



BIDIRECTIONAL CONVERSION FOR SUPERCAPACITOR USE IN ELECTRIC VEHICLES

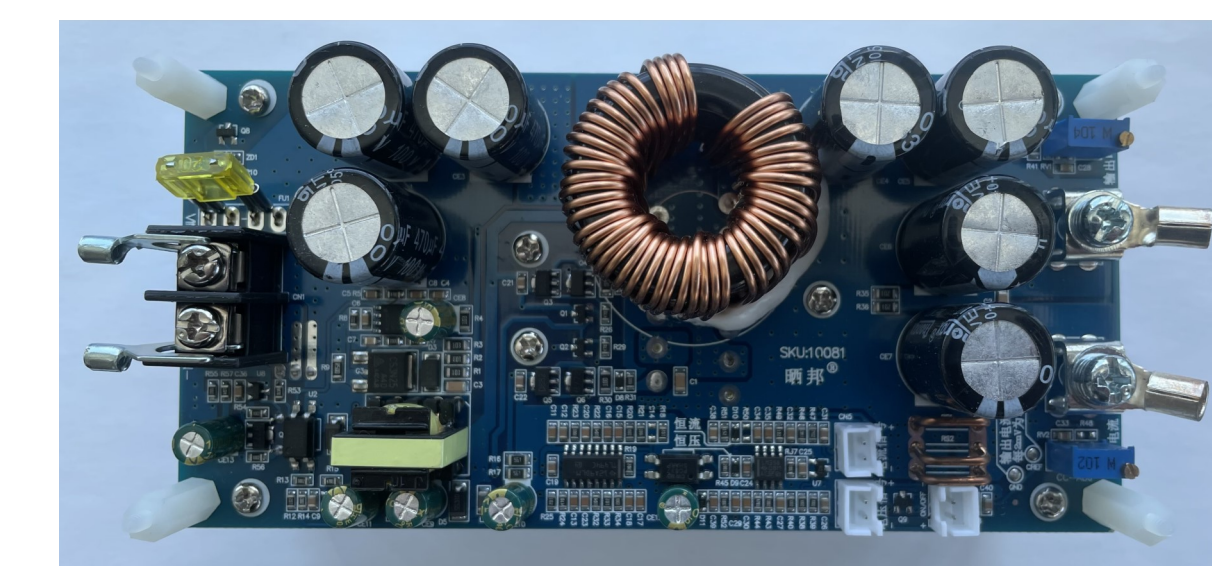
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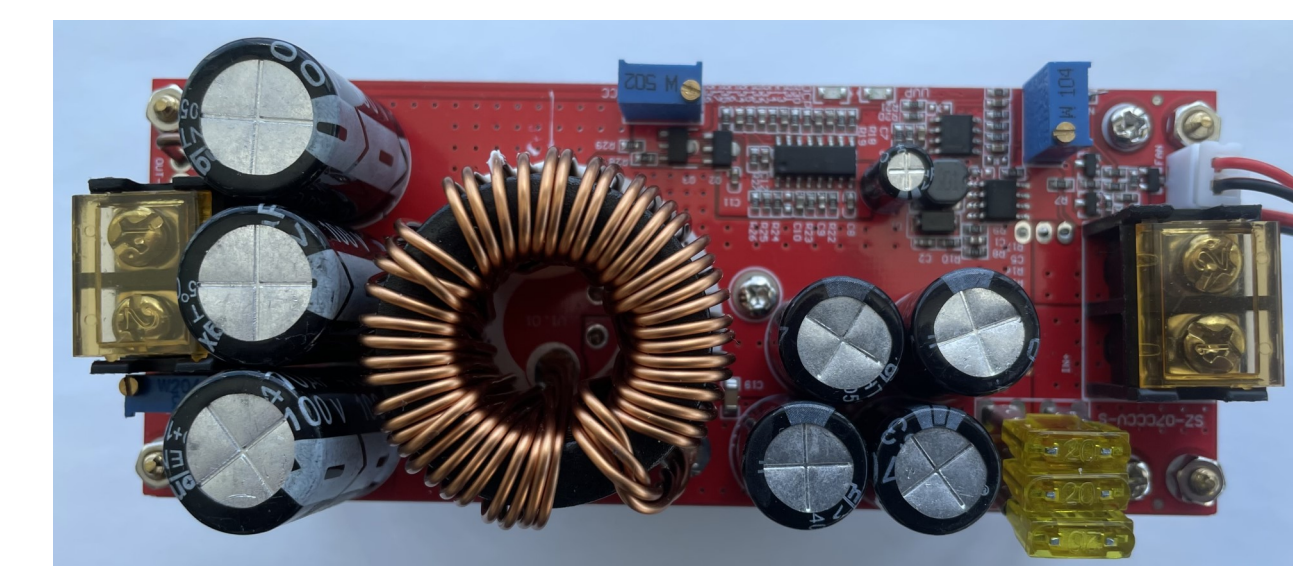
GOALS

