Backwoods Power & Water

Solar Powered Water Filtration System

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Background

- Senior Design Course (2 semester sequence)
- Concept – Fabrication – Testing & Validation
- Faculty Supervised
- Department Funded

Water Filtration System

- Project Supervisor
  — Dr. Timothy Haskew
- Team Members
  — Erica Boyle
  — Travis Cowart
  — Rachael Fleischman
  — Ryan Graves
  — Steven Guy
  — Christa Hart
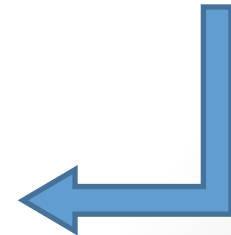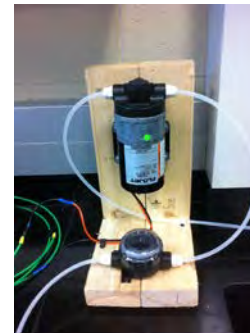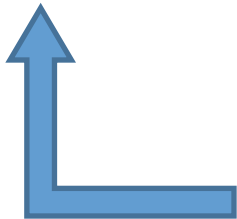
Goals/Specifications

Based on Ideal Weather Conditions

- 2.6 gal of Drinking Water Per Hour

- 4.2 gal of Clean Utility Water Per Hour

- 9.8 Hour Charge Time
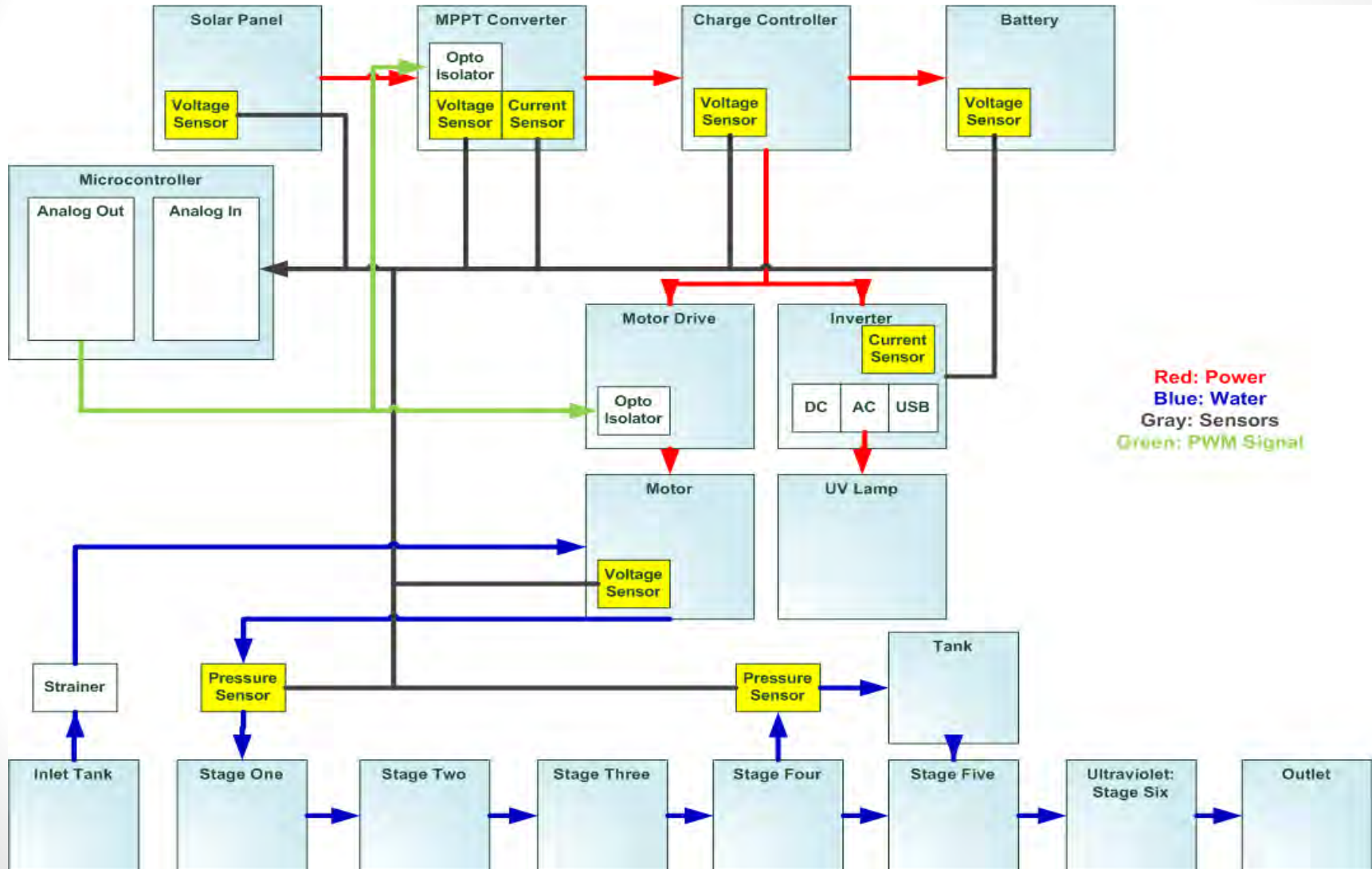
- 3.4 Hour Run Time

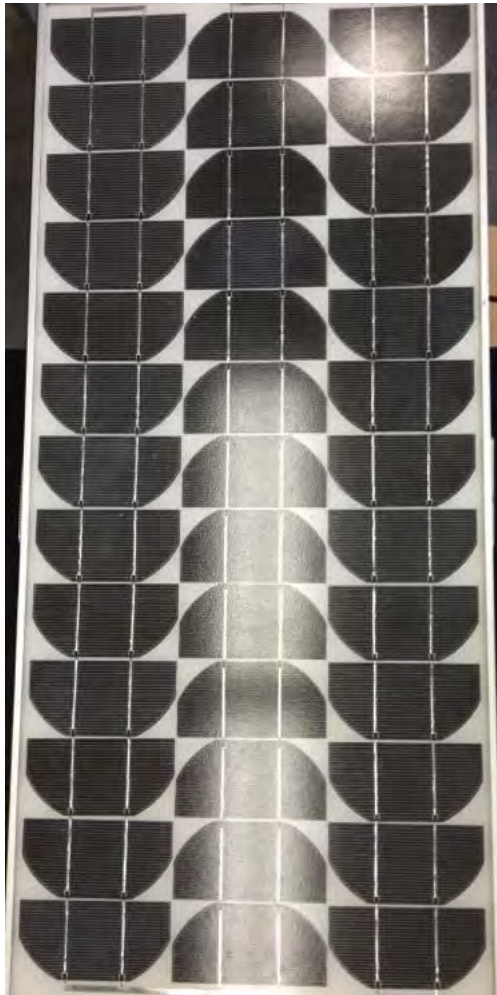- Total Time 13.2 Hours

System Overview

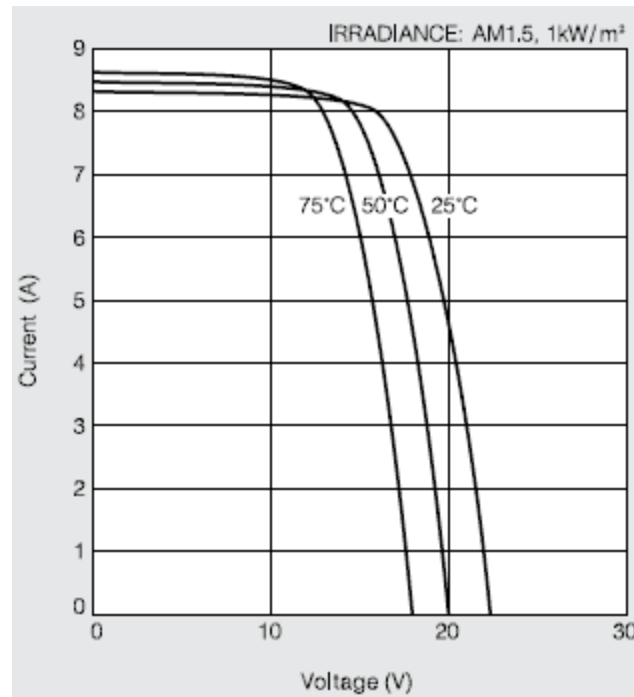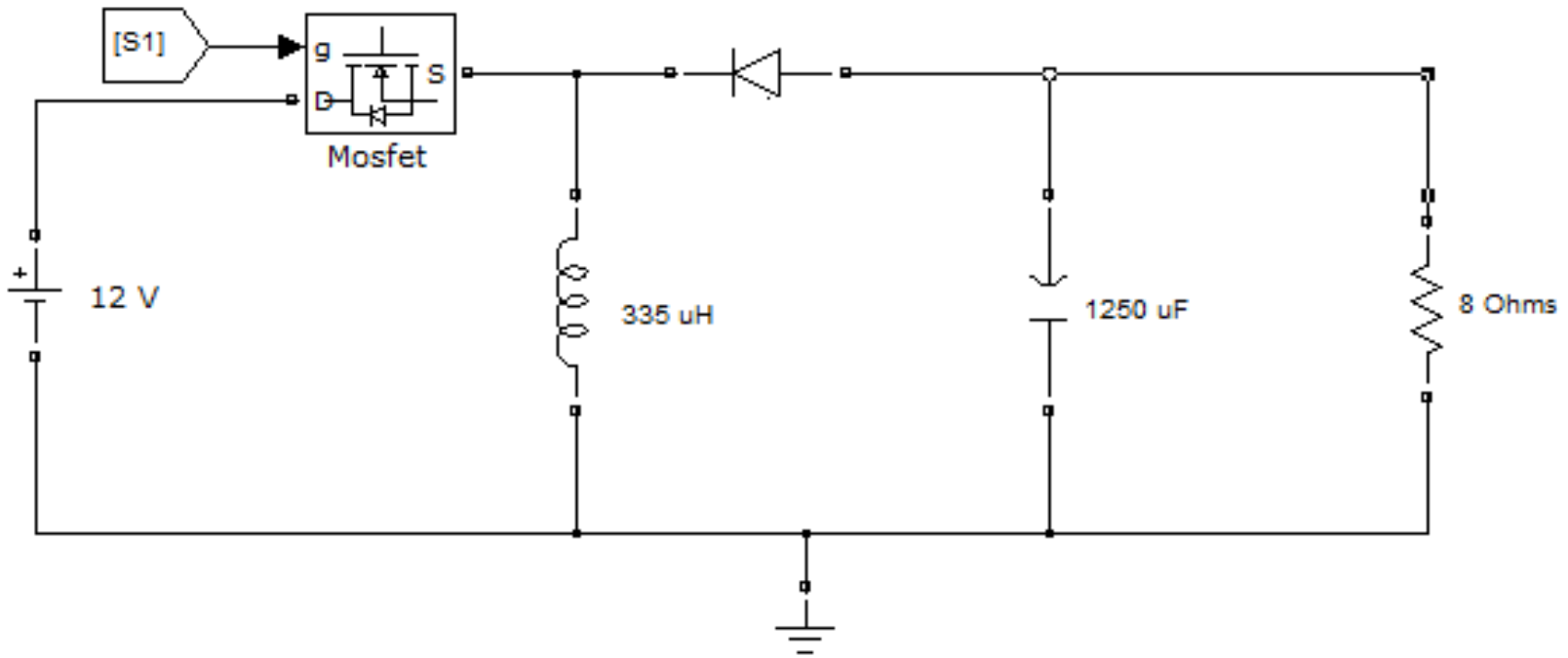[2]

