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Study of Battery Charging Circuit with Different Controllers

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Abstract:-

In this paper the battery charger circuit is simulated and proposed circuit is analyzed with variety of existing controllers. The Battery charging circuit performance has been studied and is undertaken for their theoretical verification.

Key words:- Battery charging , controllers.

- **Introduction: -**

Due to the lack of fossil fuels, environmental pollution, and the other reasons, the conventional internal combustion engine (ICE) powered vehicles faced with limitations. On the other hand, the electric vehicles (EVs), hybrid EVs (HEVs), have been growing steadily with the development of the vehicular battery over the last few years. Especially, HEVs can be a compromise of ICE powered vehicles and EVs, considering low exhaust emission and high driving efficiency.

The conventional power systems are short of large scale energy storage units, all electricity generated must be consumed by either real or dummy loads. Insufficient generation may lead to load shedding, especially during the peak hours, which significantly increases the electricity price and affects the power grid reliability, whereas excessive generation will lead to waste of energy. Also, the fast consumption of fossil fuels is causing serious problems of energy shortage in developing countries [1]. Recognized as an effective means to resolve these enormous challenges, the smart micro-grids based on renewable energy sources energy storage units, and electric vehicles (EVs) are becoming more and more popular around the world.

If the battery is charged with renewable energy, the electric car can reach zero emissions and contribute greatly to the protection of the green environment. However, smart hybrid multiport converters are need to manage the energy flow and balance the energy between renewable energy sources, electric vehicles and the grid [4]. An integrated power converter that uses relays to change the direction of power flow between the electric vehicle and the AC or DC grid However, smart hybrid multi-port converters are needed to manage the energy flow and balance the energy between renewable energy sources, electric vehicles and the grid [4]. A combination of power converters is arranged in relays used to change the direction of the power flow of the electric vehicle and the AC or DC network Due to the lack of fossil fuels, environmental pollution, and the other reasons, the conventional internal combustion engine (ICE) powered vehicles faced with limitations. On the other hand, the electric vehicles (EVs), hybrid EVs (HEVs), have been growing steadily with the development of the vehicular battery over the last few years. Especially, HEVs can be a compromise of ICE powered vehicles and EVs, considering low exhaust emission and high driving efficiency.

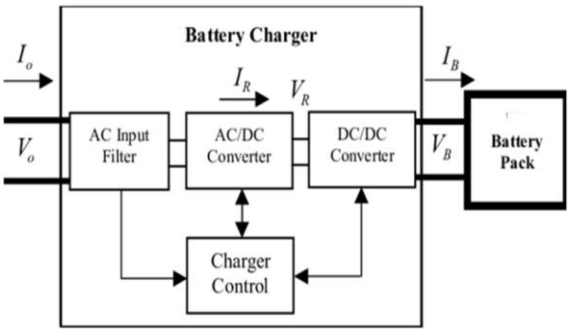
Block diagram of a common battery charger The operation of an EV battery charger depends on components and the control strategies employed. Referring to above Fig. in the first stage of control, sensing circuits provide the status of all relevant system variables required for control the algorithm as feedback signals. The control algorithm is responsible in achieving high-level steady-state and transient performance. The reference values of variables along with sensed values are used in the third stage of the control The diagram below illustrates how the key functions of Level 1, 2 and 3 chargers are implemented. All charging systems take AC power from the grid and convert it to DC power at a suitable voltage for charging the battery. In EV applications, except for bicycles, Level 1 and Level 2 chargers are completely contained within the vehicle. In Level 3 charging systems however the charging functions are split between the charging station and the vehicles on board charger.

This paper deals with comparison of performance of battery charging using different controllers. The performance of circuit has been analyzed in many papers amongst them papers [1][2] have been studied and are undertaken for their theoretical verification, graphical representation and Matlab simulation.

Battery charging circuit is considering with different types of controller and for each type of controller rise time, settling time and peak overshoot, loading effects etc. are studied, and its performance is analyzed.

