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Research Article

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"Characteristics Verification Of Battery Charging Circuit Using Different Controllers"

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ABSTRACT

Matlab is used to simulate the project battery charger using various existing linear controllers, such as SMC, FUZZY, and PID, and PI. It was shown that using intelligent controllers might improve the battery charging circuit's performance after analyzing the simulated network's performance from multiple publications. The efficiency of the battery charger was investigated and verified by Matlab simulation. Battery charger efficiency was examined and confirmed using Matlab simulation, graphical representation, and research. Fuzzy and sliding mode control (SMC), a nonlinear controller, are chosen as the control methods based on the linear controller PI. We are familiar with the principles of sliding mode control (SMC), fuzzy logic, and linear controllers, PI and PID.

Keywords: - Battery charging, SMC (sliding mode control), PI , PID control and fuzzy control.

1. Introduction:

There were issues with the conventional internal combustion engine (ICE) powered vehicles due to the scarcity of fossil resources, environmental pollution, and other factors. On the other hand, during the past several years, as car batteries have advanced, the number of electric vehicles (EVs) and hybrid EVs (HEVs) has increased gradually. HEVs, in particular, can be a compromise between ICE-powered cars and EVs because of their great driving efficiency and low exhaust emissions.

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 ed to manage the energy flow and balance the energy between renewable energy sources, electric vehicle es 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 use 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, electric vehicles (EVs), and hybrid EVs (HEVs), have been growing steadily with the development of 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.

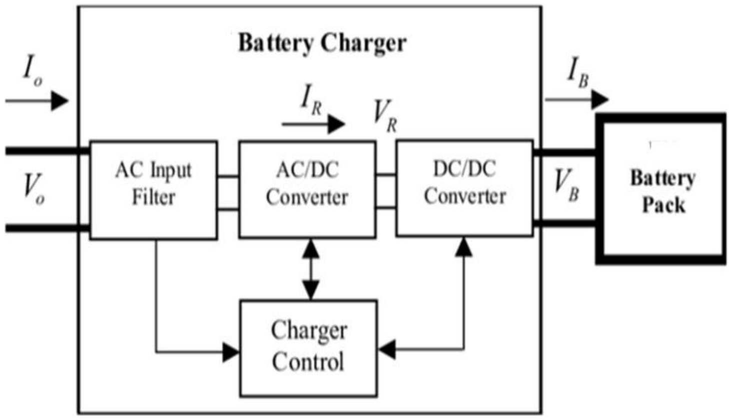
Diagram of a typical battery charger The parts and control techniques used to determine how an EV battery charger functions. With reference to the above Fig., sensing circuits supply feedback signals during the first stage of control, indicating the current state of all pertinent system variables needed to control the algorithm. Achieving both transient and high-level steady-state performance is the responsibility of the control algorithm. In the third step of the control, sensed values and reference values for the variables are employed.

The main features of Level 1, 2, and 3 chargers are implemented as shown in the diagram below. Every charging system transforms grid AC electricity into DC power at the right voltage to charge the battery. When using EVs, aside from

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 nonlinear controller sliding mode control,
- To simulate battery chargers with different types of controllers for finding the performance of circuit. This simulation will be carried out on the Matlab platform with Simulink as it user interface

To compare the performance response of each circuit.



2 Basics of sliding mode control (SMC):-

A variable structure system (VSS) is a theory that is applied to a system in order to investigate its transient behavior in accordance with a predetermined structure control law in order to accomplish control goals. The precise moment at which the control operation to modify the structure takes place is determined by the system's present state rather than by a predetermined program. This feature separates programmed controllers from variable structure systems (VSS).
From this point of view, switch-mode power supplies represent a particular class of the VSS, since controlled switches function to periodically alter their structure. A different method of implementing a control action that takes advantage of the DC-DC converters' intrinsic variable structure is provided by the SMC for VSS.
The VSS is represented by the phase plane description of each individual substructure. The phase plane description is the description of the different phase trajectories present in second-order systems. This chapter examines the key components of sliding mode control as well as phase trajectories established by the use of elementary second-order systems. The concept of sliding control is defined visually through the visualization of phase trajectories. Axes are the states of systems. The phase plane is divided into multiple substructures, and the overall phase trajectory is then created for each substructure.
The majority of people see the chattering phenomenon as an oscillating motion around the sliding surface. There are two possible ways to produce this kind of motion. First, when switching nonlinearities like delays or hysteresis are absent, the switching device should ideally be switching at a high frequency. The presence of nonlinearities in series with the converter causes a high-frequency oscillation with a small amplitude to occur close to the sliding surface.