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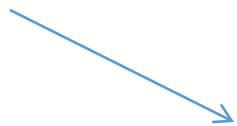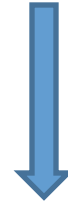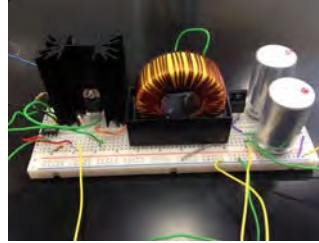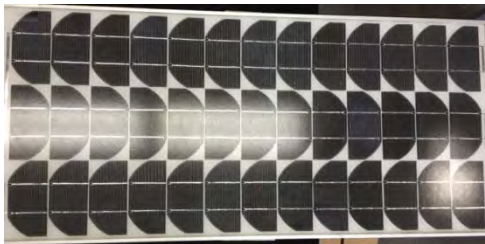
System Overview

Solar Panel

- SunWize OEM-40 Specifications
  - Maximum Power Output: 40 W
  - Open-Circuit Voltage: 21 V
  - Short-Circuit Current: 2.68 A
  - Voltage at Maximum Power: 16.7 V
  - Current at Maximum Power: 2.4 A

[1]

DC-DC Converter

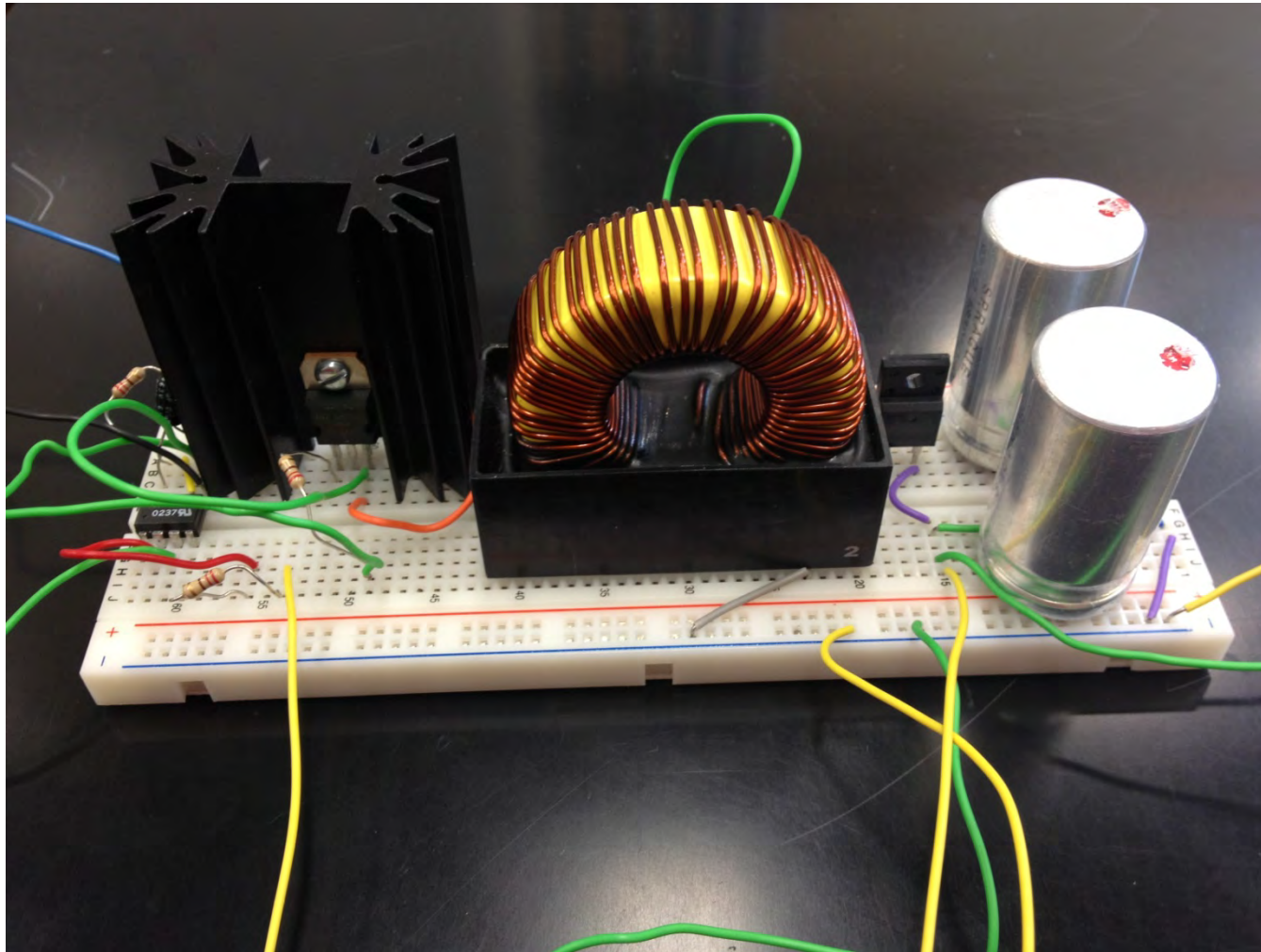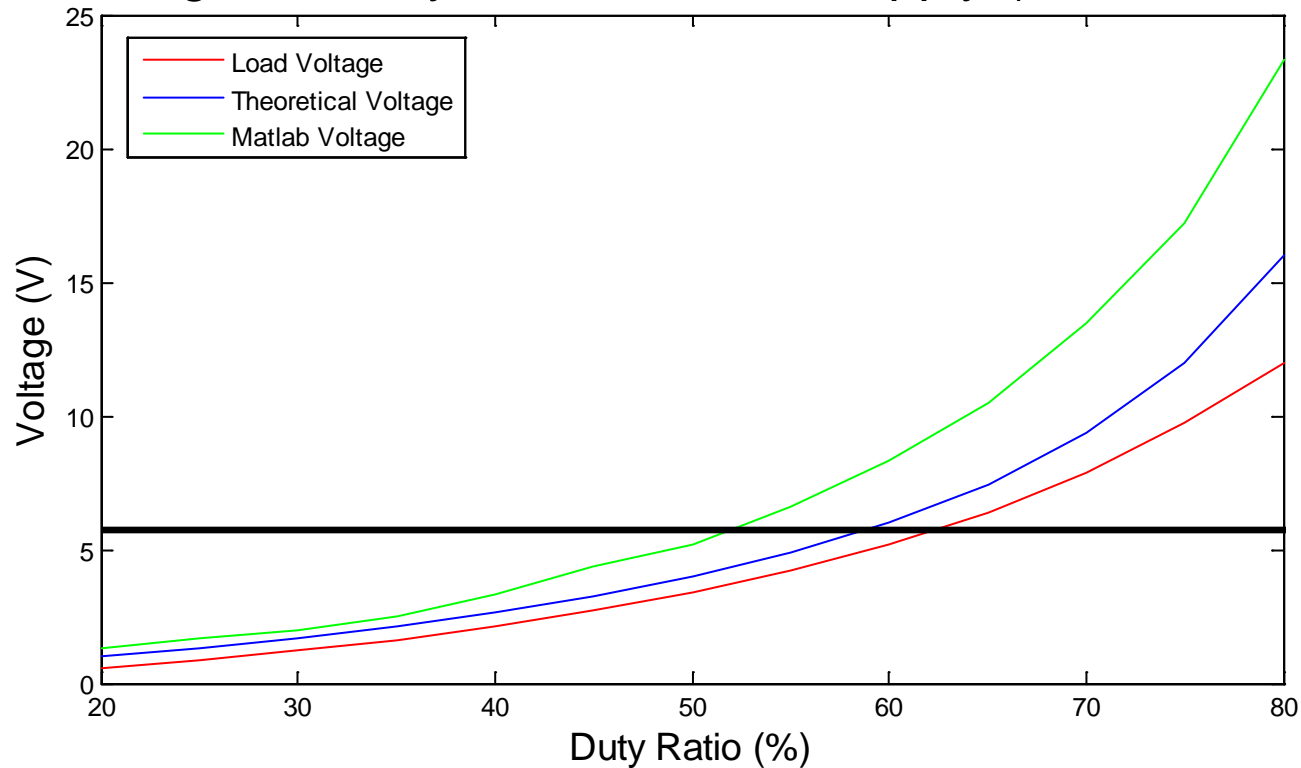# DC-DC Converter-Breadboard

