HydroWatter

A Semi-Permanent Hydro Generation System

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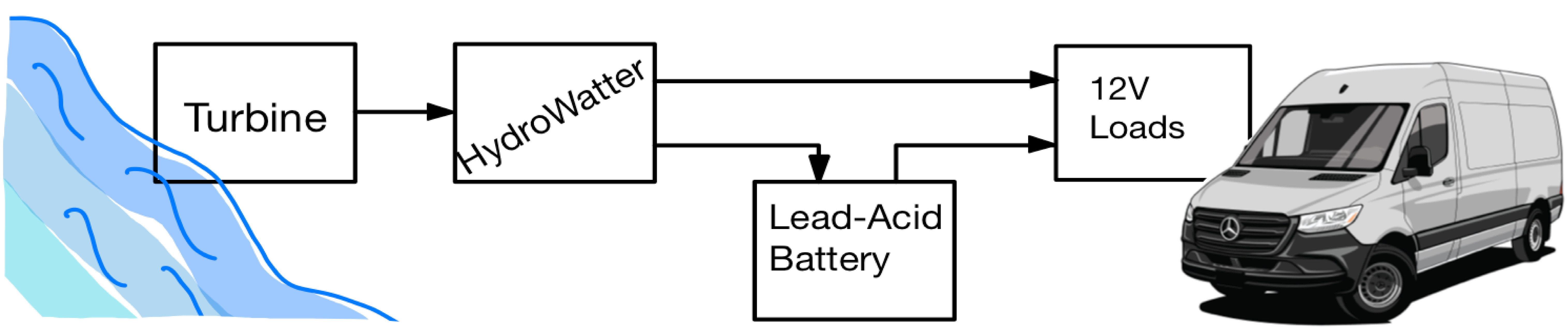
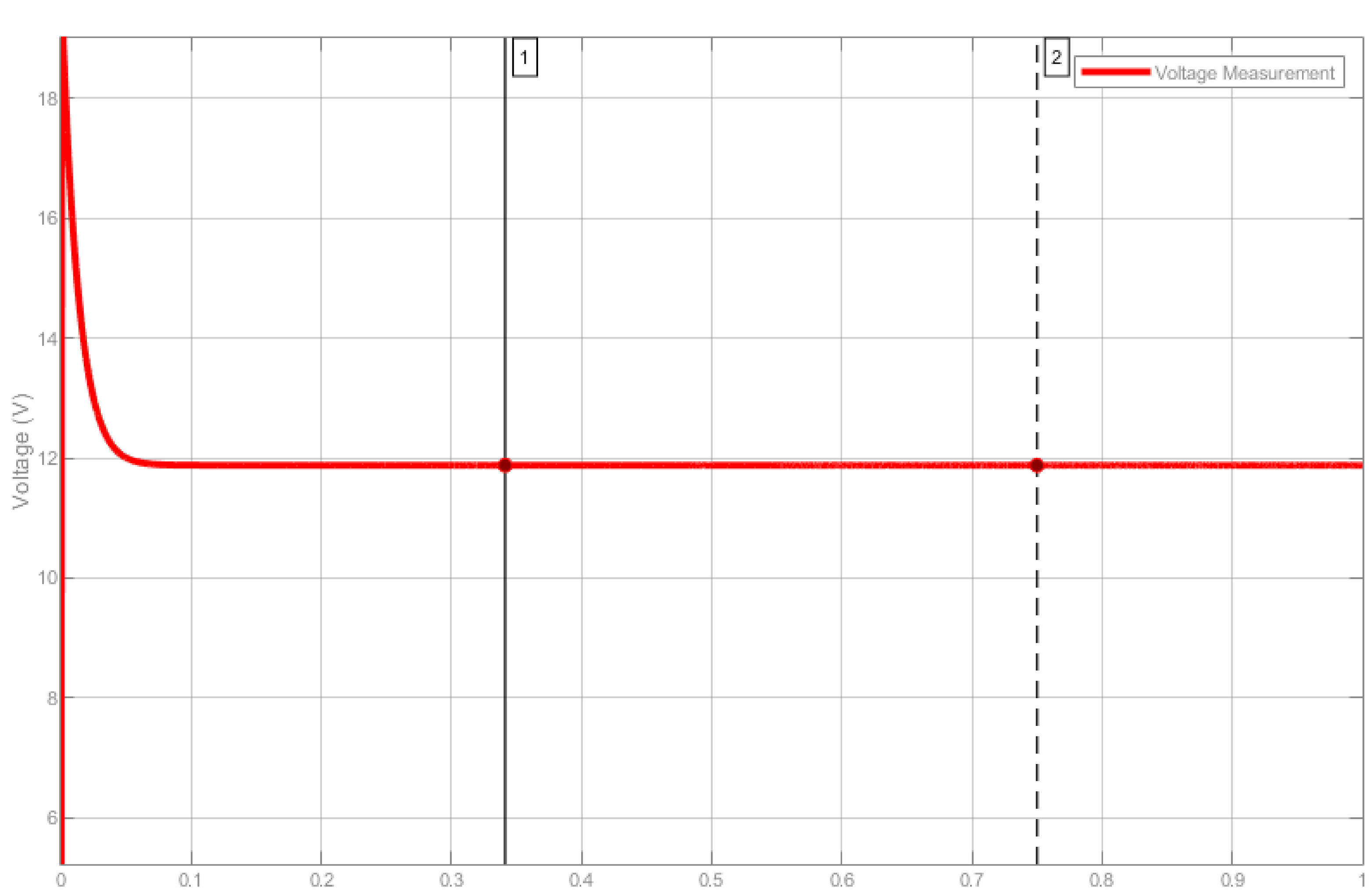
Abstract