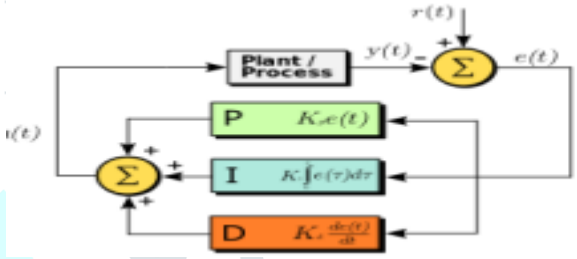
The objectives of this paper are listed below,

- To study the concept of battery charging.
- Literature survey for battery charging circuit with PI, PID and SMC, fuzzy logic circuit.
- To study the concepts of non linear controller sliding mode control,
- To simulate battery charger with different types of controllers for finding performance of circuit. This simulation will be carried out on mat lab platform with Simulink as it user interface
- To compare performance response of each circuit.



- **PID control method**

The feedback mechanism in which Proportional-integral-derivative controller (PID controller) is (controller) widely used in industrial control systems. The error value are the difference between a measured process variable and a desired set point. The controller used to minimize the error by adjusting the process through use of a manipulated variable. The PID controller algorithm involves three separate constant parameters, the proportional, the integral and derivative values, denoted P, I, and D. These values can be is evaluated in terms of on the present error, I on of past errors, and D is a prediction of future errors, based on current rate of change. Tuning the parameters in the PID controller algorithm, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of controller to an error, the degree to which the controller overshoots the set point, and the degree of system oscillation.



$$u(t) = K_p e(t) + K_i \int_0^t e(\tau)d\tau + K_d \frac{d}{dt}e(t)$$

- **Basics of sliding mode control (SMC)**

A Variable structure system (VSS) is theory which is applied to system to study the behavior of system during the transient, according to a preset structure control law, to achieve the control objectives. The instant of time, at which the control action of changing the structure occurs, are not determined by a fixed program, but in accordance with the current state of the system. This property distinguishes variable structure systems (VSS) from programmed controllers.

From this point of view, switch-mode power supplies represent a particular class of the VSS, since their structure is periodically changed by the action of controlled switches. The SMC for VSS offers an alternative way to implement a control action, which exploits the inherent variable structure nature of DC-DC converters

It is represented through the phase plane description of the constituent substructures. The phase plane description is the description of the different types of phase trajectories encountered in second order systems. Phase trajectories described by

using simple second order systems and its important features of sliding mode control are studied in this chapter. The concept of SMC is defined by graphical visualization of trajectories. Axes are the states of systems. The phase plane is divided into number of substructure and then the overall phase trajectory is composed for each substructure.

Sliding mode was studied in conjunction with DC to DC converter. Nonlinearity, a system problem is considered with this. It is focused only on the hysteresis type of switching nonlinearities since it is most relevant to any electronic implementation of the switching device, including both analog and digital circuits and microprocessor code executions.

Oscillation about the sliding surface is chattering phenomenon and generally perceived as motion which oscillates about the sliding surface. The two possible mechanisms which produce such a motion. First, in the absence of switching nonlinearities such as delays, hysteresis i.e., the switching device is switching ideally at high frequency. The presence of nonlinearities in series with the converter causes a small amplitude high frequency oscillation to appear in the neighborhood of the sliding surface.

Reaching mode: -

The trajectory starting from anywhere in the phase plane in which the representative point moves to the switching line and reaches it is called reaching mode. In other words, it is the time required to reach the error or rate of change of error to zero. The condition under which it occurs is called reaching mode.

Sliding mode: -

In this mode trajectory asymptotically tends to the origin of phase plane. To produce the discontinuous control signal which forces the system state to repeatedly cross and that immediately re-cross the surface, called “sliding surface” until it finally slides along the surface. This kind of motion is referred as sliding motion or sliding mode.

