is done either by using grid supply or solar power. This paper says about charging circuit for batteries which uses both solar power and power from the grid to charge the electric vehicles. The charging with solar helps to reduce the emission from power grid. Ever-increasing demand for fuel supply, rising fuel prices, and increased environmental awareness among masses are paving the way for electric vehicles (EVs). Although, in recent years EV market has seen an exponential growth, one of the major challenges faced by this automotive/vehicular market. Now the Indian government had ordered to Indian Vehicle Association to launch the electric vehicles with in 2023. But the charging of electric Batteries has taken more time, which compare to fossil fuel and gas. To overcome this issue use of turbo charger, to reduce the charging time as well as self charging by solar during running time is proposed. The charger uses the source from EB grid and solar as well as at parking time. The results proves that proposed work have reduced the charging time of the lithium ion battery compared to the conventional charging technique and all under controlled temperature raise.

Key words: Electric Vehicles, Turbo charger, Lithium ion battery charger Start your abstract here…

1. Introduction
In the present scenario the usage of non-conventional fuels for vehicles are in great demand and increasing in price. To reduce the non-conventional fuel usage, electric vehicles are the trending technology for the conventional vehicle replacement, by using e-bikes emission problems will be reduced. Photovoltaic systems may be installed on rooftops to build charging stations. Solar canopies installed on parking lots make an excellent choice or solar-powered EV charging stations. Photovoltaic cells that convert are solar energy into required voltage to charge the battery. As far as electric vehicles are concerned lead acid and lithium ion batteries were most commonly used, Lead acid batteries are lower cost and have higher current carrying capacity [1]. They are heavier in weight and
have only smaller life time while lithium ion batteries have lower weight, whereas they are higher cost. In this proposed method uses lithium ion battery for electric vehicles. Generally, grid supply is used to charge the batteries of the electric vehicle. The charging time is longer. This method using both grid supply and solar. Where supply for charging the battery is transmitted using both dc and ac converters. Where battery is charged either by grid or solar power [2-4]. The availability of both sources for a long duration is insufficient. So the modification technique is done by comparing both the grid supply and solar supply, the efficient supply is given to the battery. In this process only DC supply given to the components. The 230V AC supply from the power grid is rectified and given to the step down transformer which is converted into 12V. The proposed system is designed in such a way that it is easy to charge the battery. The rectifier is used to convert the AC into DC which is fed to the controller. Now calculating state of charge, depth of discharge and input temperature or measure. By using Arduino uno the outputs are displayed in voltage level indicator. Normally charging time for battery is above 7hours [5-7], where in this technique charging time is less than 1hours 30 minutes. Below charging circuit is designed, then the smart way methodology is proposed and the analysis of battery charging stated is done. In previous paper A three phase, 6 pulse SCR based rectifier topology is used to charge the battery [8] and constant current, It charges the battery upto 5.7% higher soc in short time compared to CC charging [9-20]. Constant voltage, constant current method is used to charge the battery [21]. But In this method constant voltage, different current is used to charge the battery and also determining soc and temperature of the battery [21-30]. It explore the optimal charging frequency in AC impedance analysis. The SRC proposed the optimal charging performance indicates the minimum-ac-impedance frequency fZ min [31-33]. Realistic battery module is used to charging the battery for minimize the charging time. Two types of system is used to charge the battery, one is on-board and other is off board [33].

2. Existing methods
In existing system, the battery has charging time with minimum of 6 to 7hrs. It causes major drawback for electric vehicle during emergency. And also in IC engine the diesel or petrol can fill with in 2 or 3 minutes during maximum of period [18-20].

Their major drawback in Electric vehicle has slow charging. Some methods are proposed as constant current, different voltage method used to charge the battery but life of the battery is reduced. Constant voltage, constant current method is used to charge the battery but charging time is high.

3. Problems identified
- The charging of battery is very slower
- The petrol engine causes air pollution

3.1. Objective
To reduce the charging time of batteries where used in electric vehicle by using fast charger to charge the battery and detecting the percentage and temperature of the battery and then input power will be change by using controller.