Hydro-generators, known for their sustainable, reliable energy production, can be optimized through advanced control and conversion methods. This capstone project integrates a DC-DC converter with pulse-width modulation (PWM) within a hydro-generator system, aimed at boosting energy conversion efficiency and aligned with battery charging requirements. This DC-DC buck converter takes variable hydro-generator voltage as an input and uses current control to meet the requirements of a lead acid 12V battery. PWM control is used to govern the input current to the storage system, ensuring smooth charging of the battery as well as minimizing harmonic distortions in the voltage and current waveforms. By adopting this technology, hydro-generators can significantly bolster their contribution to the efficiency and stability of renewable energy systems. Not only is this project applicable to households in rural areas needing renewable energy, but it is also ready to scale up for use with complex smart grid power conversions in the future.



Above: an abstract block diagram of our project implementation, the basic components of our project consist of a turbine or wheel, DC generator, HydroWatter- which is a DC-DC buck converter controlled by a PWM controller, and a 12V lead acid battery. The arrows indicate the direction of power transfer, the generator will output a variable voltage from 0-24V into HydroWatter, which then converts the voltage to charge the lead acid battery as well as potentially powering any loads connected in parallel with HydroWatter.



Figue 1: Simulated output voltage with 24V input at 50% duty cycle

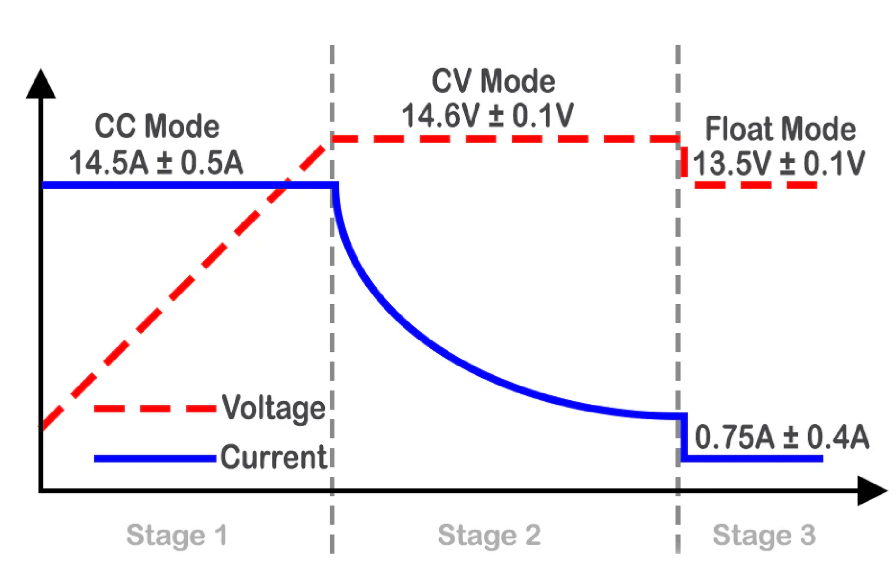


Figure 2: CC/CV charge mode diagram

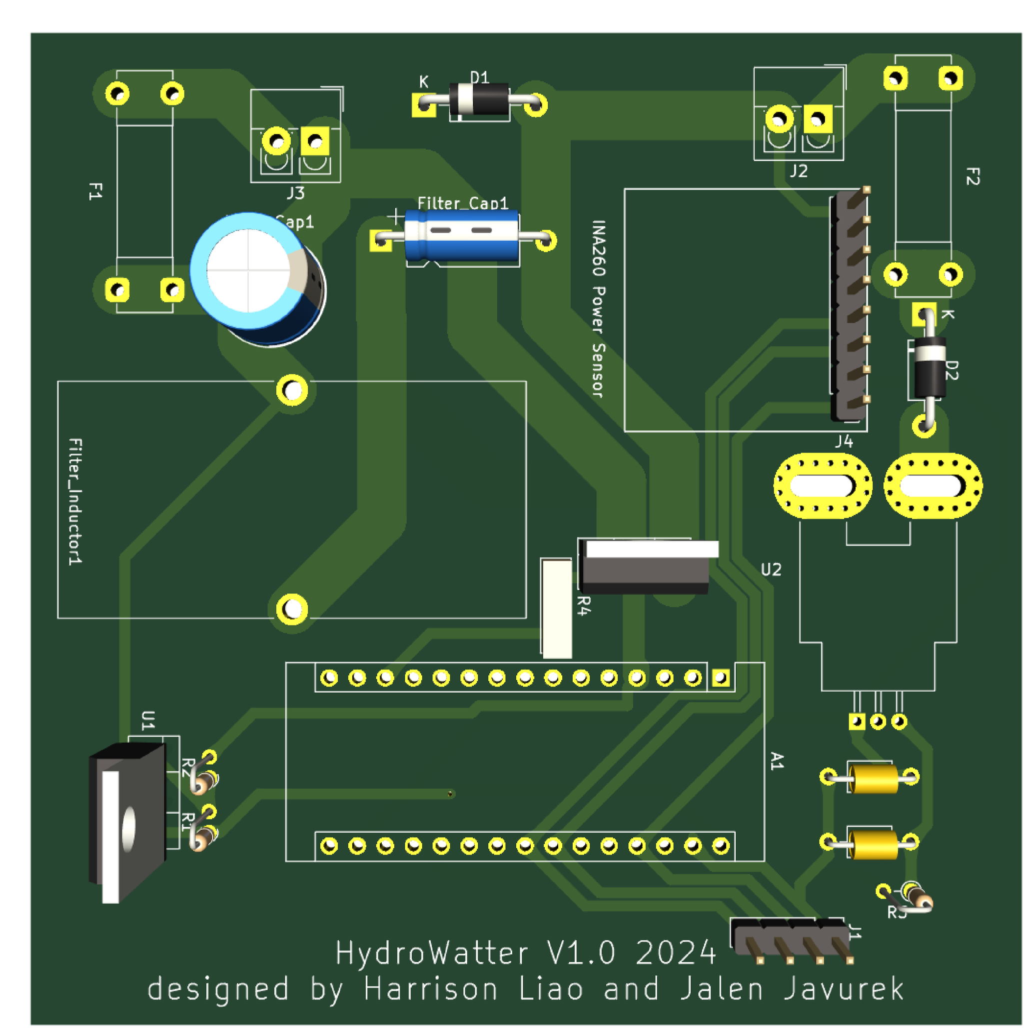


Figure 3: Render of our PCB layout

Major Design Components

DC/DC Buck Converter

- RLC Filtering
- Voltage Scaling with PWM Duty Cycle
- MOSFET/Diode selection
- Sensor Selection & Implementation

Charge Controller

- Arduino Nano Programming
- PWM output with Varying Duty Cycle
- State of Charge Algorithm
- Charge Characteristic Analysis

Circuit Board & Housing

- EMI minimization
- Trace Size and Routing
- Heat Dissipation
- Life Cycle Analysis, Eco friendly materials

User Interaction

- OLED Display
- Button or User Input
- Battery level & Power Flow Indication

Research Results

Shown in figure one above, we have simulated our buck converter, taking a 24V input and bucking down to 12V. Our simulation shows proper filtering for our switch since there are minimal ripples present. The transient response seems reasonable at 50ms to reach steady state.

Our Buck converter follows the CC/CV charging method as shown in figure 2. Constant current mode for the first stage of charging and constant voltage mode once the battery voltage reaches the desired level. We have also integrated a float mode to maintain the battery after charging is complete. These modes will be automatically switched as the charge state of the battery changes.

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