Switchable Battery Charger for Li-Ion and LiFePO4 Batteries

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Introduction

Rechargeable batteries are essential to modern electronics, with Lithium-Ion (Li-ion) and Lithium Iron Phosphate ($LiFePO_4$) being two common types that have distinct charging needs and safety considerations. This project introduces a microcontroller-managed, switchable battery charger that accommodates both chemistries on a shared hardware platform. By utilizing Arduino-based control, real-time voltage and current sensing, and MOSFET-based profile switching, the system provides charging specifically tailored to the selected battery type.

System Overview

Charger operates from a standard 120V RMS AC input stepped down by a transformer, rectified and filtered to produce approximately 17V DC. This serves as the input to the buck regulator, which provides the charging voltage (either 4.2V for Li-ion or 3.6V for $LiFePO_4$).

Key features include:

- Voltage Regulation: Resistor pairs determine charger output: Li-ion (4.2V) or $LiFePO_4$ (3.6V).
- Feedback Switching: Two N-channel MOSFETs, controlled by the Arduino select the appropriate feedback resistor network for the chosen battery chemistry.
- Battery Path Selection: An SPDT switch manually directs the charger's output power to the selected battery.
- Sensing: Voltage and current is monitored via two ACS712 current sensors, with their outputs connected to Arduino analog inputs.
- Control: The Arduino manages the buck regulator ON/OFF pin for charging control and implements an improvised CC-CV charging logic and safety cutoffs based on measured values.