Reaching mode: -

Reaching mode is the trajectory, starting from any point in the phase plane, along which the representative point travels until it reaches the switching line. Stated differently, it refers to the amount of time needed to get the error or rate of change of mistake to zero. Reaching situation is the state in which it takes place.

Sliding mode: -

The mode trajectory in question asymptotically trends towards the phase plane's origin. to generate the discontinuous control signal that drives the system state to continuously cross the surface and then recross it right away—a process known as the "sliding surface"—until it eventually slides along the surface. Sliding motion or sliding mode are terms used to describe this type of motion.
As illustrated in figure 3.3.

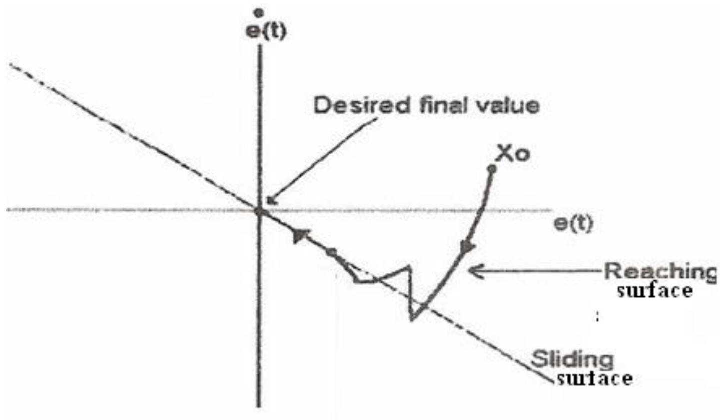


Figure No. 3.3 Modes in SMC.

It is common practice to characterize second-order systems using the phase plane description. The system states are the axes of the phase plane. A Representative Point (RP), whose coordinates on the phase plane represent the system's current states, represents the instantaneous state of the system on the phase plane. The motion of the RP on the phase plane under various input and beginning conditions is studied in the system. There are two parts to the control topology: linear and non-linear. One can choose the non-linear parameter, but it's up to the evolution of the system states concerning time on the phase plane, sometimes referred to as the phase trajectories or state trajectories, which represent the dynamic features of the system.

3. Fuzzy control system:-

The technique of creating fuzzy rules is essential to the design of a fuzzy logic controller. According to Weiss and Donnel (1979), the fuzzy production rule system has four structures, which are as follows: • A collection of guidelines that stand in for the expert decision-maker's heuristic approaches and policies. • A collection of input data that are evaluated right before a decision is made. • A procedure for assessing, in the case that data is available, whether a proposed action complies with the stated guidelines. • A process for coming up with promising activities and figuring out when to give up on finding better ones. The following are the different steps that go into building a fuzzy logic controller: • Step1: Find the plane's input, output, and state variables under

3. Simulated model of battery charging with PI controller:-

Figure 4.1.1 illustrates a Matlab-based battery charging simulation. It is made up of an IGBT switch, a 48 V DC supply, and an inductor that has a resistance of 0.201 Ω and a 5.783e-4 H value [1].This converter is intended to produce an output of 24 V DC.

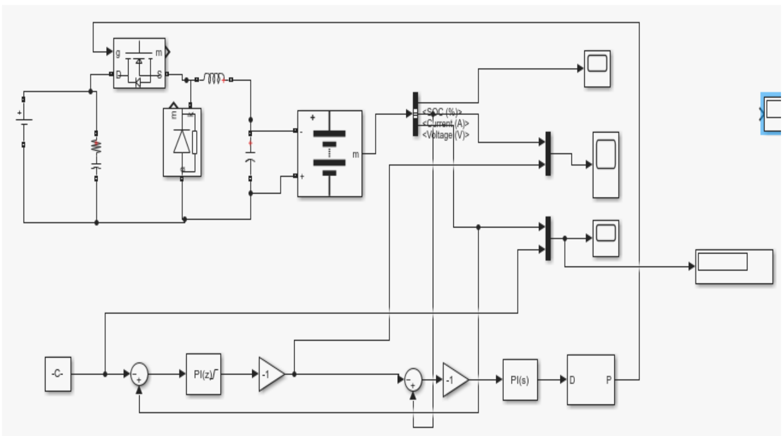


Figure No 3.1 Battery Charging with PI Controller in Matlab Simulink.