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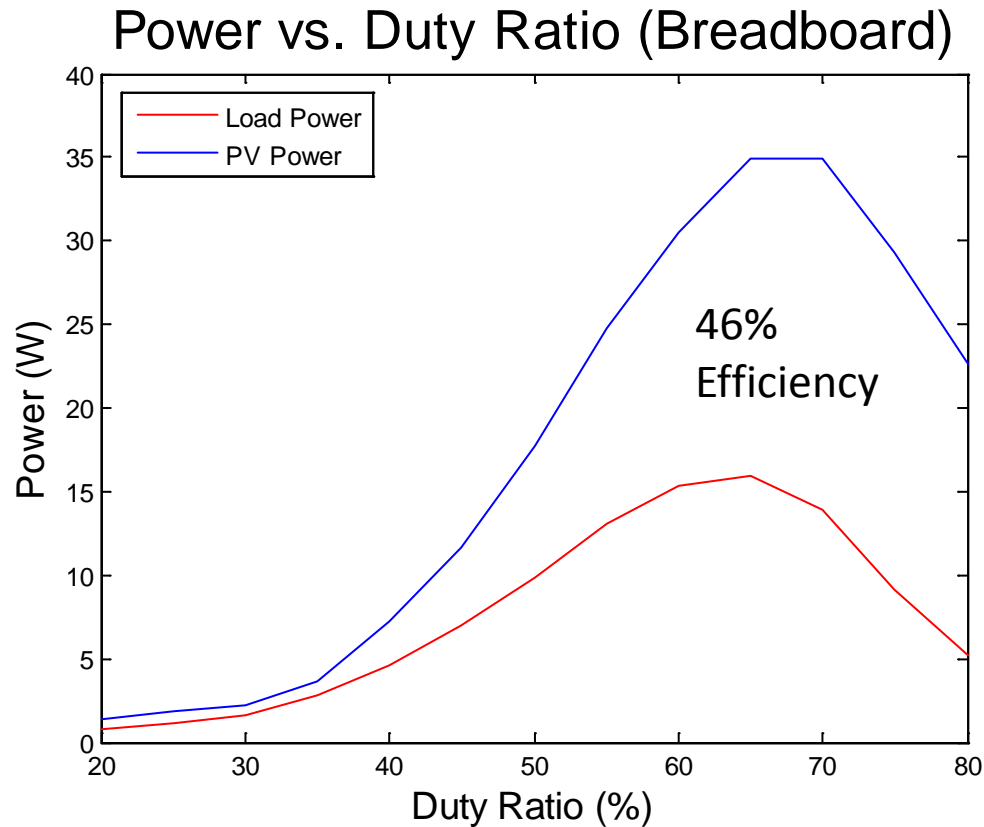# Converter Voltage vs. Expectations

Voltage vs. Duty Ratio with 6 V Supply (Breadboard)

Solar Simulator / Load Power on Breadboard

Power vs. Duty Ratio (Breadboard)

Legend: Load Power (red), PV Power (blue)

46% Efficiency

X-axis: Duty Ratio (%)
Y-axis: Power (W)

Charge Controller

- Steca Solarix

- 8 A

- Two LEDs
  - Controller Status
  - Battery SOC

Charge Controller

LED 1 (Info) for operating status and fault messages

LED 2 (Battery) for charge status, load shedding and early warning

Plug-in fuse:
8 A controller: 10 A
12 A controller: 15 A
20 A controller: 20 A
30 A controller: 30 A

Integrated temperature sensor

Connection terminals

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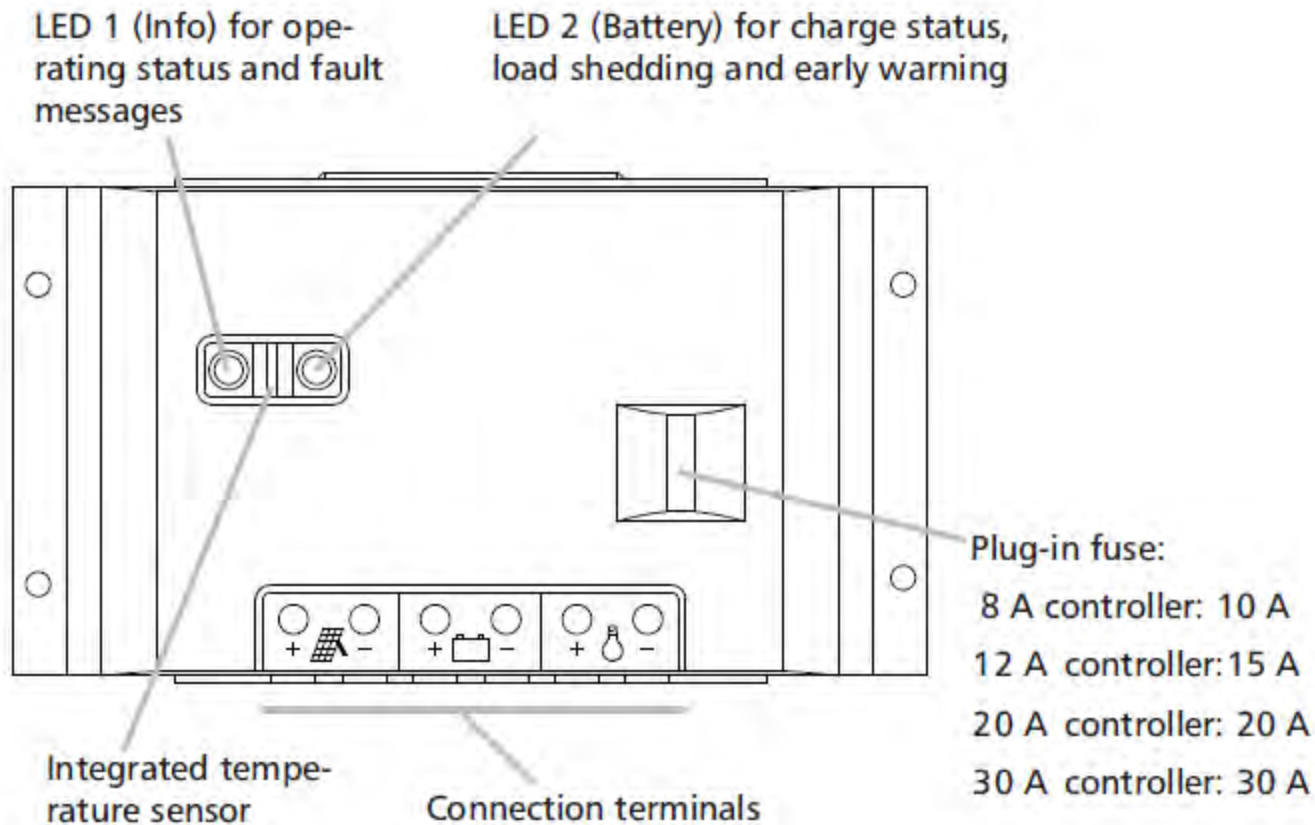
Battery