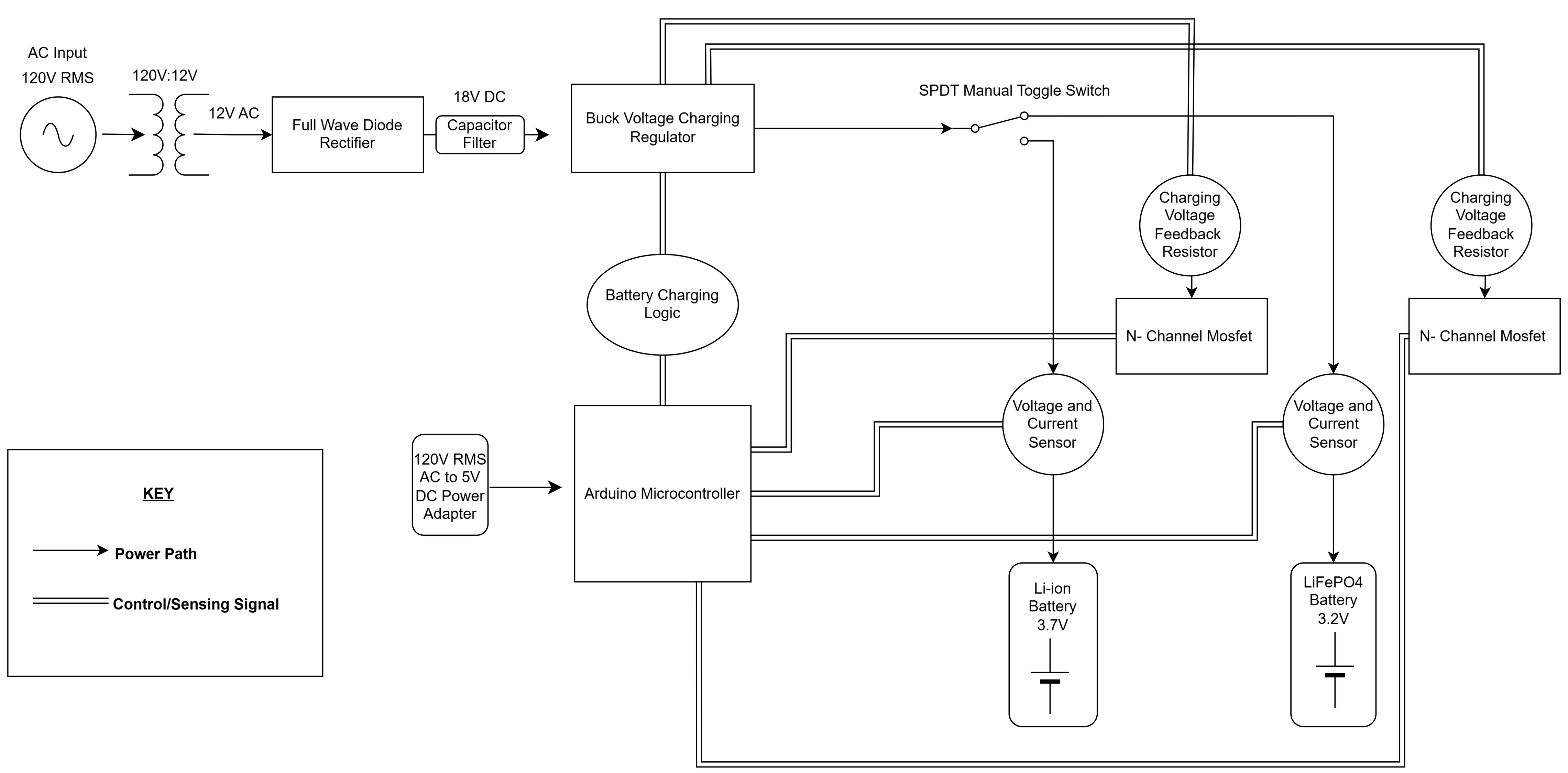

Figure 1. Block Diagram of the Battery Charger

Charging Method

The charging process:

1. Battery selected via user input and SPDT switch is flipped to match battery.
2. Arduino enables the corresponding battery voltage on the charger through a MOSFET.
3. A soft start delays charger activation for 2 seconds to limit inrush current.
4. The Arduino reads voltage and current of the battery through a sensor.
5. If current exceeds 1A, charging is immediately disabled to protect the battery.
6. After battery reaches full charge, Arduino waits for current to drop below 50 mA to terminate charging.
   This creates a passive constant-current behavior at the beginning where the current is high, but not regulated, and a constant-voltage phase as the battery voltage reaches the target.