The circuit's output voltage of 14.12 V, which must settle at 24 V, has a 0.3 msec settling period. These buck converter transients can be compensated for using a variety of controller types.

4. Control Methods:-

The block diagram with several controllable techniques for DC-DC converters and the disturbances affecting the converter's behavior and stability is displayed in Figure 4.2.1. Either the output voltage, the inductor current, or both could be the feedback signal. Analog or digital control might be used for the feedback mechanism. Using these control techniques SMC and SMC PID are non-linear control methods, while PI and PID are linear control methods. Below is a comparison of linear and nonlinear control techniques.

4.1 PI control method:-

The PI adjusted buck converter circuit has a 0.3 msec settling period and an initial 24 V output voltage overshoot. Following a 0.3 ms settling time, the output voltage is 24 V and the inductor current is 114.9 A.

Battery voltage:-

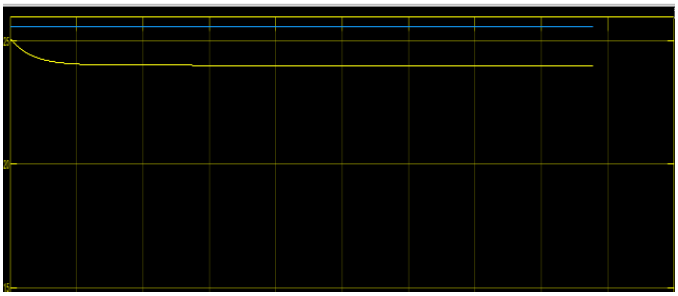
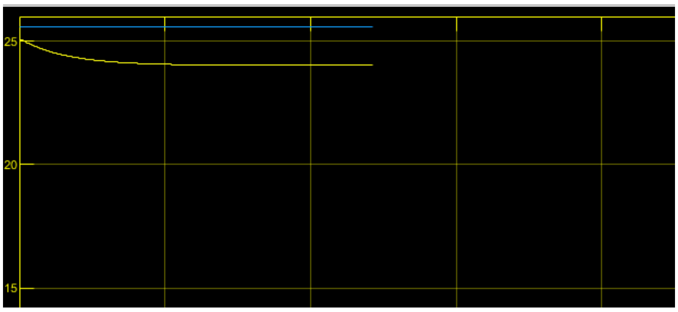


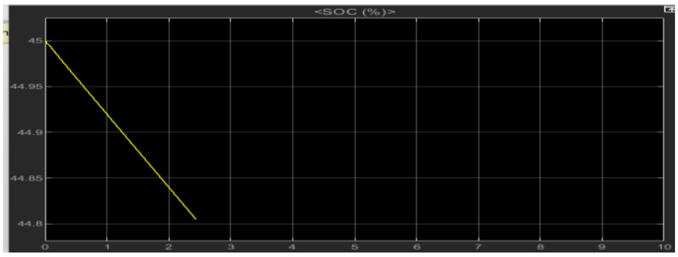
Figure No. 4.1.1 Load voltage of battery charging with PI in Matlab/Simulink™ model.

current:-



FigureNo.4.1.2 current from simulation.

SOC OF BATTERY:



