INTELLIGENT BATTERY MANAGEMENT SYSTEM FOR HYBRID VEHICLE

Dr. Rahul Mapari, Professor, Department of E&TC Engineering, PCET's Pimpri Chinchwad College of Engineering and Research, Ravet, Pune, MH, India
Dr. Archana A. Chaugule, Professor, Department of Computer Engineering, PCET's Pimpri Chinchwad College of Engineering and Research, Ravet, Pune, MH, India
[1]rahul.mapari@pccoer.in, [2]archana.chaugule@pccoer.in

ABSTRACT: Electric vehicles are now a significant component of the automotive industry due to two main factors: a decrease in our reliance on oil and a reduction in air pollution, both of which help us work toward the creation of an environmentally friendly environment. Total driving mileage, charging time, driving mileage after each charge, safety during battery charging and discharging processes, lifetime, charging speed, charging/discharging capacity, and temperature increase are the main factors that EV consumers take into account. The battery is charged using a new, improved pulse charging technique that relies on a neural network and PID control action. The charging unit in this design is created utilising a PID controller. The Feed Forward Neural Network was used to determine the parameters for PID control. Battery management system (BMS) guarantees that this battery charging system is designed to charge the battery efficiently in a shorter amount of time. System implementation is done in MATLAB/Simulink.

KEYWORDS: BMS, Electric vehicles (EV), Neural Network (NN), PID (Proportional, Integral and Derivative) controller

1. INTRODUCTION

Li-ion batteries are a viable kind of energy storage because of their high energy density and low self-discharge rate. One of the major challenges for batteries in the EV sectors is to increase power handling capacity, energy density, monitoring and safety of lithium-ion batteries, combined with quick charging capabilities [1]. Low ambient temperature, which is common in EV markets, makes the issue worse since it causes slower Li+ ion diffusion at the electrolyte and electrodes, which has a negative impact on the intercalation's kinetics. Due to the heat produced while performing quick battery charging, it is challenging to remove in a skilled and consistent manner, which raises worries about safety-related issues[2-4]. The development of battery technology and battery management systems, which include monitoring, safety, and control of battery parameters and serve as the brain of the battery system, are essential to the new advancement of electric vehicle technology. Improper operations such as over-current, over-voltage or over-charging/discharging will cause significant safety issue to the batteries, noticeably accelerate the aging process, and even fire hazards if left unattended [5-7]. BMS is so crucial in assuring the safety and performance of batteries. Additionally, it has the function of automatic cut off, which means that when charging and discharging levels go above the predetermined limits, the battery is immediately disconnected from the electrical circuit and the load side [8–10]. Manufacturers face several obstacles when introducing electrified solutions, including customer adoption of EVs and battery electric cars that are not hybridised with internal combustion engines. The greatest obstacles to the adoption of electric vehicles are their lengthy charging periods and higher rang anxiety than gasoline-powered vehicles. Energy storage system needs may differ greatly depending on the different types of electric vehicles. Battery runtime may be increased with the use of several software and hardware approaches. By developing a more advanced charging algorithm and enhancing output performance, battery characteristics can be enhanced [11–12].

