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Development of Pulse Charger for Electric Vehicle Batteries

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Abstract. The issue of slow charging and early battery life deterioration affects emerging new battery technologies. This study suggests a quick pulse charging technique that guards against battery deterioration and provides sustainable operation. The research primarily focuses on newly developed batteries charged from a solar sourceutilizing a pulsed approach. ANSYS or MATLAB/Simulink are used for the different simulations. The charger circuit comprises the Photovoltaic panel,transformer, a passive element like a capacitor, voltage regulator, and bridge rectifier. An optocoupler, an isolation circuit, and a DSP controller comprise the control circuit. The charger circuit receives power directly from the solar panel, and the duty ratio is configured in the Arduino software, which controls the output voltage.

1 Introduction

These days, electric vehicle (EV) battery charges have garnered much attention. They are built using high-quality Charging - Discharging techniques to extend battery life and optimize battery performance thereby gives sustainable operation. By permitting battery charging processes, it is conceivable to create Highly Efficient, Reliable, and Compact EVs to address the challenge. This study suggests a battery charger for electric cars using pulse-current charging. It applies positive, negative, and zero currents per every cycle. Pulse current approaches are typically employed widely in sophisticated battery systems because they regulate chemical reactions, remove polarization worries, boost power transfer rate, reduce charging time, lower internal temperature, and improve charging efficiency.

The challenge's goal is to create a quick charging method for batteries utilizing pulses of controlled size and duty, also known as "pulse charging," and to determine the battery performance that will be achieved using this technique.

The batteries are of two basic types of primary and secondary. EV battery chargers can be generically categorized as having an ability for unidirectional or bidirectional power flow in both off-board and on-board setups [3]. Most electric vehicle (EV) needs sustainable charging and that can be completed at home, for a whole night, or in a garage where an EV can be connected to a convenience outlet for Level 1 (slow) charging.

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It is common knowledge that the primary way for a battery EV charger for private and public facilities is level 2 charging,which requires a 240V outlet [4].

Table 1 overviews these charging power levels based on part [5]. The disadvantage of CC charging is that its high charging current introduces heat loss, and that CV charging is a short charging time but cannot be fully charged and degradation occurs. Levels of Power Charging: A Level 1 charger is typically used for charging at home or the office. It uses a convenience outlet as the energy supply interface, and the expected power level is 1.4kW for 120Vac (US) and 1.9kW for 240Vac (EU). The charging time of the Level 1 charger takes around 4-11 hours. Level 2 chargers are found to be used at private or public outlets, and the expected power level is 4kW. Level 3 chargers are Off-board 3-phase commercial chargers analogous to a filling station. The predicted power level for Level 3 chargers is 50kW. The Charging time for these charges is around 0.4-1 hour, whereas for level 2 is 2-6 hours. [4,5].

The use boost charging method, the battery draws a high current quickly. The pulse currents' frequency and duty cycle are interdependent. We also surveyed materials used, charging, and discharging characteristics. EV charger creates a non-linear load (creates weak power factor and non-linear load). An active power factor correction (PFC) boost converter is a feature of contemporary EV battery chargers. [1].

The increased discharge capacity of the pulse-charged battery shows that the pulse technique may effectively use the battery's active components without overcharging while still providing long cycling life [2]. Reactive currents are reduced using PWM with phase shift, triangular and trapezoidal modulation in the active bridges or switches. To minimize the influence on power quality and maximize the real power available from a utility outlet, an EV charger must pull the utility current with low distortion and at a high-power factor.

2 Pulse Charging Methodology

2.1 Battery Charger Block Diagram

Battery chargers are different, but conventional pulse chargers are the most effective. The existing studies found that the perks of using a pulse charger are fast charging, enhanced battery life, efficient charging, battery conditioning and maintenance, and other such parameters. Here in this project, we tried to use the pulse charging technique to charge a battery. The corresponding block diagram is displayed in Fig 1 below.