4.2. 3. Simulated model of battery charging with PID controller:-

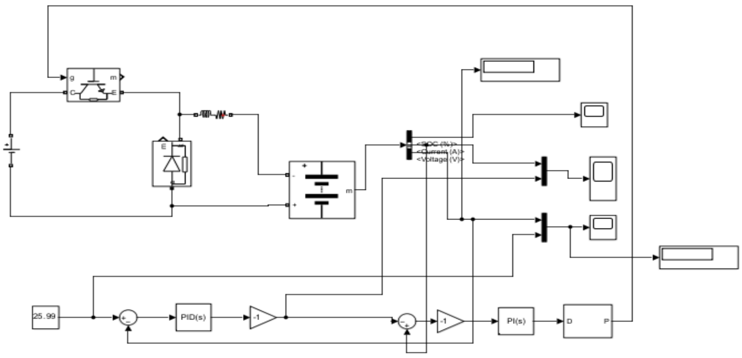
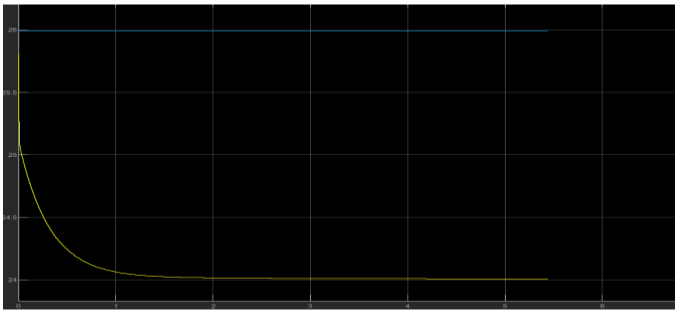
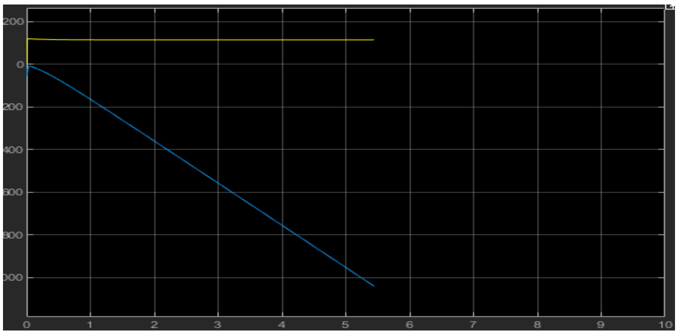


Figure No.4.2.1 Simulated model of battery charging with PID controller

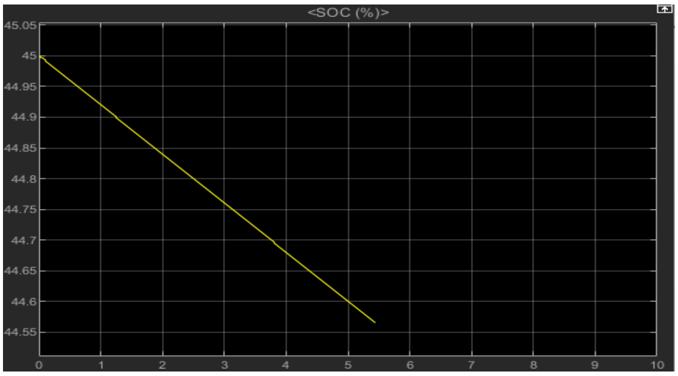
VOLTAGE WAVEFORM:-



CURRENT WAVEFORM:



SOC WAVEFORM:-



5. Simulated model of battery charging with SMC controller:-

Out of all the control methods mentioned above, sliding mode control is the only one that is non-linear. Its effectiveness is examined and compared to other linear approaches. SMC might be used in place of switch-mode power supplies. Figure No. 5.1 displays the simulation controller block diagram for SMC.

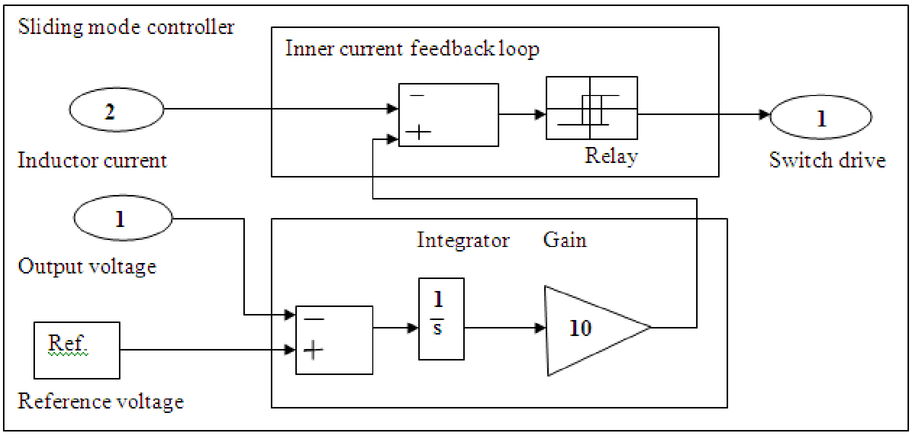


Figure No. 5.1 The simulation controller block diagram SMC.