2. PROPOSED SYSTEM ARCHITECTURE

This paper discusses the development of an intelligent battery management system based on pulse charging. PID and artificial neural networks are primarily used by the system (ANN). The main concept of the suggested design is to change the charging pulses' ideal frequency and duty cycle. Utilizing an electronic design automation (EDA) tool allows for this. ANN is used to monitor and manage a number of battery-related factors. The planned battery management system is built, implemented, and its performance is verified using MATLAB. Below is a quick summary of the proposed design's specifics. The charging device is crucial to this model. Here, pulse charging technique—which has recently become quite popular—is chosen. Controlling the charge current pulses given to the battery while it charges is the essential component of this technology. Here, the battery is charged in a method that optimises the charging time through the use of charge pulses. Battery heating, polarisation, state of charge, varying battery impedances, and other aspects are taken into account in addition to time optimization. Ions diffuse through the electrode materials during the pause between each and every charge pulse. This helps the charging process become more efficient. In addition to ensuring that the battery performs at its peak, one may ensure a long and prolonged life span for the battery by carefully choosing the parameters of the charge current pulses. In light of these considerations, PID control is regarded as the optimum choice for a control strategy for designing the necessary charging unit. The charge pulses' pulse width modulation, or PWM, is managed by a MOSFET circuit. We are really regulating the battery's charging and discharging cycles by modulating the PWM of the charge pulses. This circuit uses a current booster and rectifier to increase power, which accelerates the charging process and cuts down on time. PID causes the MOSFET circuit to turn on. Performance of the PID controller depends on Kp, Ki, and Kd settings, which are controller parameters. However, it is impossible to set settings perfectly because of issues like overshoot and slowed system reaction time. The performance of Li-Ion batteries may be improved by precisely planning and managing the charge voltage and current. This results in benefits including increased longevity, lower costs, higher charging efficiency, and—most importantly—a shorter charge time. As a result, this research suggests parameter tuning, which involves developing, monitoring, and regulating utilising PID control and ANN. The recommended neural network is feed forward. Another crucial factor to take into account is the distribution of incoming charge pulses among the linked battery packs. Therefore, BMS(BMS) is made to choose how, where, and when to provide charge pulses to the battery packs so that they can assist in recharging the battery more quickly. BMS operates using both chemical and digital batteries. While chemical batteries take imprints throughout the charging and draining process, digital batteries are employed to interact with the user. Digital battery represents the software created to govern the monitoring and distribution of charge pulses, while chemical battery represents the battery packs actually utilised for charging. Neural networks are employed in this study to achieve this goal. Where BMS are specially configured according to the fixed rated capacity, the measurement of inward and outward flowing of coulombs is connected to the capacity of the battery. Corresponding rise or reduction in the coulomb count assesses the battery capacity. The utilised filter removes the high frequency components, which helps to lower the suggested design's THD value.

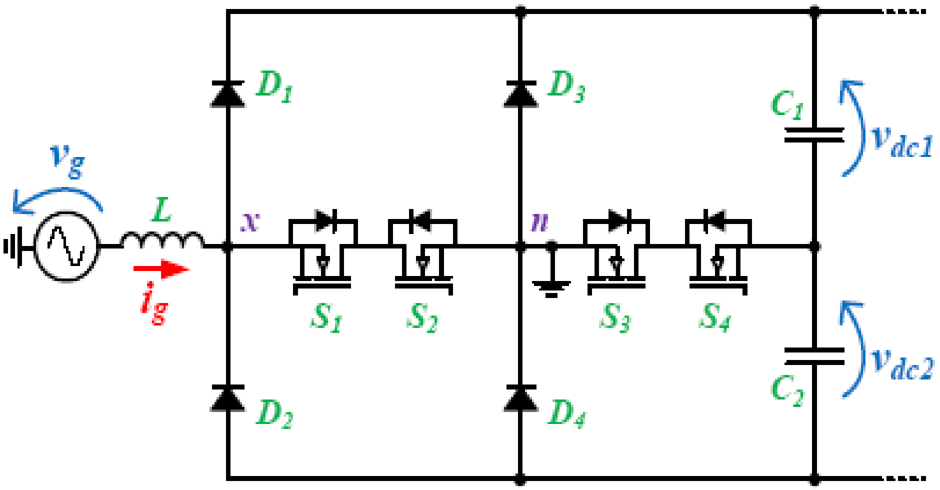

Figure 1: Five level active rectifiers for EV battery chargers

The five step lively rectifiers for electric car battery chargers are shown in figure 1. The four MOSFET switches S1, S2, S3, and S4 are similar to. The four diodes D1, D2, D3, and D4 are analogous to the two capacitors C1 and C2, which have voltages of Vdc1 and Vdc2, respectively. Figure 2 shows the grade-by-grade functioning of the five level vivacious rectifiers mentioned before. Vg, and Ig are the voltage and current of the grid, respectively. L is the inductor.