- Sunxtender

- Sealed Lead Acid

- 12 V

- 49 Ah

Charging Rates

Discharging Rates
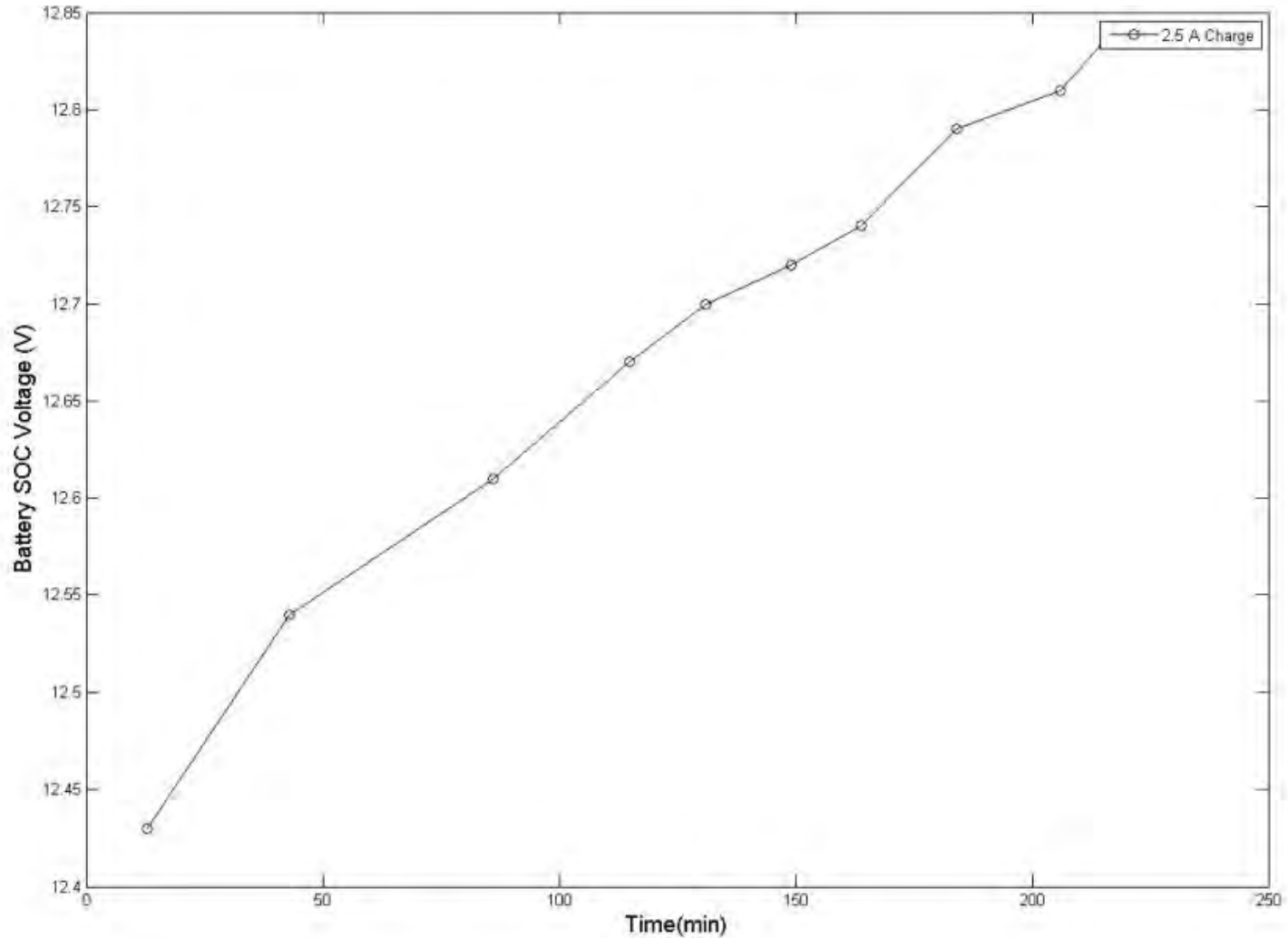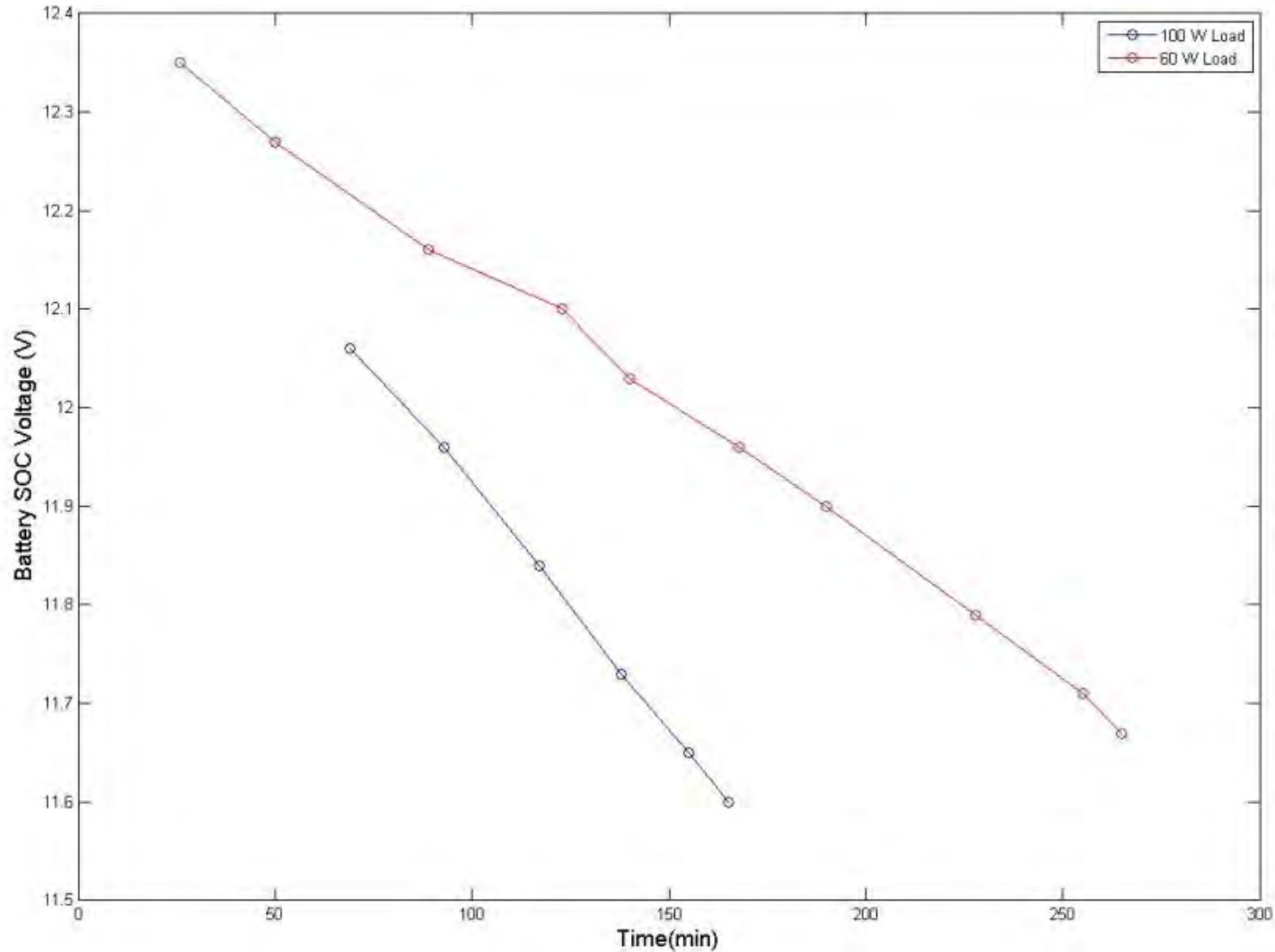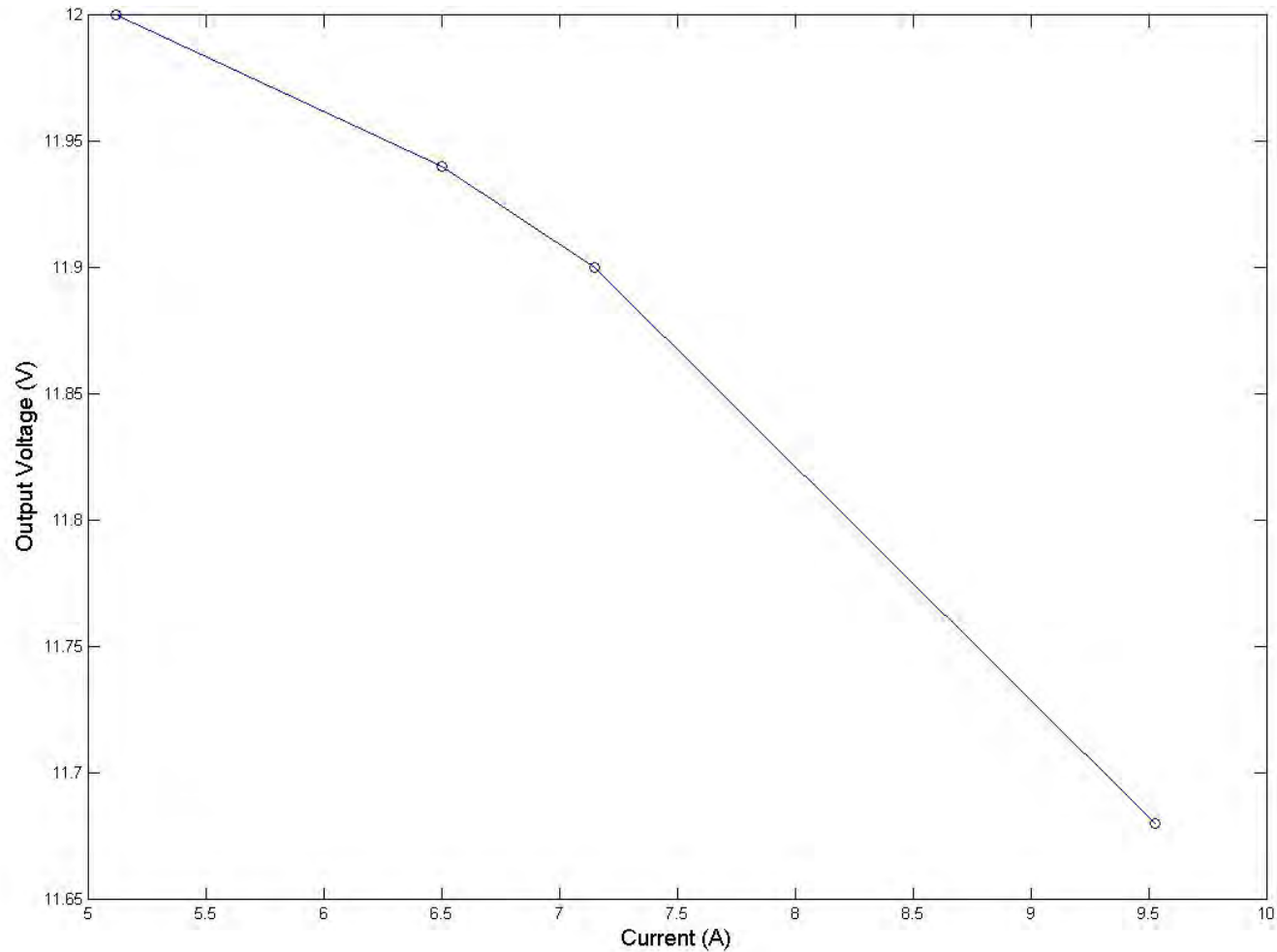
16
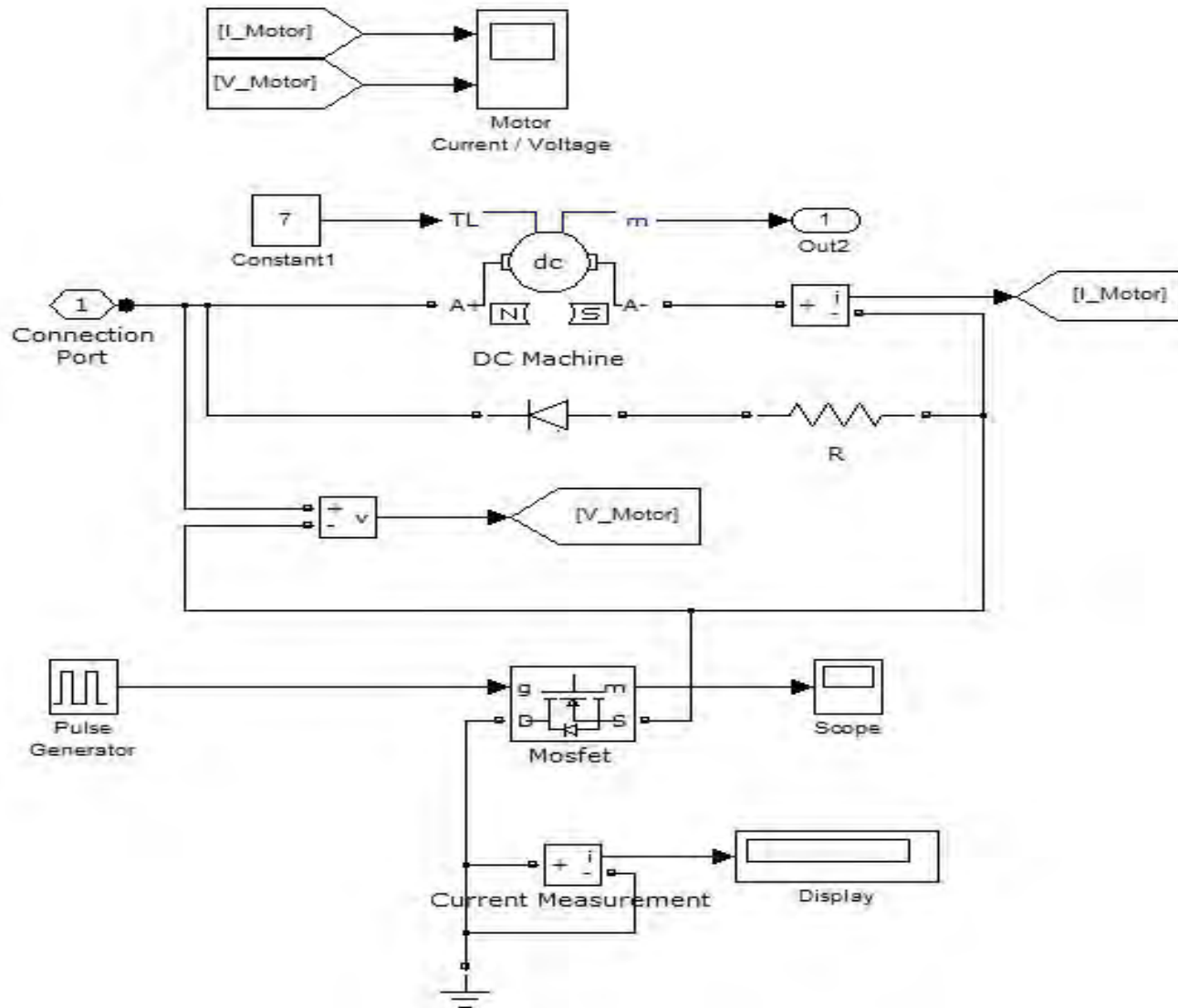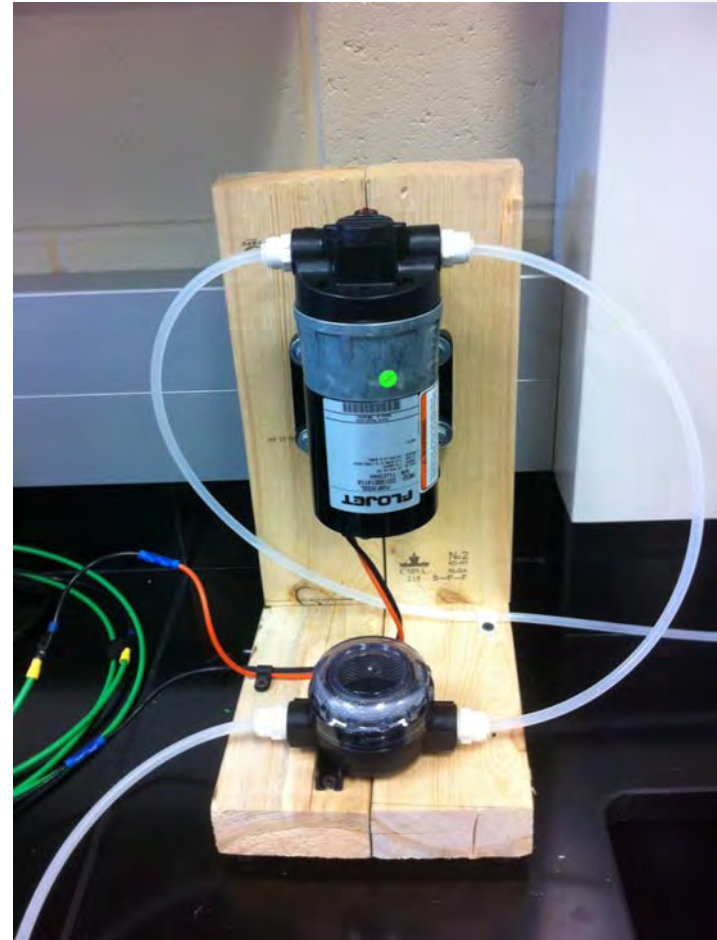
Output Voltage Under Various Loads