5.2. Simulated model of battery charging with SMC controller:-

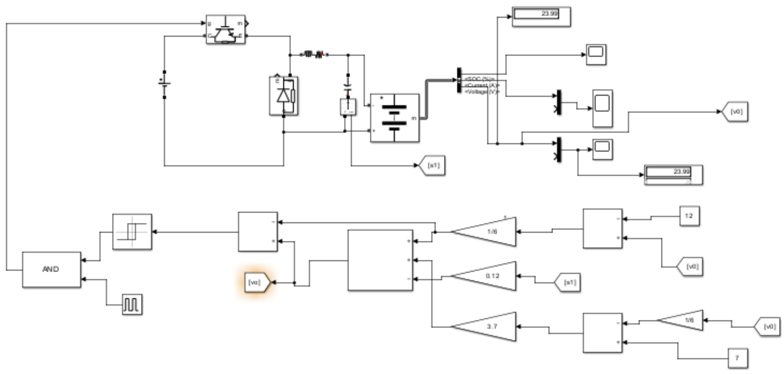
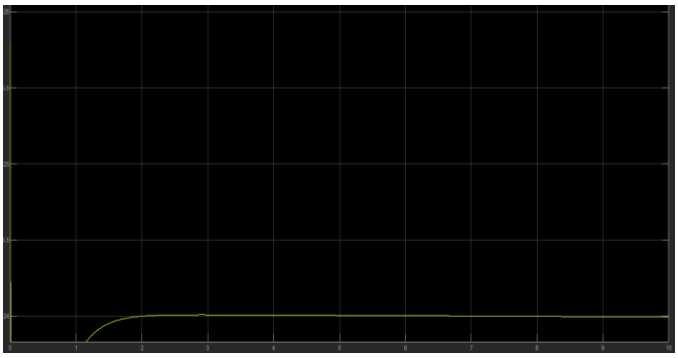
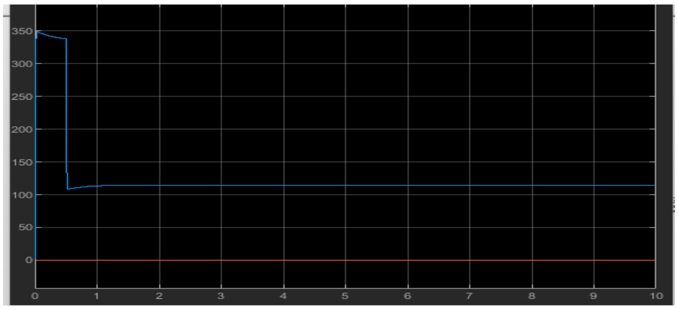


Figure No. 5.2.1 Simulation diagram for Battery charging with SMC

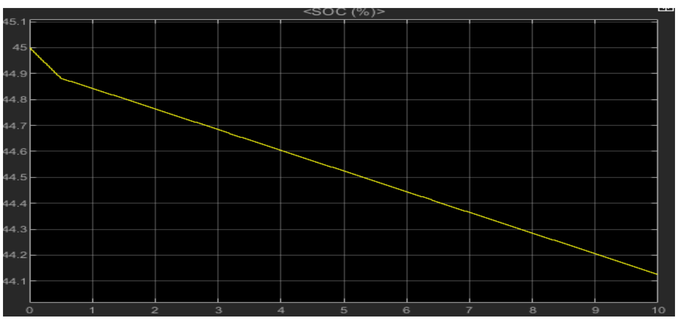
VOLTAGE WAVEFORM: -



CURRENT WAVEFORM:



SOC WAVEFORM:-



6. Selection of various parameters for the circuit:-

There are two parts to the control topology: linear and non-linear. The designer has the option to choose the non-linear parameter and modify the linear portion to obtain the best values for the given application. After the integral's output is amplified using a gain and the result is deducted from the inductor loop, a hysteresis is applied to the difference. The absence of a standardized process for choosing the gain is a significant limitation of this paradigm. These are the limitations of the hysteresis parameters, which can be chosen by measuring the peak-to-peak inductor current.

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
IGBT	IGBT	0.001

Conclusion:

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

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