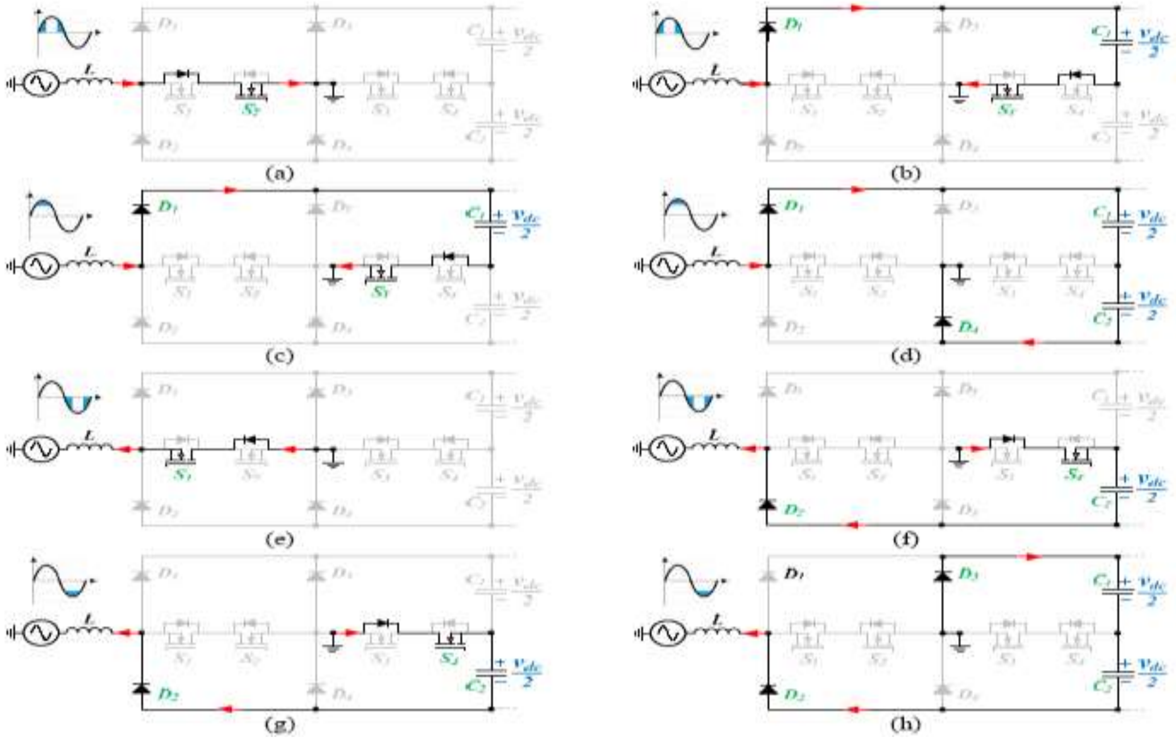

Figure 2: Step by step operation of proposed five level active rectifier.

The corresponding pulse pattern of all MOSFET switches used in the project are as shown in Figure 2.

NEURAL NETWORK

Artificial intelligence enables us to solve challenging issues. In synthetic intelligence, neural networks are a classic example of how a system may be modified to assess intricate strategies. Several applications, including voice synthesis, diagnostic issues, business & finance, robot manipulation, sign processing, and many more issues that fall under the category of pattern Recognition, have demonstrated the value of synthetic neural communities. Kalman filter, machine learning algorithms with fuzzy logic and support vector machines, as well as a variety of neural networks like the radial foundation function neural network, feed ahead neural internet, returned propagation neural internet, and others, are examples of the new advanced & adaptive artificial intelligence systems. Systems that can mechanically adjust themselves in response to changing environments are referred to as adaptive systems.

The network has to be educated as the first step of the prediction model. The neural network training signal is the prediction error between plant output and neural community output. Figure 3 demonstrates the method. Figure 4 provides an illustration of the model's interior form. The input sign is "u," while the output sign is "y." "W" stands for the weights, while "b" is the bias of the neighbourhood.