Motor Drive and Motor

Motor/Pump

- Flojet Duplex II Diaphragm Pump

- Tested Operation with DC Power Supply
  - 9 to 13 Volts

- Combined Testing with Filtration System

Motor Drive

- High Speed Optocoupler
  - Isolates Arduino

- Logic Level N-Channel MOSFET (IRL2703PBF)
  — 30 V, 24 A Max Rating

- Ultrafast Recovery Diode
  — 300 V, 10 A Rating
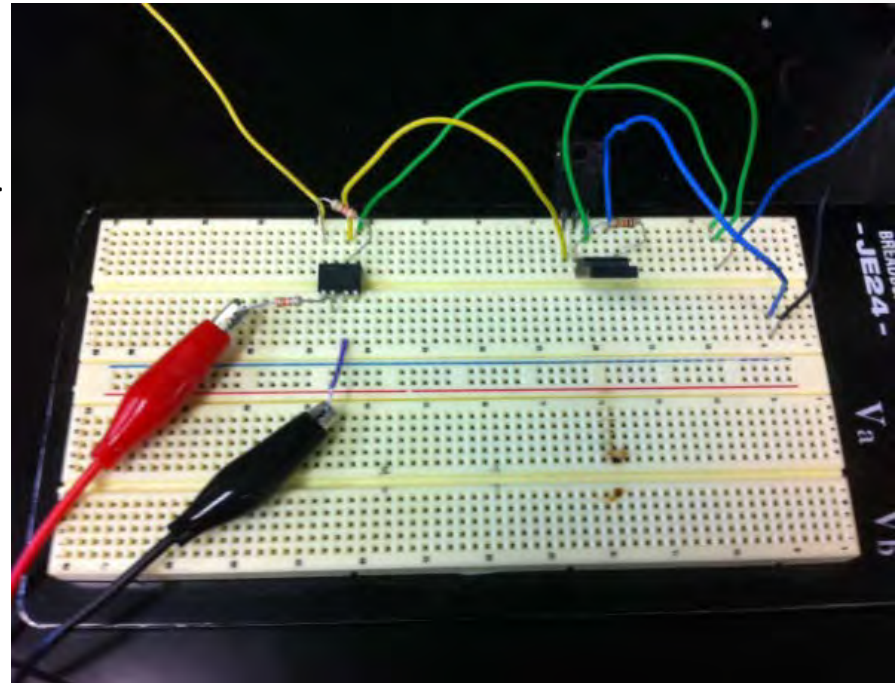
Water Output vs. Power Consumption

- At What Voltage Should the Pump Operate?
  - Does Using the Motor Drive to Regulate Voltage Help Us Produce More Water?

  - What is the Best Compromise for the Production of Clean Drinkable Water vs. Utility Water?

# Clean Drinkable and Utility Water

- Testing Done for Water vs. Power Consumption
  - Used DC Power Supply
  - Tested from 9 to 13 Volts
    - In 0.25 V Increments

- Data Converted to Find Watt-Hours Consumed per Gallon

Voltage (V)	13	12.75	12.5	12.25	12	11.75	11.5	11.25	11	10.75	10.5	10.25	10	9.75	9.5	9.25	9
Clean Water Watt-Hours per Gallon (Wh/G)	27.99	26.35	25.58		25.77	25.07	24.45	24.08	23.44	22.78	22.95	21.83	22.35	21.38	20.98	20.21	19.65
Utility Water Watt-Hours per Gallon (Wh/G)	18.94	18.34	17.79	17.41	17.04	16.59	16.35	15.75	15.47	15.06	14.66	14.19	13.7	13.28	12.69	12.41	11.96