- ◆ Gain insight into effects of DC to DC (DCDC) conversion on supercapacitor output
- ◆ Investigate benefits and drawbacks of one-way, variable DCDC Converters available on the market
- ◆ Develop a system that utilizes both up and down conversion dependent on system conditions
- ◆ Use with supercapacitors to determine efficacy in overcoming their characteristic low maximum voltages
- ◆ Design overall system to allow for switching between charging and discharging supercapacitor bank
- ◆ Eventually integrate into an electric bike

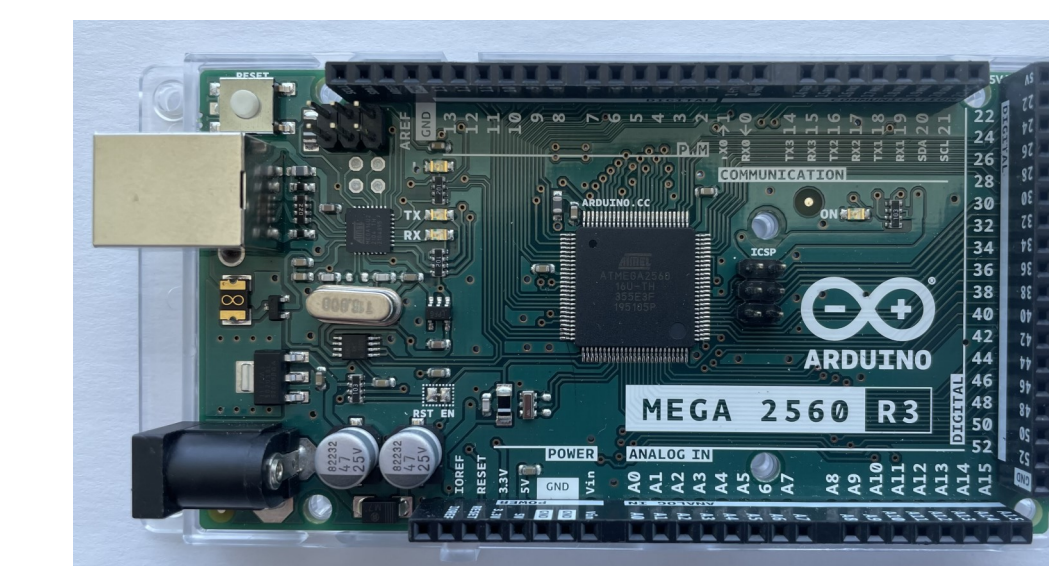
EQUIPMENT



800W Step-Down (Buck)
DCDC Converter



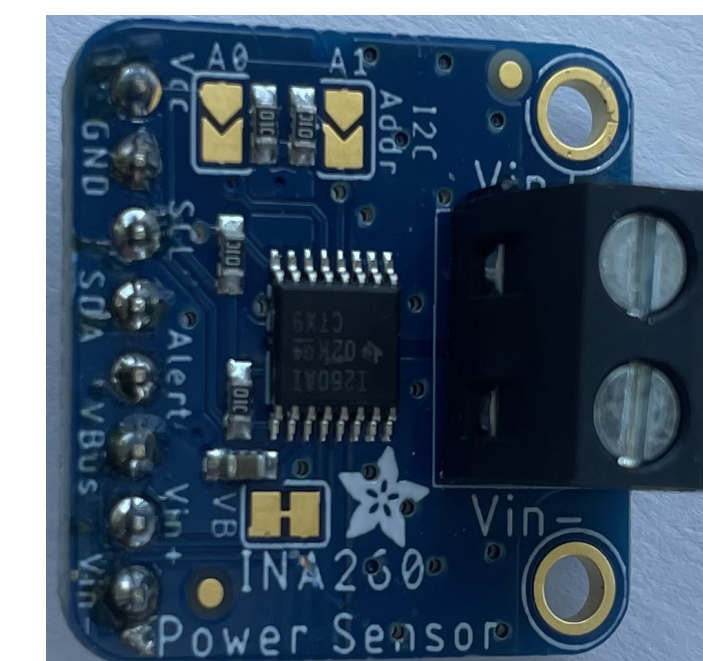
1500W Step-Up (Boost) DCDC
Converter



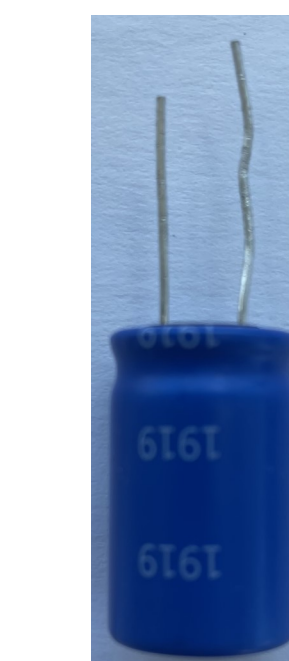
Arduino Mega 2560
Microcontroller



Crydom 30A Solid
State Switches



Adafruit INA260 Power
Sensor Breakouts



Various
Supercapacitors



Monolithic Power180W Smart DC
Motor

SYSTEM FEATURES

Main Features

- ◆ Adafruit INA260—Power, Voltage, and Current Sensing
 - Take measurements at key points of system
- ◆ Arduino Mega 2560
 - System command and control
- ◆ Solid State Switches
 - Toggle on or off the input, output and mode based off command signals from Arduino
- ◆ Boost Converter
 - Enables ability to overcome supercapacitor bank lower voltage requirements and drive higher voltage load
- ◆ Buck Converter
 - Enable supercapacitor charging from higher voltage source
- ◆ DC Motor
 - Replicate load type of target application at smaller scale

Additional Features

- ◆ Python Program
 - Take data sent over serial from Arduino and direct into excel for easy manipulation later
 - Saves time and increase amount of data collected

ADVANTAGES AND CHALLENGES

Advantages

- ◆ Higher power output with same energy expenditure
- ◆ Constant output supplied, overcoming nonlinear discharge behavior of standalone supercapacitors
- ◆ Charge supercapacitors at alternative voltages and adjustable input currents
- ◆ Enable expanded vehicle efficiency techniques like storing and reusing energy from braking

Challenges

- ◆ Delayed Voltage Matching
 - Boost output takes time to match desired output voltage
- ◆ Booster Input Voltage
 - Low Voltage Protection cuts off output below a certain level (8-10V) preventing full discharge
- ◆ Charge Losses
 - Slower charge speed at higher input power

CONCLUSION

1. DCDC Conversion is a necessary operation for use of supercapacitors in EVs or other power applications
2. When used in tandem, bidirectional conversion systems with supercapacitors open up avenues for improved power efficiency and battery life