2.1.1 Components of the pulse charger

Solar Power Supply: The voltage from a PV source or sun is DC, but not stable. *Pulse Charge Controller:* To stabilize this DC supply from solar cells, a DC-DC converter is used. The DC-DC converter or voltage regulator adjusts the voltage level generated by the solar panels to meet the needs of the load or battery system. Here, a boost converter increases the voltage at the load side. *DSP Controller:* The pulses to switch ON or OFF the MOSFET is given using a DSP Controller coded in Assembly language. *Battery:* The combined working of the DSP charger supplies the battery, i.e., charges the battery. *Optocoupler*: Optocoupler protects the battery from over currents from the input supply. Itis also helpful to shut down the supply when the controller tells you to, i.e., when the batteryis fully charged or charged to a preset SOC.

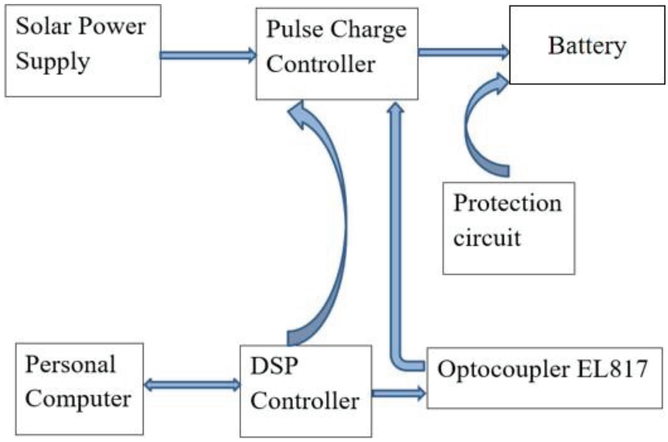

Fig 1. Pulse Charger using DSP Controller.

2.2 Pulse Charger Circuit

The simulation of the pulse charger circuit in MATLAB software is represented in Fig 2. This pulse charger uses a boost converter, which raises the voltage from its input to its output (load). Power for the boost converter is from a DC voltage source of 12V. As voltage is stepped up to conserve the power, the current is stepped down simultaneously. A boost converter uses a capacitor to store energy temporarily. Energy is stored in the inductor before it is turned on.

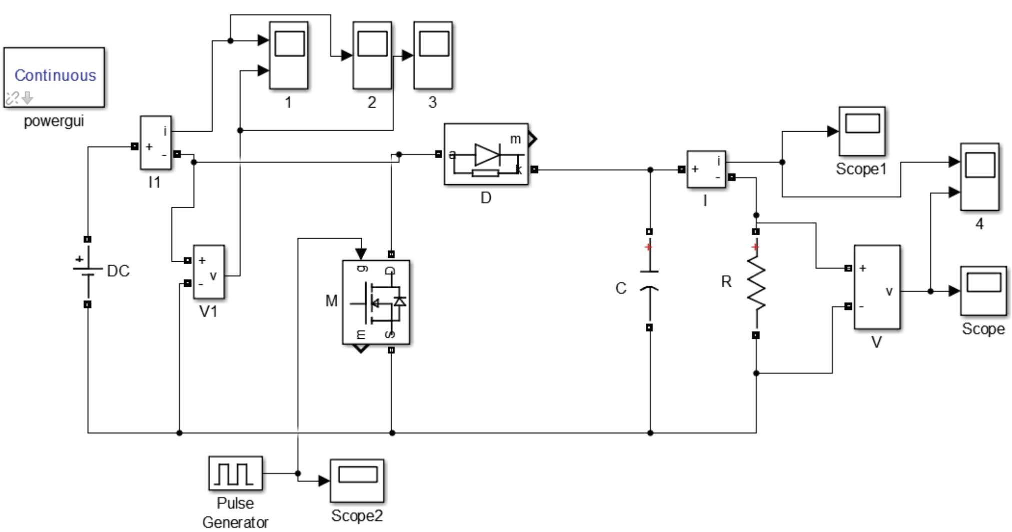

Fig 2. Simulink diagram of proposed pulse charger circuit.

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This energy is transmitted to the output capacitor when the inductor is switched off, increasing the output voltage. The capacitor also aids in reducing ripple and smoothing down output voltage. A discrete PI controller is used in the feedback loop to control the pulses given to the switch. The duty cycle of pulses is slightly >50%. A triangular waveform of switching frequency 1kHz is compared with the PI controller to produce on and off pulses. These pulses are given to the MOSFET, which controls the charging of the battery.