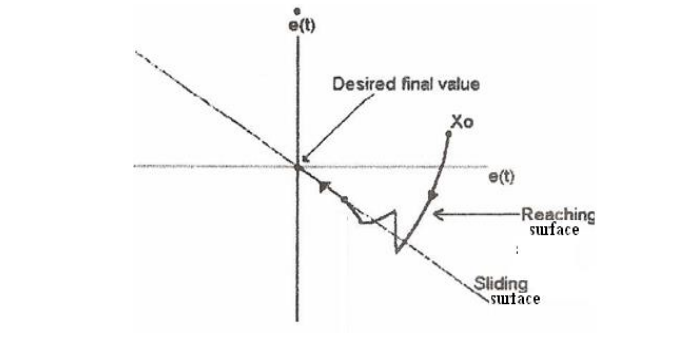


Figure : Modes in SMC.

The phase plane description is used widely to characterize second order systems. The axes of the phase plane are the system states. The instantaneous state of the system is represented on the phase plane by a Representative Point (RP) whose coordinates on the phase plane are the present states of the system. The study of the system involves the motion of the RP on the phase plane under different input and initial conditions. The evolution of the system states with respect to time on the phase plane, referred to as the phase trajectories or the state trajectories, represent the dynamic properties of the system.

- **Fuzzy control system: -**

In designing a fuzzy logic controller, the process of forming fuzzy rules plays a vital role. There are four structures of the fuzzy production rule system (Weiss and Donnel, 1979) which are as follows: • A set of rules that represents the policies and heuristic strategies of the expert decision-maker. • A set of input data that are assessed immediately prior to the actual decision. • A method for evaluating any proposed action in terms of its conformity to the expressed rules when there is available data. • A method for generating promising actions and determining when to stop searching for better ones. The various steps involved in designing a fuzzy logic controller are as follows: • Step 1: Locate the input, output, and state variables of the plane under consideration. I • Step 2: Split the complete universe of discourse spanned by each variable into a number of fuzzy subsets, assigning each with a linguistic label. The subsets include all the elements in the universe. • Step 3: Obtain the membership function for each fuzzy subset. • Step 4: Assign the fuzzy relationships between the inputs or states of fuzzy subsets on one side and the output of fuzzy subsets on the other side, thereby forming the rule base. • Step 5: Choose appropriate scaling factors for the input and output variables for normalizing the variables between [0, 1] and [-1, I] interval. • Step 6: Carry out the fuzzification process. • Step 7: Identify the output contributed from each rule using fuzzy approximate reasoning. • Step 8: Combine the fuzzy outputs obtained from each rule. • Step 9: Finally, apply defuzzification to form a crisp output.

- **FEEDFORWARD CONTROL METHOD**

Feedforward control based on the change of value or interference, generates the appropriate control action to change the manipulated variables, and keeps controlled variable on the set value. So it has the characteristics of not affect system stability. Because the variables of feedforward control are directly calculated by the signal source and feedforward model, control variables directly response to the change of the signal source while can speed up the

rate of regulation. Feedforward control is simple in concept, robust and has good dynamic performance [4]. It is especially effective in handling a disturbance that can be measured.

- **Selection of various parameters for the circuit: -**

The control topology consists of a linear and non-linear part. The non-linear parameter can be selected, while it is left to the designer to tune the linear part and get the optimum values depending on the application. The output of the integral is amplified through a gain and the result is subtracted from the inductor loop, the difference is passed through a hysteresis. One major drawback of this model is the lack of a standard procedure to select the gain. The parameter can be selected by measuring the peak-to-peak inductor current and these are the limits for the circuit parameters.

Parameter Name	Symbol	value
INPUT VOLTAGE	Vin	48 V
OUTPUT VOLTAGE	Vo	24 V
BATTERY	LITHUM ION	45V
INDUCTOR	L	5.783e-4
RESISTANCES	R	.201 ohm
IGBT	IGBT	0.001

- **Conclusion:-**

  - The performances of proposed systems with different traditional and intelligent controllers are compared for its stability analysis.
  - Development of prototype model for battery charging system with controllers.
  - proposed system volume of vehicle get reduced and controller gives stability improvement by reducing its settling time, rising time and chattering in circuit.