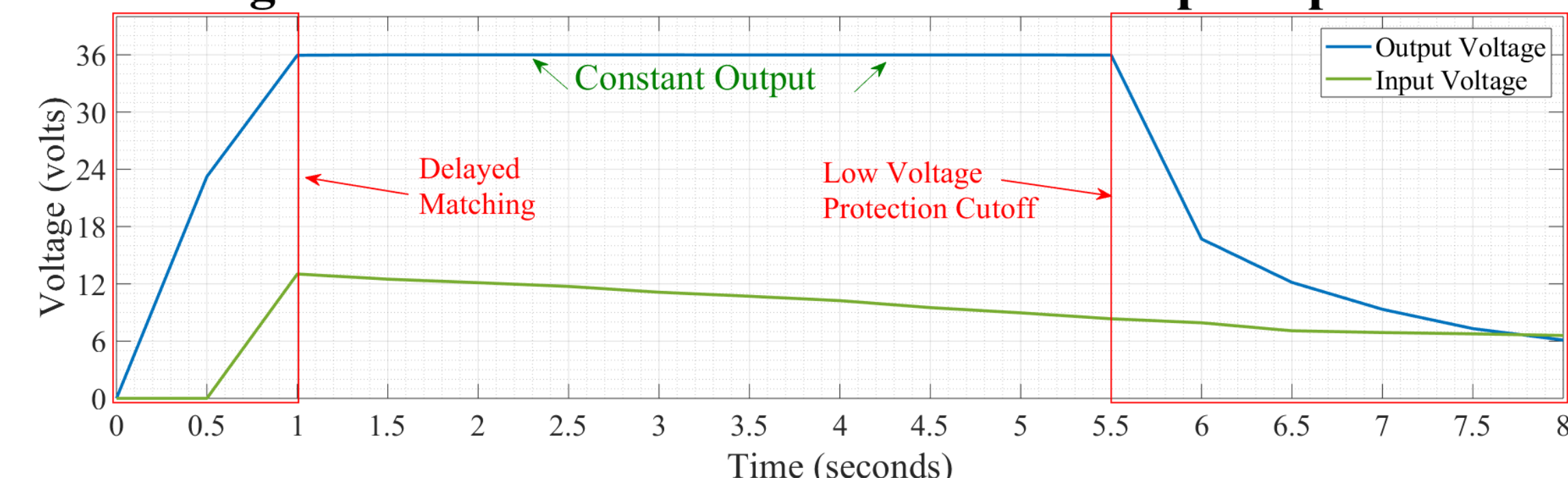
SciCom
Let's Talk Science



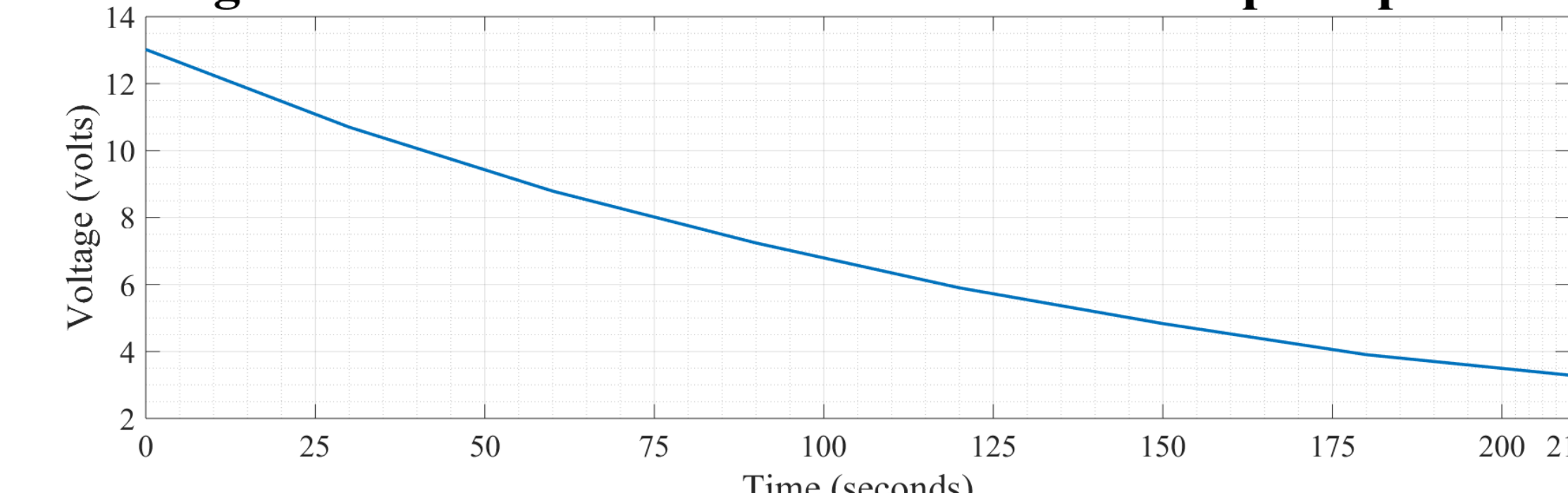
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DATA: STANDALONE VS CONVERTED SUPERCAPACITOR OUTPUT