Results and Discussion

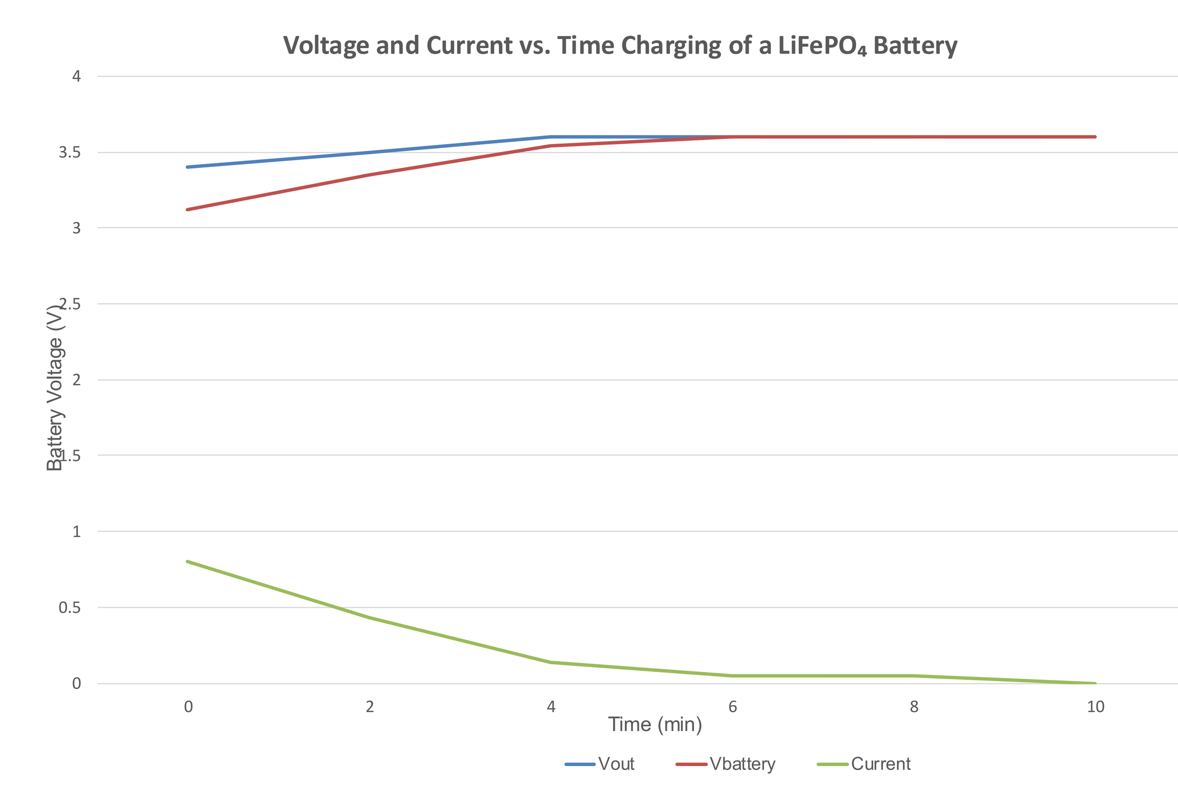

Figure 2. LiFePO4 Charging at 3.6V for 10 minutes

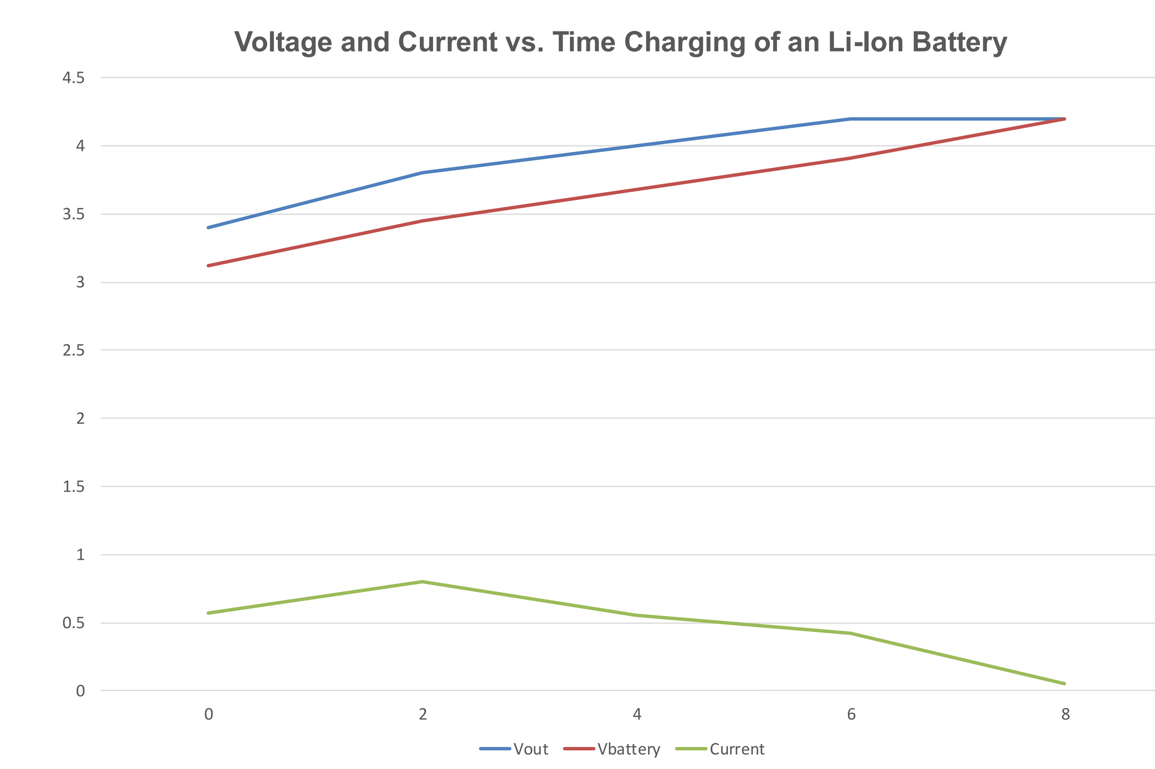

Figure 3. Li-Ion Charging at 4.2V for 10 minutes

Charger's performance for $LiFePO_4$ (Figure 2) and Li-ion (Figure 3) batteries was evaluated over a 10-minute charging period. Observation demonstrates the charger operating correctly in the Constant Voltage (CV) phase for both battery chemistries.

Charger Output Voltage (Vout):

- Maintained at ~3.60V for $LiFePO_4$, battery voltage rose from ~3.15V, approaching the 3.60V target
- Maintained at ~4.20V for Li-ion, battery voltage rose from ~3.5V, approaching the 4.2V targe

Charging Current (Current):

- $LiFePO_4$: Tapered from an initial ~0.8A down to ~0.1A.
- Li-ion: Tapered from an initial ~0.65A down to <0.3A.

Although the full implementation of the SPDT has not been verified for quantifiable results, the batteries manage to charge functionally when plugged in individually.

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