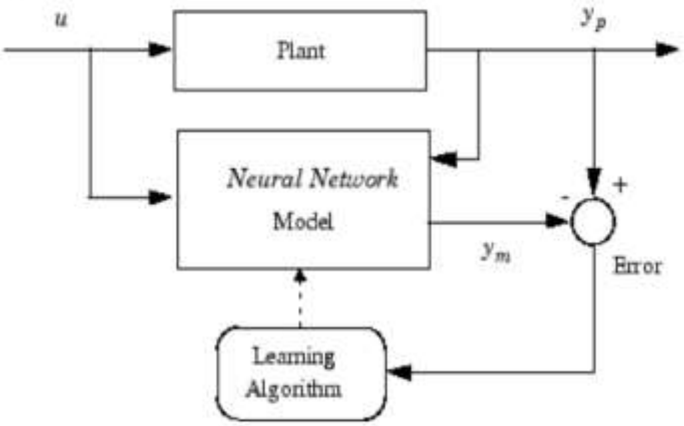

Fig 3: Training process for the network

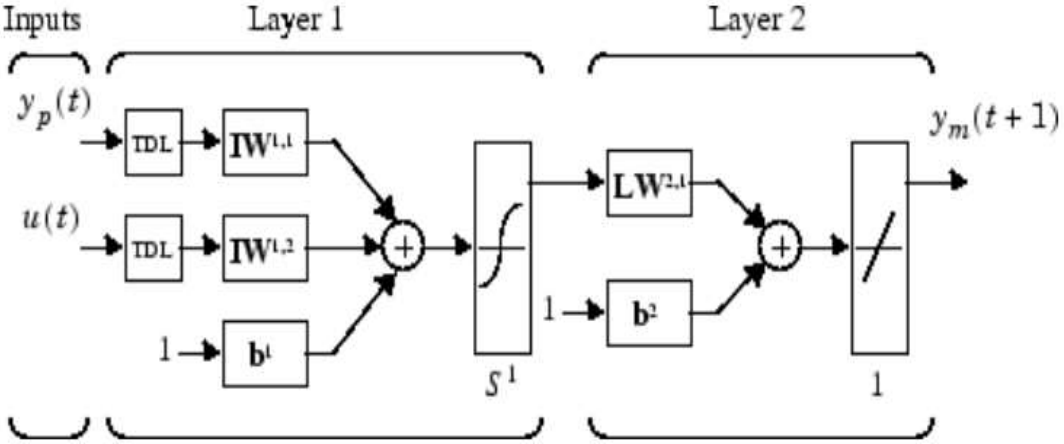

Fig 4: Internal structure of neural network model.

The numerical optimization is given by,

$$J = \sum_{j=N_1}^{N_2} (y_r(t+j) - y_m(t+j))^2 + \rho \sum_{j=1}^{N_u} (u'(t+j-1) - u'(t+j-1))^2$$

where monitoring mistakes and manipulation increments are assessed over the timeframes n1, n2, and nu. Yr is the intended response, ym is the network version reaction, and u' is the manage sign. The sum of squares of control increments' impact on the performance index is determined by cost.

The whole manipulation process is shown in Figure 9. The controller consists of an optimization block and a neural community version. The most trustworthy value of "u" is provided as an input to the community version after the optimization block finds the values of "u" that restrict j.

3. SIMULATION RESULTS

Utilizing MATLAB 2015, a software programme, the suggested active rectifier for creating the pulses is built through software simulation. The results received are as listed below. A simulation of the suggested design-