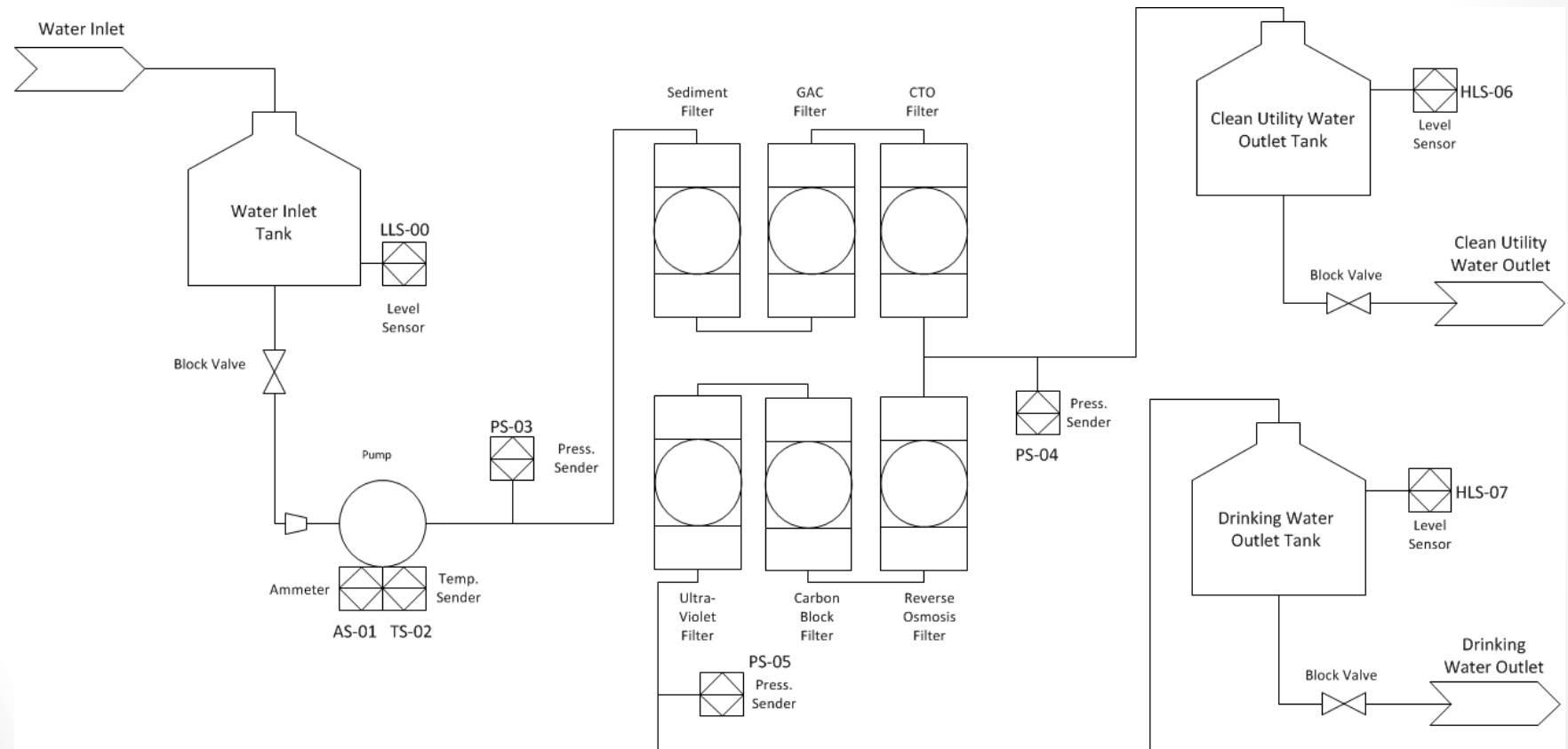# Drinkable Water Power Consumption and Flow Rate vs. Voltage
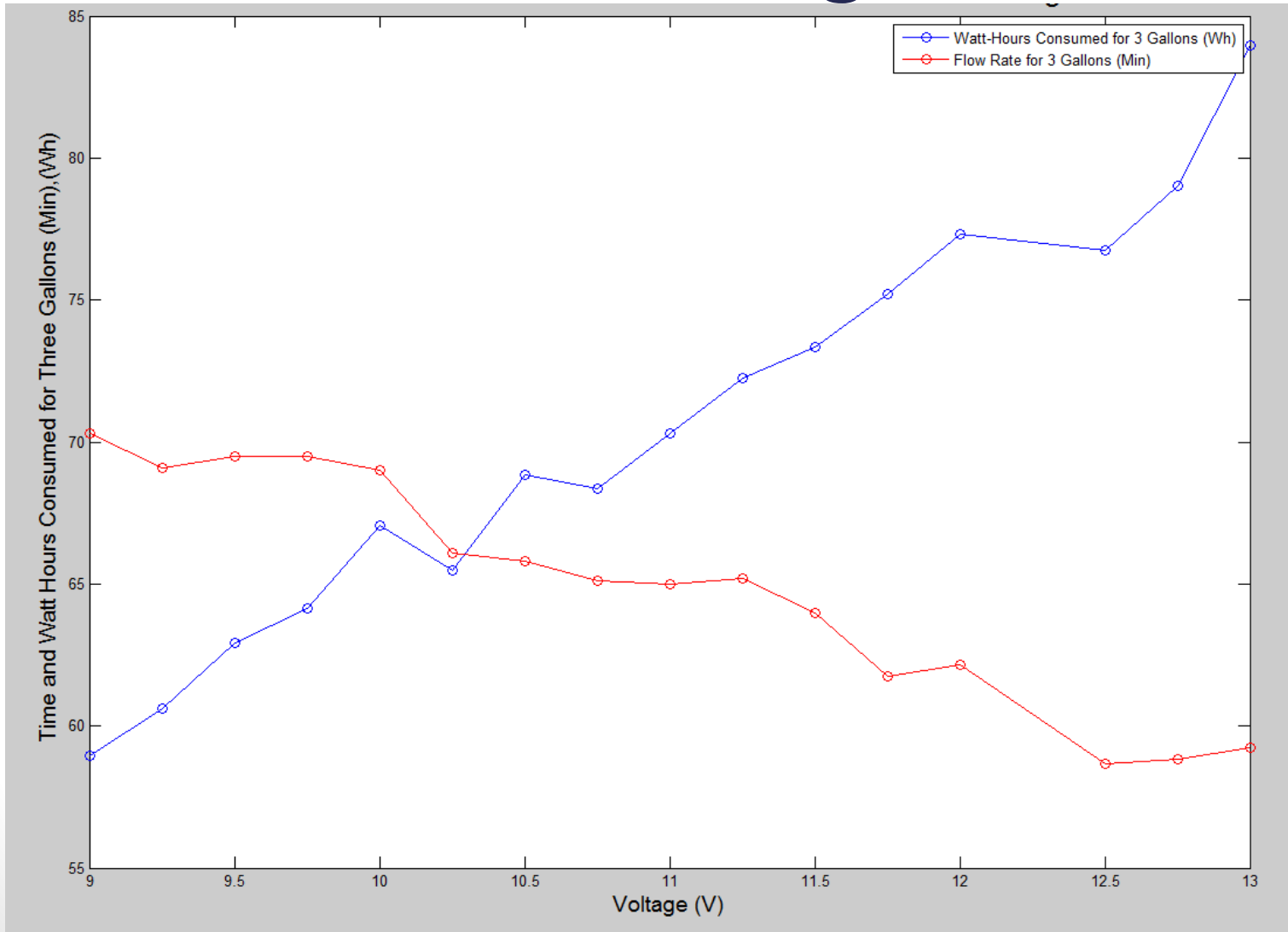
Utility Water Power Consumption and Flow Rate vs. Voltage
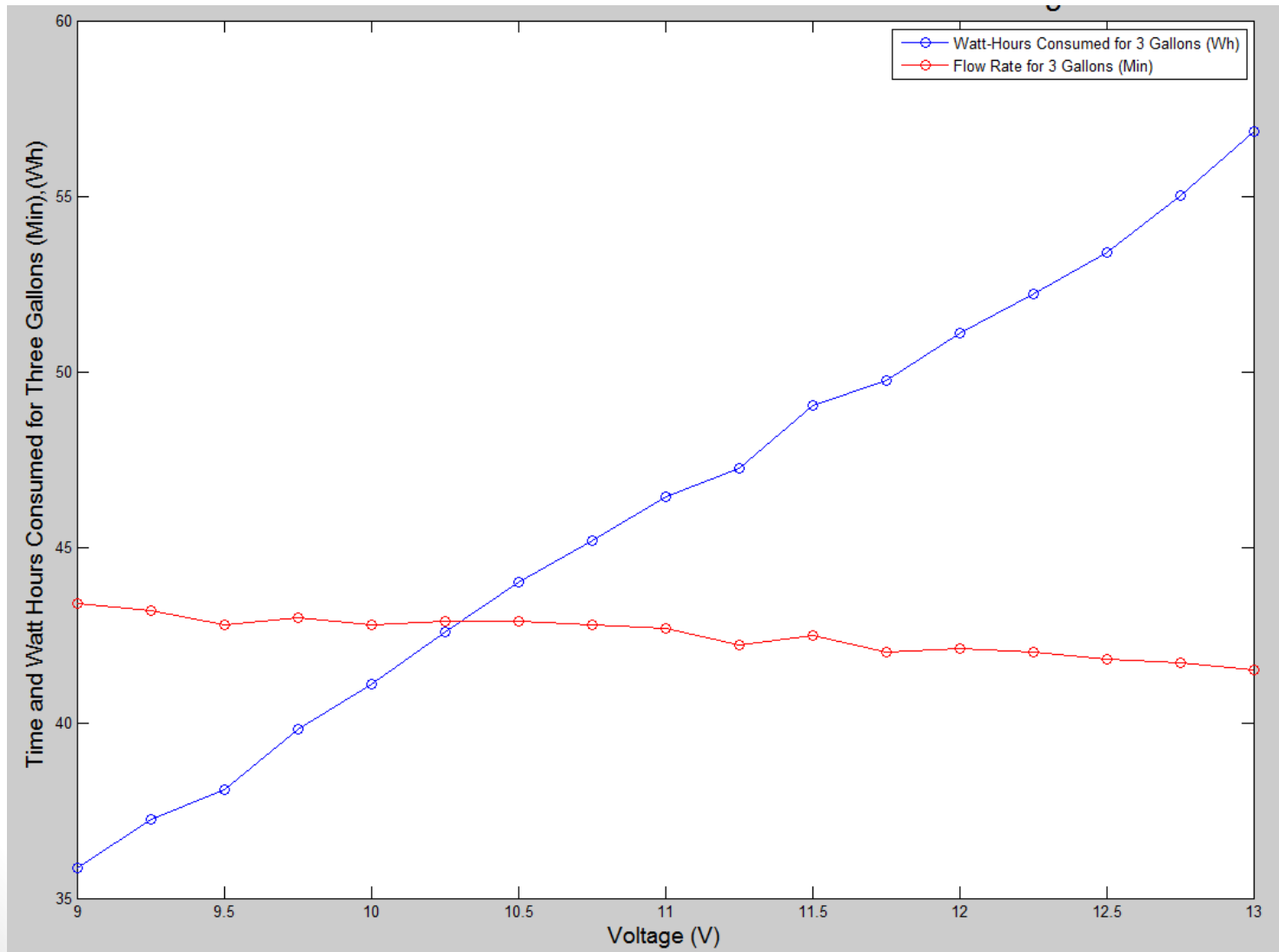
P&ID

Piping and Instrumentation Diagram

Filtration System

- 5 Stages Using Various Filters Including (1) Sediment Filter, (3) Carbon Filters and (1) Reverse Osmosis Membrane
- Final (6th) Stage Uses UV Sterilization Lamp
  - Standard Voltage: 120 Volts, 60 Hz
- Max Flow Rate: 75 gpd
- Feed Water Pressure: 40-95 psi
- Flow Rates at 70 psi
  - Drinking Water: 3.2 gph
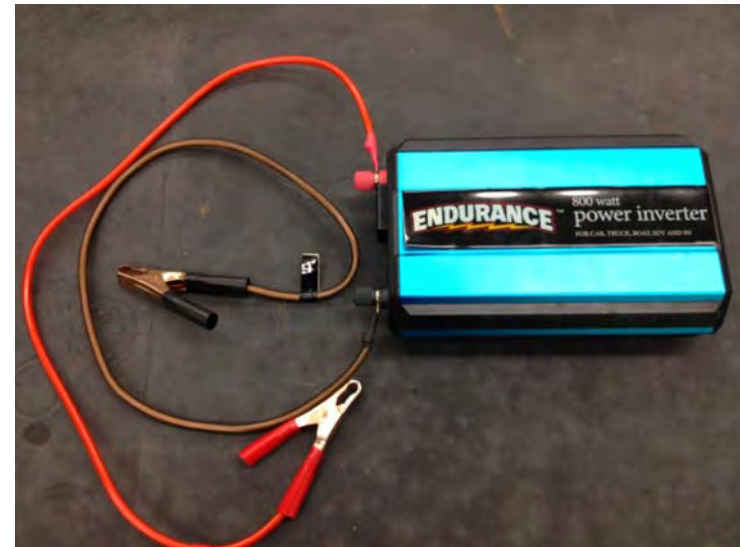 - Utility Water: 4.5 gph