1. Moreno, J., Ortuzar, M.E., and Dixon J.W. (2006) EnergyManagement System for a Hybrid Electric Vehicle Using Ultracapacitors and Neural Networks. IEEE Transactions on Industrial Electronics. 56(2), 614–623
2. Jeong, H.-G. and Lee, K.-B. (2013). A Controller Design for a Stability Improvement of an On-Board Battery Charger. Journal of Electrical Engineering & Technology. 8(4), 951–958.
3. Bak, Y. S., Lee, E.S., and Lee, K.-B. (2015) Indirect Matrix Converter for Hybrid Electric Vehicle Application with Three-phase and Single-Phase Outputs. Energies. 8(5), 3849–3866
4. Ivan, S., Nandor, B., and Emil, L. (2016). Single-Phase OnBoard Integrated Battery Chargers for EVs Based on Multiphase Machines. IEEE Transactions on Power Electronics. 31(9), 6511–6523.
5. Jeong, H.-G. and Lee, K.-B. (2013). Controller Design for a Quick System suitable for Electric vehicles. Journal of Electrical Engineering & Technology. 8(5), 1120–1130
6. Shi, C., Tang, Y., and Khaligh, A. (2017). A Three-Phase Integrated Onboard Charger for Plug-in Electric Vehicles. IEEE Transactions on Power Electronics. 33(99), 4716–4725
7. Gu, B.-G. and Nam, K.h. (2006). A DC-Link Capacitor Minimization Method Through Direct Capacitor Current Control. IEEE Transactions on Industry Applications. 42(2), 573–581
8. Kim, S.-K. and Lee, K.-B. (2015). Robust One-Step ahead State Predictor using Adaptive Proportional-Integral Observer. IET Power Electronics. 8(12), 2411–2417.
9. A Comprehensive Review on Control Techniques for Power Management of Isolated DC Microgrid System Operation K. M. BHARGAVI1 , N. S. JAYALAKSHMI 1 , (Member, IEEE),
10. A Linear Parameter Varying Control Approach for DC/DC Converters in All-Electric Boats Soroush Azizi , 1 Mohammad Hassan Asemani , 1 Navid Vafamand , 1 Saleh Mobayen , 2,3 and Mohammad Hassan Khooban, Volume 2021,

Article ID 8848904, 12 pages https://doi.org/10.1155/2021/8848904

11. Optimizing the Hyperparameters of a Mixed Integer Linear Programming Solver to Speed Up Electric Vehicle Charging Control Takahiro Ishihara1 and Steffen Limmer2
12. Control Methods for Performance Improvement of an Integrated On-Board Battery Charger in Hybrid Electric Vehicles Yeongsu Bak 1,* and Ho-Sung Kang 2, Electronics 2021, 10, 2506. https://doi.org/10.3390/electronics10202506
13. Design and Control Methods of Bidirectional DC-DC Converter for the Optimal DC-Link Voltage of PMSM Drive Tae-Hoon Kim*, Jung-Hyo Lee† and Chung-Yuen Won**, J Electr Eng Technol Vol. 9, No. 6: 1944-1953, 2014
14. Gautam, D.S.; Musavi, F.; Eberle, W.; Dunford, W.G. A zero-voltage switching full-bridge DC—DC converter with capacitive output filter for plug-in hybrid electric vehicle battery charging. IEEE Trans. Power Electron. 2013,
15. Amjadi, Z.; Williamson, S.S. Power-electronics-based solutions for plug-in hybrid electric vehicle energy storage and management systems. IEEE Trans. Ind. Electron. 2010, 57, 608–616
16. Modulation, P.; Marsadek, M.; Rahmat, N.A.; Hoon, Y.; Aljanad, A. A three-level universal electric vehicle charger based on voltage-oriented control and pulse-width modulation. Energies 2019, 12, 2375.