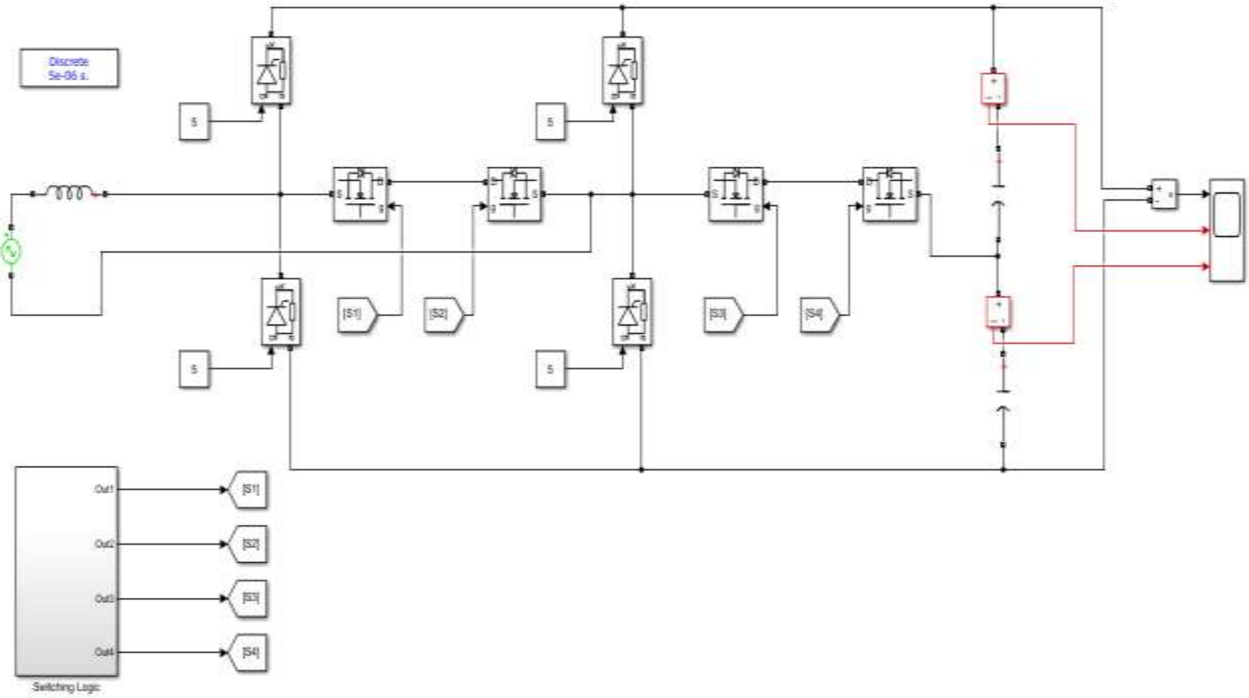

Figure 5: Simulation model of proposed design

Figure 5 depicts the simulation model for the suggested design. For this reason, the simulation model is likewise constructed using four MOSFET switches, four diodes, capacitors, and one inductor, as specified theoretically.

Power Grid Voltage (V_g)

The graph of electricity grid voltage in volts towards time in seconds is depicted in figure 6. It is determined that clean +/- 230 v is obtained and maintained.

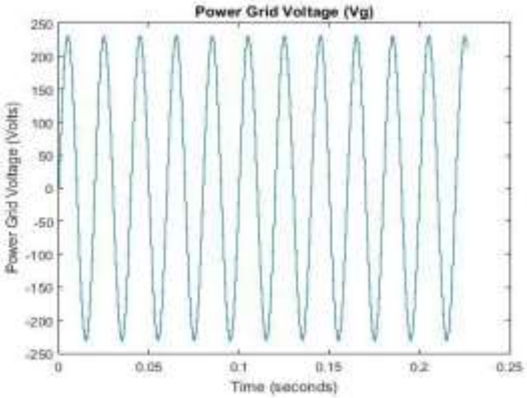

Figure 6: Power Grid Voltage waveform

Power Grid Current (i_g)

Figure 7 shows a graph of the current in amps and the time in seconds. There are +/- 60/70 spikes in the system's transition phase in advance. The contemporary period then decreases to +/- 50a. The machine's transition phase settling time is somewhat less than 0.025s, which makes it more dependable and environmentally friendly.

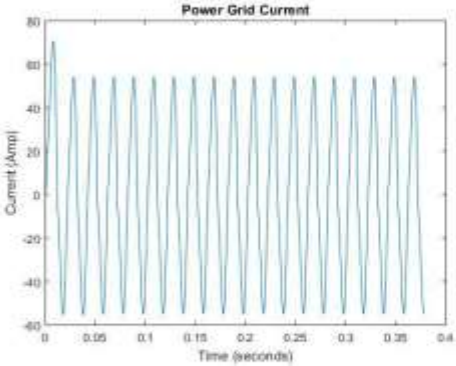

Figure 7: Power Grid Current waveform.

Output DC voltage:

The obtained output DC voltage is nearly 240V.

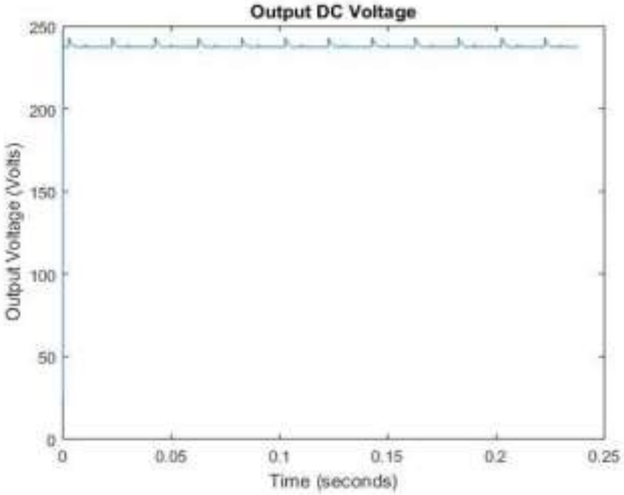

Figure 8: Output DC voltage

Power factor

The obtained power factor reading of the proposed system is about 0.934, the same is depicted in figure 8.