4. Block diagram
Figure 1 explains the block diagram of proposed work and it consists of EB source, Renewable energy, Battery, Battery level detector, Arduino, relay, Current controller. The controller detects the SOC and Temperature for the battery to charge. The SOC of the battery is detected using battery level detector and temperature of the battery to be measured using temperature sensor. Arduino plays a major role of the proposed work. It is used as controller of the work. In this paper lithium ion battery is used because lithium ion battery is familiar in EVs now days. During night hours renewable energy will not available, hence controller does the change of input power to EB source.
5. Components used

Table 1: components used in proposed work.

| APPARATUS                          | RATING                              | QUANTITY |
|------------------------------------|-------------------------------------|----------|
| Solar panel, EB grid Source        | (36V,8AH),(230v)                    | 1,1      |
| relay, battery level detector      | (5v dc input),(12v-70v)             | 3,1      |
| Step down Transformer             | 230v/12v-5A                         | 5        |
| Dc converter (or) Rectifier       | AC-DC(output 13.6v,5A)              | 1        |
| Lithium ion battery               | 36v-6A                              | 1        |
| Micro controller (ARDUINO)         | Atmega                              | 1        |
| Current controller                 | 5A, 3A                              | Each 1   |

The above table 1 gives the details of the components used in proposed work which includes source side and battery side specifications.
6. Battery specifications

Figure 2 shows three 36-volt lithium ion battery. Specification of the battery used as shown in table 2. The important things as, cells are connected in series connection to get the battery pack voltage as to meet the EV rated voltage. In this example the resulting pack voltage is 36 volts. In this paper 36V, 6Ah lithium ion battery is used. This assumes that individual batteries are the same capacity of battery pack. Do not mix and match different size of battery pack in the same batteries. Portable equipment needing higher voltages use battery pack with two or more cells connected in series.

![Figure 2. 36V Lithium Ion Battery.](image)

6.1. Specification of battery

| Terminology           | Specification |
|-----------------------|---------------|
| Nominal Voltage       | 36v           |
| Type                  | Lithium ion battery |
| Initial Current       | 3c            |
| Capacity              | 6Ah           |
| Charging Hour         | 1hour 30mins  |
| Cycle use             | 36v,6A        |
| Charging Instruction  | 45°C          |
| Battery               | 36v           |
| Initial current       | 1A            |

7. Hardware Setup

The 230V AC supply from the grid is given to the step down transformers which is converted in series for 12v-36v and also parallel connection for 6A. The rectifier circuit is used to convert the AC supply
into DC supply which is fed to the bridge rectifier. In fast charger, the Arduino plays a major role of control the battery charging process.

![Figure 3. Hardware Setup of Proposed System.](image)

For charging, the power supply is taken from Renewable energy and electricity board is fed to the controller. The input power supply of Renewable energy is compared with EB grid and close the circuit to the battery. The state of charge is measured by battery level detector which gives signal to the controller. If the state of charge is less than 30% the input power of battery is 37.6V,5A, If the state of charge is greater than 30% the input power is 37.6V,3A which is control by current controller. During the high power input, the battery temperature is detected by temperature sensor. If this exceeds the set level, controller stops charging. The temperature range of lithium ion battery is 45°C. If the battery temperature is greater than 37°C The input power is reduce to 37.6V,1.5A by controller. Finally the charger is designed as based on temperature and state of charge of battery

8. Results and Discussion

| State of Charge in percentage | Lithium ion battery voltage (36v Battery) | Normal / Conventional charger (time taken) | Proposed Fast charger (time taken) |
|--------------------------------|------------------------------------------|------------------------------------------|----------------------------------|
| 100%                          | 36+                                      | 5h                                       | 1h 35m                           |
| 75%                           | 34.5+                                    | 3h 30m                                   | 55m                              |
| 50%                           | 33+                                      | 2h 45m                                   | 45m                              |
| 25%                           | 31.5+                                    | 1h 45m                                   | 30m                              |
| 0%                            | 29+                                      | Nil                                      | Nil                              |

In existing method, the normal mode charging has take more than 5 hours to charge the battery up-to 100%. It’s the major drawback of electric vehicle. To overcome this drawback, fast charger has introduced. It can charge the battery with 1hour 30 minutes, but life cycle of battery has reduced. And
also temperature also increase, due to high temperature battery can result in explosion. And also internal resistance of battery has been increase. Thus proposed fast charger is used to overcome this above drawback and hence it charge the battery based on temperature and percentage of battery as shown in table 3 and its graphical representation as in figure 4.