2.3 Pulse Charger Simulation Studies

The gate pulses produced from the output of a comparator which compares the output of a PI controller and triangular waveform, as in Fig 2, are shown below in Fig 3. These pulses are provided to the MOSFET (switch), so the charging of the battery is controlled using these pulses.

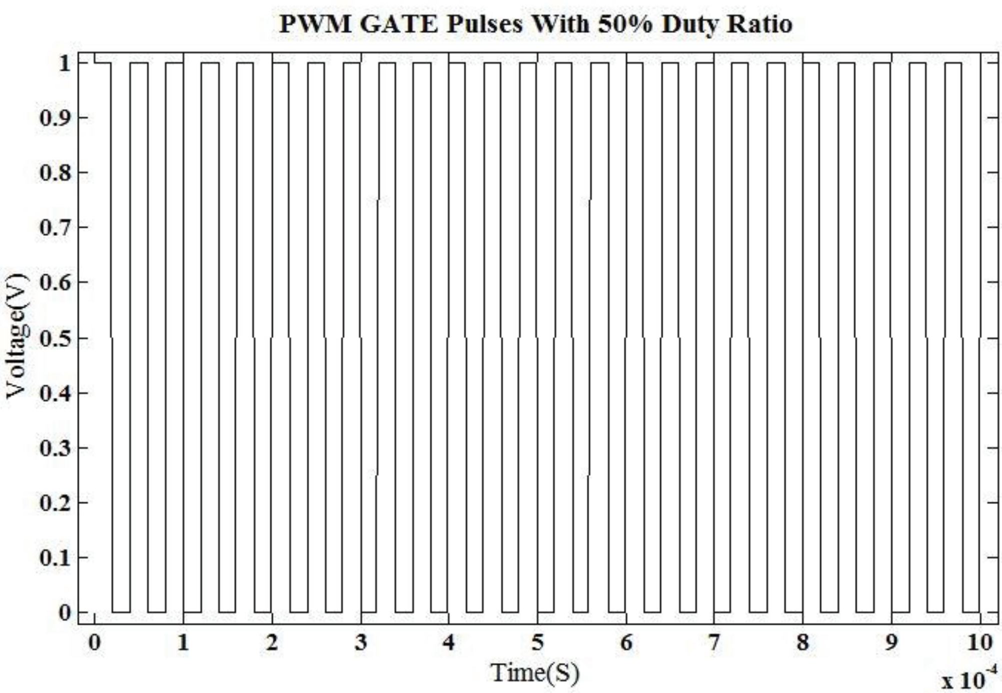

Fig 3. PWM Gate Pulses with 50% duty ratio.

The graph in Fig 4 represents MATLAB's scope result of pulse charger input voltage and input current.According to the conventional boost converter topology, the output voltage is stepped up from its input voltage. This can be observed that, this high voltage can charge the battery efficiently without any power loss.

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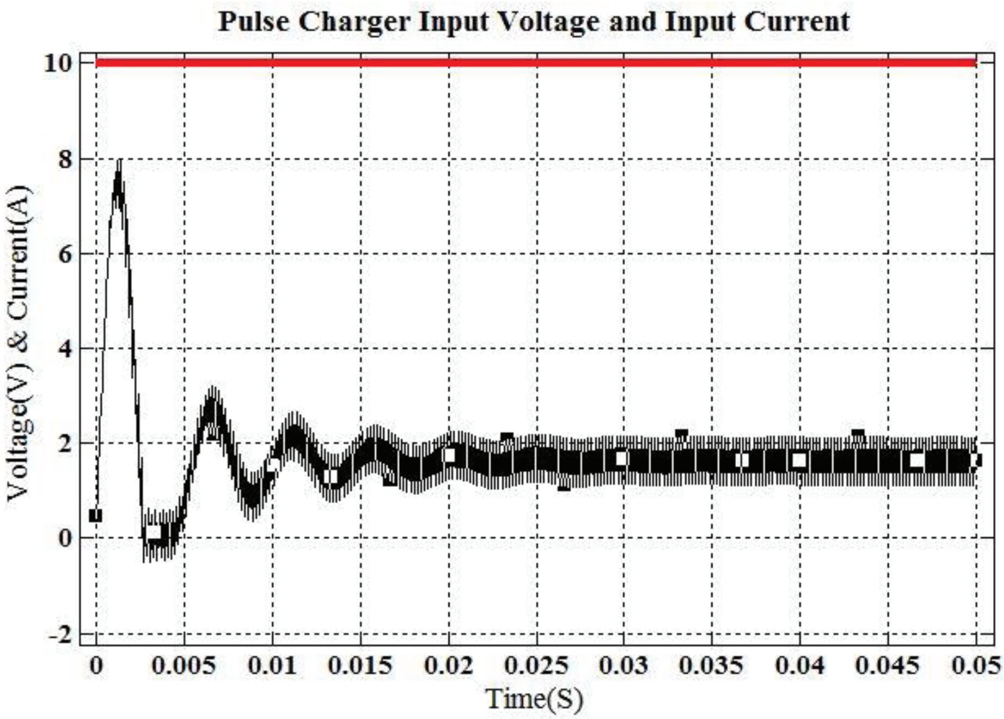