Drinking Water vs. Utility Water
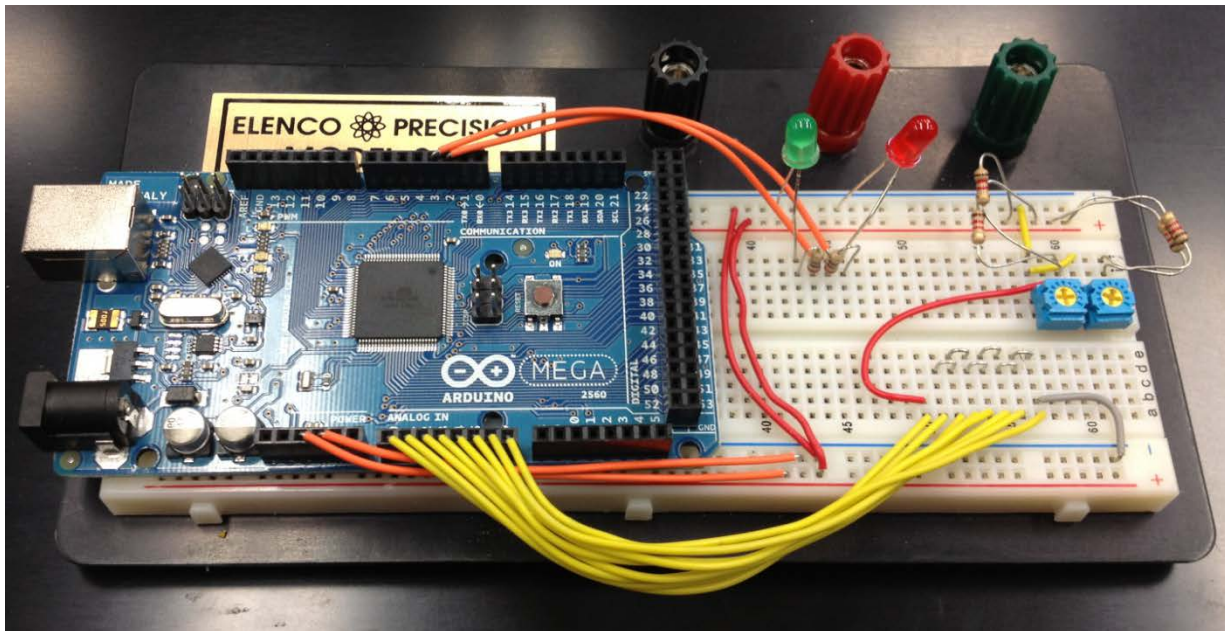
Inverter

- Specifications
  - Input: 10-16 VDC
  - Output: 120 VAC / 60 Hz
  - USB Port
  - Standard 12 V Outlet
  - Power Consumption with Lamp Connected: 18.2 W

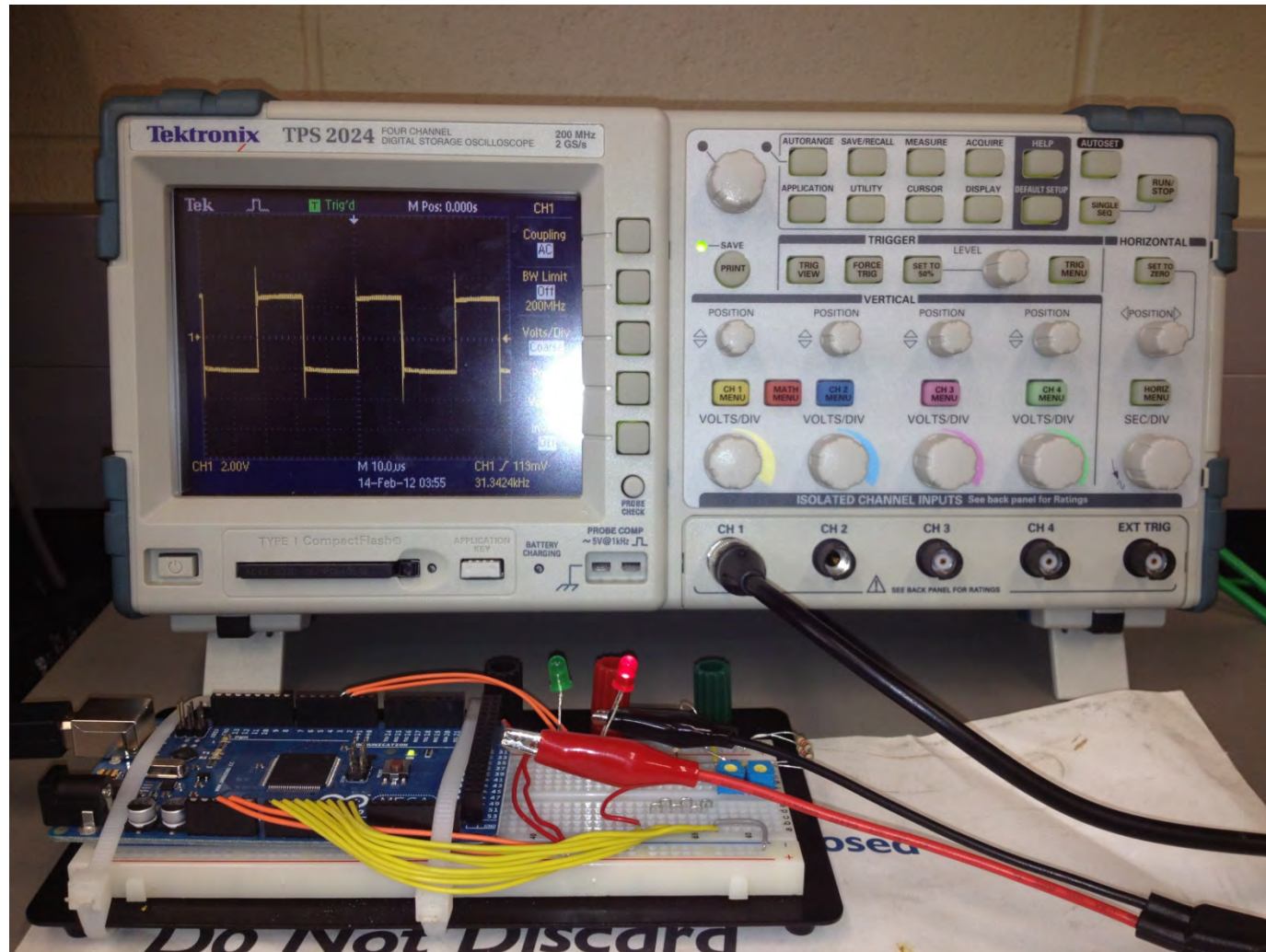# Controller

Arduino Mega 2560

- Appropriate I/O
  - Analog Inputs (10-Bit)
    - Pressure Sensors
    - Voltage Sensors
    - Current Sensors
  - Digital Outputs
    - LED Indicators
  - PWM Outputs (8-Bit)
    - Power Electronics
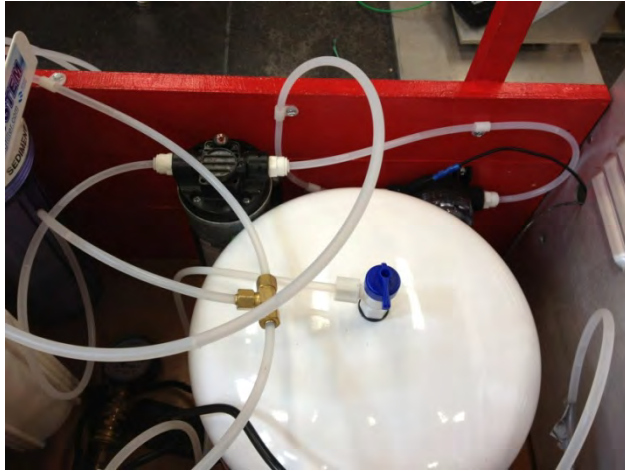
Controller

Arduino Mega 2560

Implementation

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Before

After

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Implementation

Motor, Pump, Strainer

Filtration – First Three Stages

Filtration – Final Three Stages

Implementation

Battery, Charge Controller, Electronics

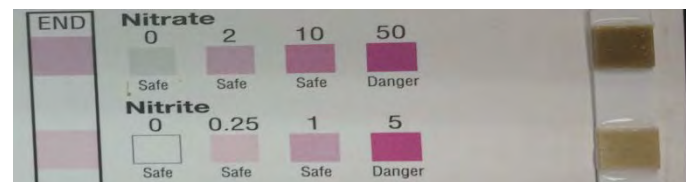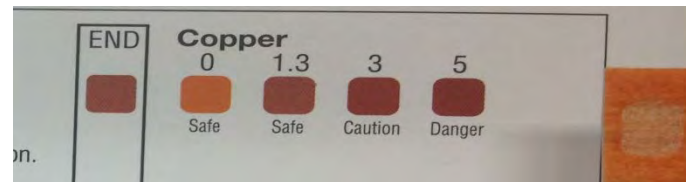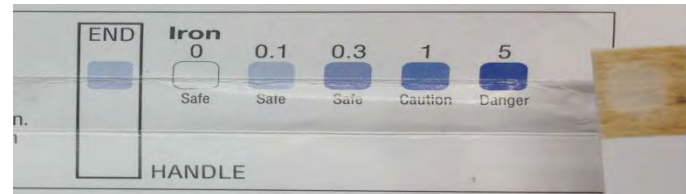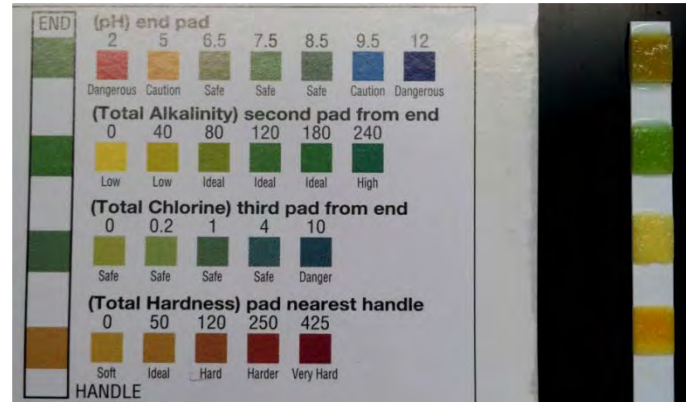