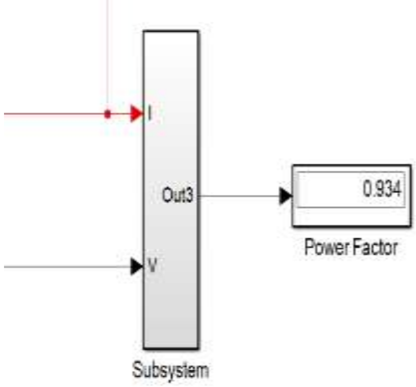

Figure 8: Power factor

Total Harmonic Distortion

Figure 9 displays a bar graph of the obtained total harmonic distortion (THD) in comparison to a few other approach authors' THD. Also included is table 1, which is of the same type. It has been determined that the acquired THD from the suggested method is 2.8, which is significantly less than the THD of the prior systems, which were 8.3, 4.9, and 2.9. In our suggested device, we've included a low skip filter that blocks the majority of high frequency components. This reduces the intended output's total harmonic distortion.

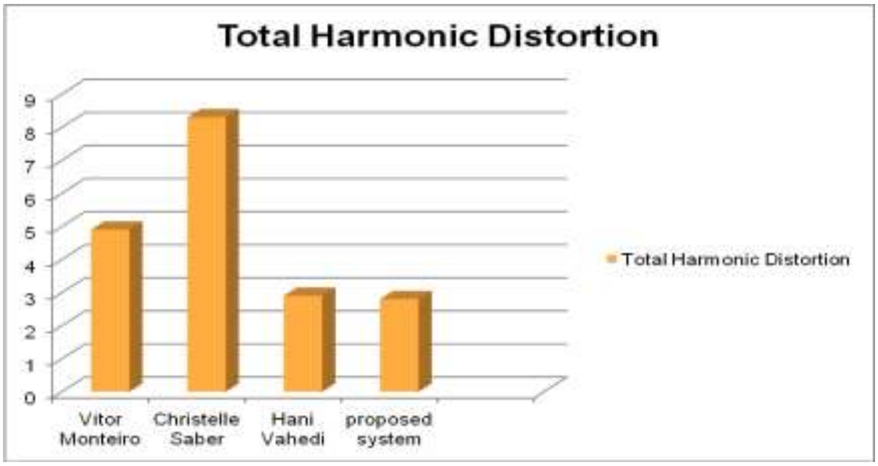

Figure 9: Obtained THD compared with existing technique authors THD

COMPARISON OF PERFORMANCE PARAMETERS

The comparison of performance parameters between the ones in the earlier research and the ones proposed in this research are depicted by table 2.

Table 2: Comparison of performance parameters.

Sr. No.	Parameters	Ideal	Earlier Research	Proposed System
1	Voltage	12V	10/11V	11.95V

2	Charge Efficiency	99% ideally	75-80%	90%
3	Charge time	3-10 hours	140min [16] ;110min [17]	35 min
4	SOH	100%	89.87% [18]	91%
5	SOC	50% (Practically)	90% [19]	93%
6	Temperature rise	22°	21.5°	20°
7	Charge current settlement time	80ms	20ms[16]	18ms
8	Life span	8 yrs	25% more [16]	35% more

4. CONCLUSION

Concerns about the availability of energy resources and the environmental impact of transportation infrastructure based on petroleum have increased interest in electric transportation infrastructure. Therefore, electric vehicles (EV), hybrid electric vehicles (HEV), and plug-in hybrid electric vehicles (HEV) have attracted a lot of attention in recent years. Battery technology and related system problems continue to be a major challenge in vehicle electrification. Many manufacturers now prioritise target-fast charging capability as a crucial design element for EV battery packs in order to reduce range anxiety and satisfy customer expectations. It's important to suggest an ideal charging system that may provide benefits like quick charging and higher efficiency without compromising battery life. The pulse charging technology takes care of a detailed control and monitor over charge current pulses when charging the battery. In order to reduce the amount of time needed for charging, it automatically modifies the charge pulse frequency. The main benefits of pulse charging, which themselves are the demanding characteristics of today's customers, are shorter charging times, larger charge rates, and higher energy efficiency. In this study, an improved fast-charging approach based on PID control action monitored by Neural Networks is devised and presented after reviewing all the relevant elements and research gaps. The programme for doing this is implemented in MATLAB/Simulink. Simulation findings demonstrate the viability of the suggested concept. The primary goal of the suggested design, which is to decrease battery charging time, is effectively accomplished.

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