Fig 4. Pulse Charger Input Voltage and Input Current.

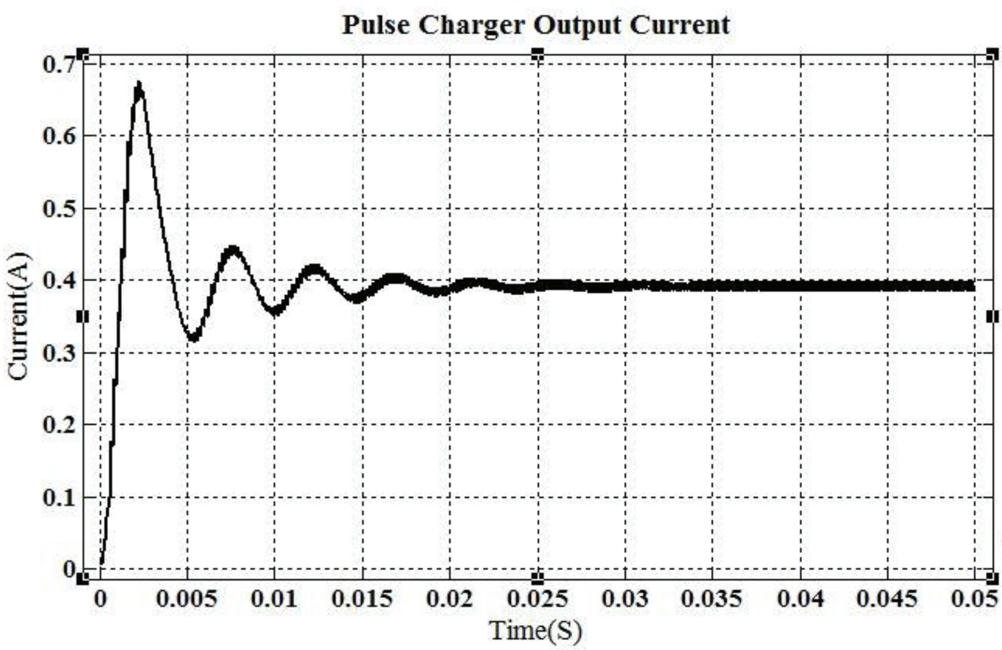

Fig 5. Pulse Charger Output Current

The waveform in Fig 5 represents the scope result of the pulse charger output current. As voltage is stepped up, as shown in Fig.4, and to conserve the power, the output current is stepped down, which can be seen from the above waveform. In this waveform, current increases quickly up to a certain point then begins to gently decline until it hits a minimum value and continues to produce the same constant output. The above waveform is for stop time = 0.5 seconds. For a stop time of 0.05 seconds final output current is around 0.4A. The current supply value should gradually decrease during the charging process as the battery gets closer to being fully charged.

3 Conclusion

The attempt was made to charge a battery using the pulse charging method in this work. The development of the pulse charge circuit has been done using MATLAB and the simulation results were presented. The simulation results of the output current and output voltage characteristics shows that the battery charging current is constant after 0.2s. Thus, shows that, as the battery approaches full charge during the charging process, there should be a steady drop in the current supply value and makes the battery for sustainable operation.

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