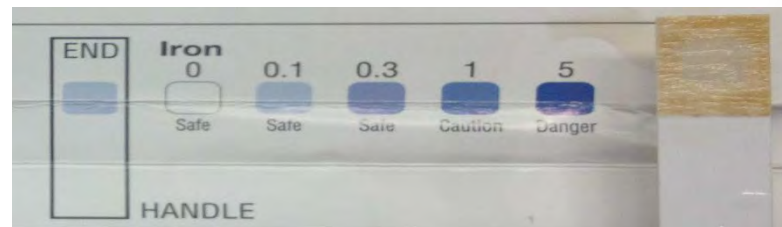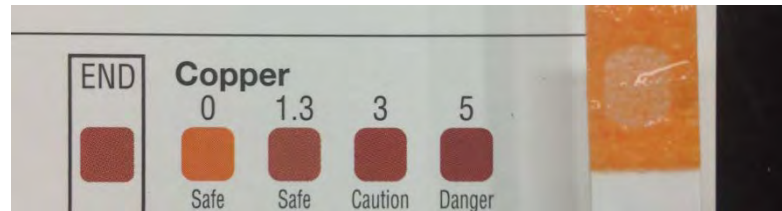Solar Panel Mounted on Top

Water Testing

Before

After

Water Testing Results

Input Water

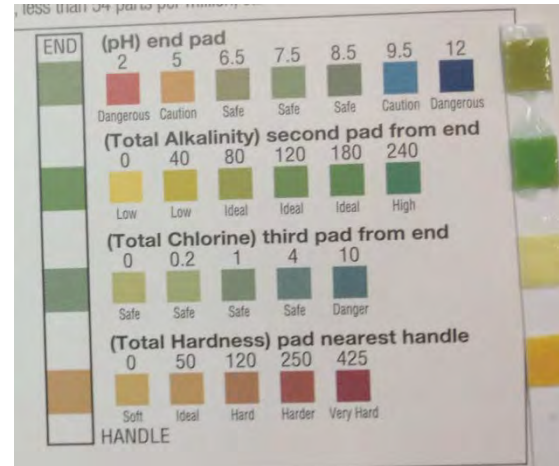| pH	5
Alkalinity	200 ppm
Chlorine	0 ppm
Hardness	100 ppm
Fe	0 ppm
Cu	0 ppm
NO_3^-/NO_2^-	Unknown

Water Testing Results

Utility Water

pH	7.5
Alkalinity	120 ppm
Chlorine	0 ppm
Hardness	35 ppm
Fe	0 ppm
Cu	0 ppm
NO_3^- / NO_2^-	Unknown

Water Testing Results

Drinking Water

pH	7.5
Chlorine	0 ppm
Hardness	45 ppm
Fe	0 ppm
Cu	0 ppm
NO_3^- / NO_2^-	0 ppm
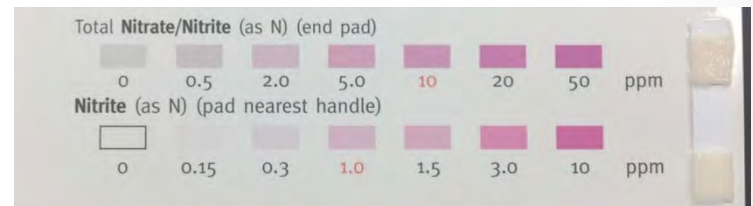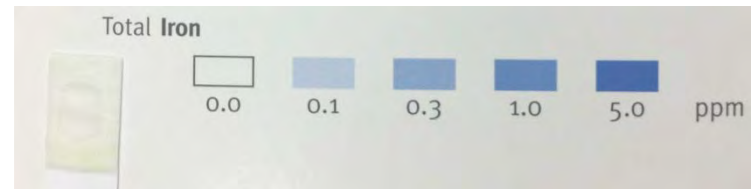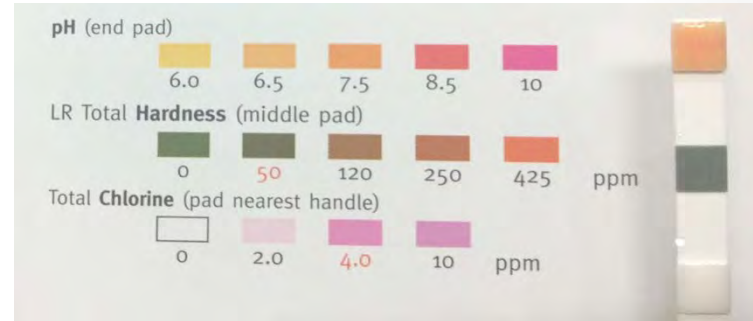
Water Testing Results

Drinking Water

Pb	Negative
Pesticides	Negative
Bacteria	Purple

Negative: LEFT line (next to number 1) is darker than the RIGHT line (next to number 2).

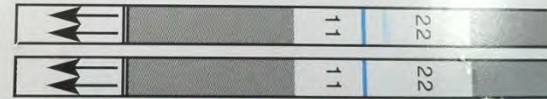If you only see one line next to number 1, the test is negative.

LEAD · Pb · LEAD · Pb
LEAD · Pb · LEAD · Pb
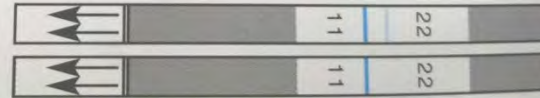
Positive: RIGHT line (next to number 2) is darker than LEFT line (next to number 1).

Negative: LEFT line (next to number 1) is darker than the RIGHT line (next to number 2).

If you only see one line next to number 1, the test is negative.

PESTICIDE   PESTICIDE
PESTICIDE   PESTICIDE

Positive: RIGHT line (next to number 2) is darker than LEFT line (next to

Operation

- User Must Supply Their Own Inlet Tank and Outlet Tank for Utility Water
  - Must Attach Hoses to Tank

- Inlet Water Must be Semi-Clear, Non-Stagnant

- Switch Panel Will Have 2 Switches
  - Power On
  - Water On

Budget Breakdown ($819)
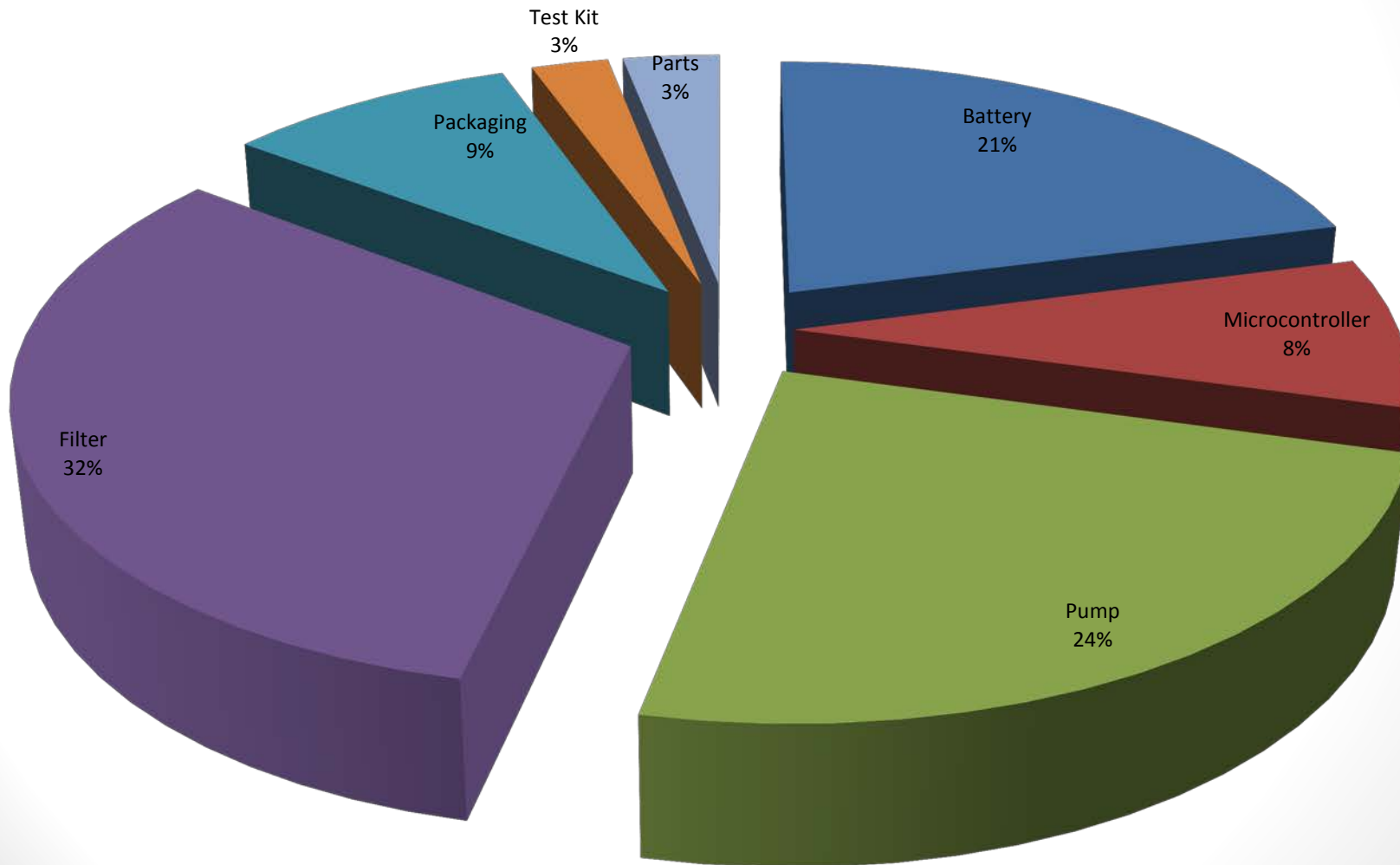
Conclusion

- Portable, Solar Powered Water Filtration Device

- 2.6 gph of Drinking Water and 4.2 gph of Clean/Utility Water

- 90 Watt-hours

- 3.4 Hour Runtime Under Ideal Weather

Questions

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