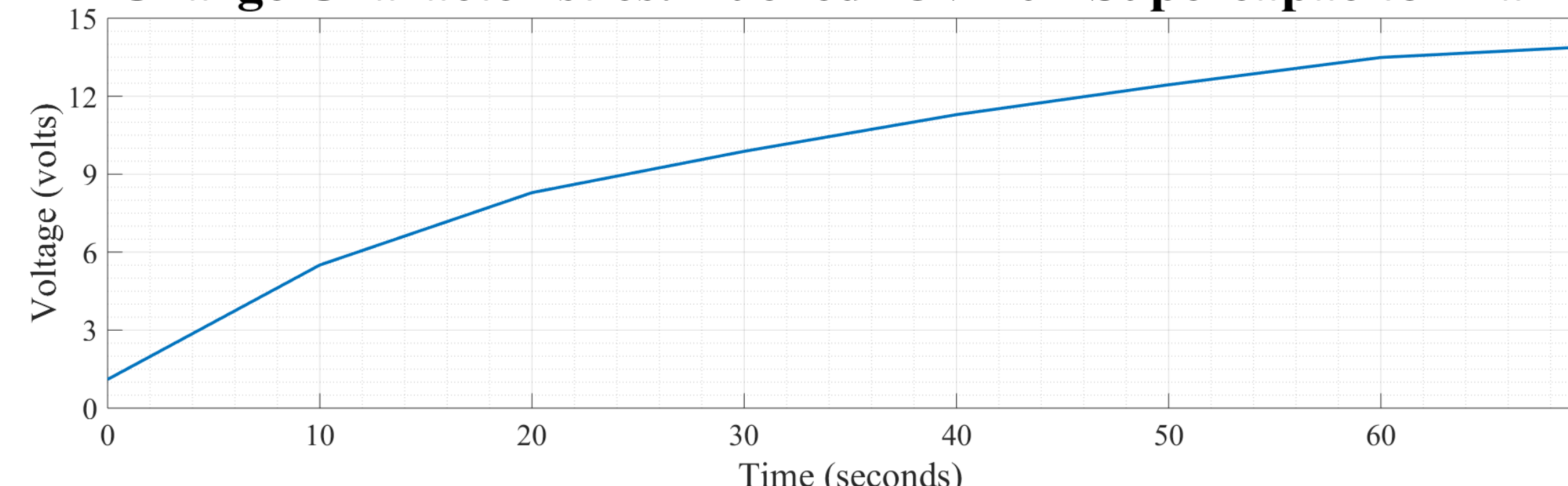
Discharge Characteristics: Boosted 15V 10F Supercapacitor Bank



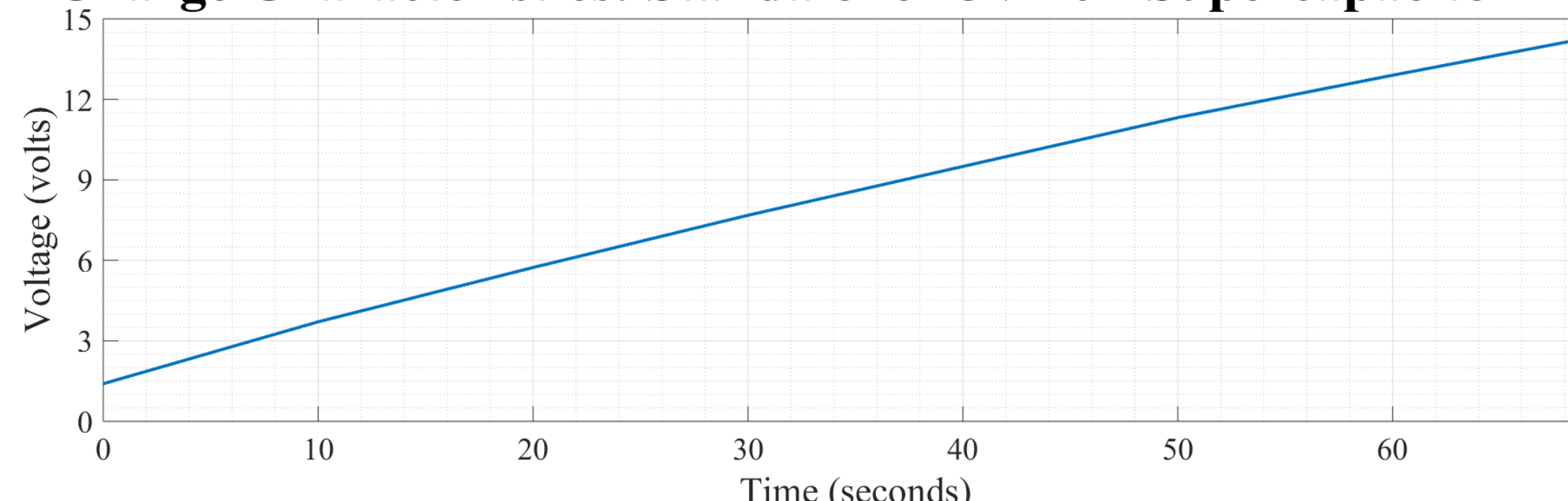
Discharge Characteristics: Standalone 15V 10F Supercapacitor Bank



Charge Characteristics: Bucked 15V 10F Supercapacitor Bank



Charge Characteristics: Standalone 15V 10F Supercapacitor Bank



SYSTEM FLOW