Figure 4. Result comparison of conventional charger with proposed charger.

9. Conclusion
In this paper, the development of charging circuit for a battery with performance characteristics analysis and also taking into consideration the supply of both the electricity and renewable energy (solar power) was done. The proposed work, utilizes both solar energy and grid electricity for charging lithium ion battery. The voltage from these two sources is compared and which has the high value is used to charge the battery. Electricity is preferred during night hours and also during insufficient solar energy. Arduino is used as controller of the battery charging in different ways. The result table proves that the proposed charger charges the battery with 1h 35 minutes., where the conventional charger takes more than 5 hours to reach the same level. At last, this method concluding that this approach reduces the pollution and increase the usage of EVs as a result creating pollution free environment and reduces the charging time of the lithium ion battery.

References

[1]. Sitharthan R, Geethanjali M and Pandy TKS 2016 Adaptive protection scheme for smart microgrid with electronically coupled distributed generations Alexandria Engineering Journal 55(3) 2539-2550
[2]. Fathima AH, and Palanisamy K 2014 Battery energy storage applications in wind integrated systems—a review IEEE International Conference on Smart Electric Grid 1-8
[3]. Prabaharan N and Palanisamy K 2015 Investigation of single-phase reduced switch count asymmetric multilevel inverter using advanced pulse width modulation technique International Journal of Renewable Energy Research 5(3) 879-890.
[4]. Jerin ARA, Kaliannan P and Subramaniam U 2017 Improved fault ride through capability of DFIG based wind turbines using synchronous reference frame control based dynamic voltage restorer. ISA transactions 70 465-474
[5]. Sitharthan, R, Sundarabalan CK, Devabalaji KR, Nataraj SK and Karthikeyan M 2018 Improved fault ride through capability of DFIG-wind turbines using customized dynamic voltage restorer Sustainable cities and society 39 114-125

[6]. Prabhaharan N and Palanisamy K 2016 A single-phase grid connected hybrid multilevel inverter for interfacing photo-voltaic system Energy Procedia 103 250-255

[7]. Palanisamy K, Mishra JS, Raglend IJ and Kothari DP 2010 Instantaneous power theory based unified power quality conditioner (UPQC) IEEE Joint International Conference on Power Electronics, Drives and Energy Systems 1-5

[8]. Sitharthan R and Geethanjali M 2017 An adaptive Elman neural network with C-PSO learning algorithm-based pitch angle controller for DFIG based WECS Journal of Vibration and Control 23(5) 716-730

[9]. Sitharthan R and Geethanjali M 2015 Application of the superconducting fault current limiter strategy to improve the fault ride-through capability of a doubly-fed induction generator–based wind energy conversion system Simulation 91(12) 1081-1087

[10]. Sitharthan R, Karthikeyan M, Sundar DS and Rajasekaran S 2020 Adaptive hybrid intelligent MPPT controller to approximate effectual wind speed and optimal rotor speed of variable speed wind turbine ISA transactions 96 479-489

[11]. Sitharthan R, Devabalaji KR and Jeas A 2017 An Levenberg–Marquardt trained feed-forward back-propagation based intelligent pitch angle controller for wind generation system Renewable Energy Focus 22 24-32

[12]. Sitharthan R, Sundarabalan CK, Devabalaji KR, Yuvaraj T and Mohamed Imran A 2019 Automated power management strategy for wind power generation system using pitch angle controller Measurement and Control 52(3-4) 169-182

[13]. Sundar DS, Umamaheswari C, Sridarshini T, Karthikeyan M, Sitharthan R, Raja AS and Carrasco MF 2019 Compact four-port circulator based on 2D photonic crystals with a 90° rotation of the light wave for photonic integrated circuits applications Laser Physics 29(6) 066201

[14]. Sitharthan R, Parthasarathy T, Sheeba Rani S and Ramya KC 2019. An improved radial basis function neural network control strategy-based maximum power point tracking controller for wind power generation system Transactions of the Institute of Measurement and Control 41(11) 3158-3170

[15]. Rajesh M and Gnanasakar JM 2017 Path observation based physical routing protocol for wireless ad hoc networks Wireless Personal Communications 97(1) 1267-1289

[16]. Palanisamy K, Varghese LJ, Raglend IJ and Kothari DP 2009. Comparison of intelligent techniques to solve economic load dispatch problem with line flow constraints IEEE International Advance Computing Conference 446-452

[17]. Sitharthan R, Ponnusamy M, Karthikeyan M and Sundar DS 2019 Analysis on smart material suitable for autogenous microelectronic application Materials Research Express 6(10) 105709

[18]. Rajaram R, Palanisamy K, Ramasamy S and Ramanathan P 2014 Selective harmonic elimination in PWM inverter using fire fly and fireworks algorithm International Journal of Innovative Research in Advanced Engineering 1(8) 55-62

[19]. Sitharthan R, Swaminathan JN and Parthasarathy T 2018 March. Exploration of wind energy in India: A short review IEEE National Power Engineering Conference 1-5

[20]. Karthikeyan M, Sitharthan R, Ali T and Roy B 2020 Compact multiband CPW fed monopole antenna with square ring and T-shaped strips Microwave and Optical Technology Letters 62(2) 926-932
[21]. Sundar D Sridarshini T, Sitharthan R, Madurakavi Karthikeyan, Sivanantha Raja A, and Marcos Flores Carrasco 2019 Performance investigation of 16/32-channel DWDM PON and long-reach PON systems using an ASE noise source In *Advances in Optoelectronic Technology and Industry Development: Proceedings of the 12th International Symposium on Photonics and Optoelectronics* 93

[22]. Sitharthan R and Geethanjali M 2014 Wind Energy Utilization in India: A Review *Middle-East J. Sci. Res.* **22** 796–801 doi:10.5829/idosi.mejsr.2014.22.06.21944

[23]. Sitharthan R and Geethanjali M 2014 ANFIS based wind speed sensor-less MPPT controller for variable speed wind energy conversion systems *Australian Journal of Basic and Applied Sciences* **8** 14-23

[24]. Jerin ARA, Kaliannan P, Subramaniam U and El Moursi MS 2018 Review on FRT solutions for improving transient stability in DFIG-WTs *IET Renewable Power Generation* **12(15)** 1786-1799

[25]. Prabaharan N, Jerin ARA, Palanisamy K and Umashankar S 2017 Integration of single-phase reduced switch multilevel inverter topology for grid connected photovoltaic system *Energy Procedia* **138** 1177-1183

[26]. Rameshkumar K, Indragandhi V, Palanisamy K and Arunkumari T 2017 Model predictive current control of single phase shunt active power filter *Energy Procedia* **117** 658-665

[27]. Fathima AH and Palanisamy K 2016 Energy storage systems for energy management of renewables in distributed generation systems *Energy Management of Distributed Generation Systems* **157**

[28]. Rajesh M 2020 Streamlining Radio Network Organizing Enlargement Towards Microcellular Frameworks *Wireless Personal Communications* 1-13

[29]. Subbiah B, Obaidat MS, Sriram S, Manoharn R and Chandrasekaran SK 2020 Selection of intermediate routes for secure data communication systems using graph theory application and grey wolf optimisation algorithm in MANETs *IET Networks* doi:10.1049/iet-net.2020.0051

[30]. Singh RR and Chelliah TR 2017 Enforcement of cost-effective energy conservation on single-fed asynchronous machine using a novel switching strategy *Energy* **126** 179-191

[31]. Amalorpavaraj RAJ, Palanisamy K, Umashankar S and Thirumoorthy AD 2016 Power quality improvement of grid connected wind farms through voltage restoration using dynamic voltage restorer *International Journal of Renewable Energy Research* **6**(1) 53-60

[32]. Singh RR, Chelliah TR, Khare D and Ramesh US 2016 November. Energy saving strategy on electric propulsion system integrated with doubly fed asynchronous motors *IEEE Power India International Conference* 1-6

[33]. Singh RR, Mohan H and Chelliah TR 2016 November. Performance of doubly fed machines influenced to electrical perturbation in pumped storage plant-a comparative electromechanical analysis *IEEE 7th India International Conference on Power Electronics* 1-6