Personal Hydroelectric Generator Team 7

Final Presentation

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Presentation Overview

Project Background
- Problem Scope
- Needs Statement
- Goal Statement
- Background
- Constraints
- Objectives

Concept Generation
- Initial Design Concept
- Final Design Concept
- Main Components Description

Design of Experiments
- Waterproof Testing
- Heat Dispersion Testing
- Electrical Output Testing
- Torque Testing
- System Buoyancy

Conclusions
- Project Management
- Entrepreneurial Aspects
- Future Works
- Acknowledgements

Problem Statement

There is a high demand for electricity in remote locations not connected to a power grid. Currently, there are few effective, simple, and quiet ways to generate power in these locations.

Needs Statement & Goal Statement

- Need Statement:

"People in remote locations do not have access to electricity for powering their electrical devices."

- Goal Statement:

"Develop a portable device that transforms organic kinetic energy of flowing water into usable electricity."

Background on Hydropower

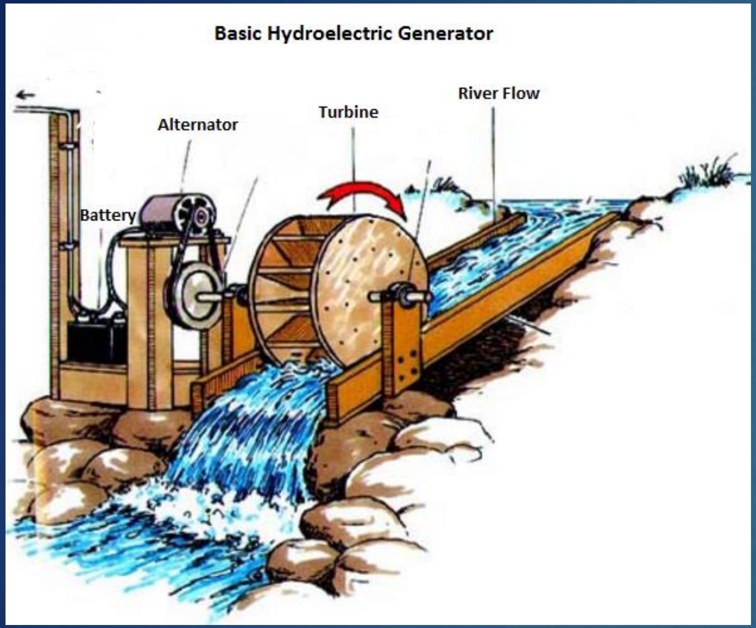
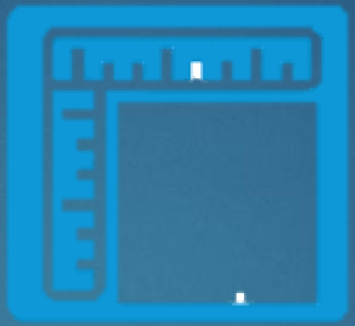


Fig. 1 - Basic Hydroelectric Generator

- **Large scale** hydropower applications like dams use the **potential gravitational energy** of water at different elevations
- **Smaller scale** applications like in Figure 1 use the **kinetic energy of flowing water** and convert it to electrical energy
- Both processes produce electricity with the use of an **alternator** or **generator**

Benefits of Small Scale Hydropower

Easy installation and maintenance



Minimal Space Required

Noise Free

Sustainable source of electricity

Small environmental impact

Target Market

ENGINEERS WITHOUT BORDERS USA

U.S.ARMY

Project Constraints

- Weight
  - < 70lb
- Waterproof
  - Protect electrical components
- Safe and Reliable
  - Little environmental and human impact
- Generate Electricity
  - Charge a battery

Objectives

- Produce enough power to satisfy the need of our target consumers.
  - Supplemental emergency power generation
  - Environmentally conscious recreational camper
  - Companies in remote locations

- Maximize portability
  - Modular design so weight can be distributed to multiple sources
  - Fast and simple assembly and disassembly
  - Minimize weight for ease of portability

- Environmentally friendly and safe
  - Minimize physical footprint during installation and operations
  - Protected from harming or obstructing local wildlife in their natural habitats
  - Obvious warning signs of generator in use to protect other people using waterway

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Initial Design Concept

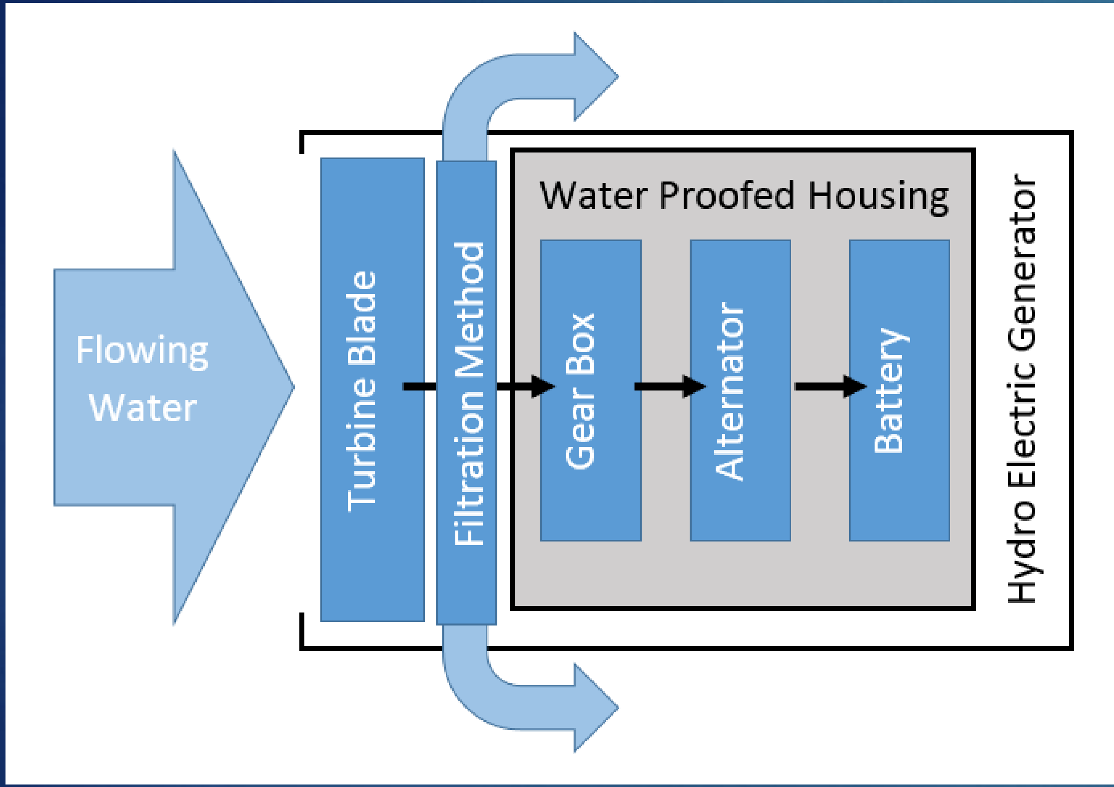


Fig. 2 – Initial Design Flowchart

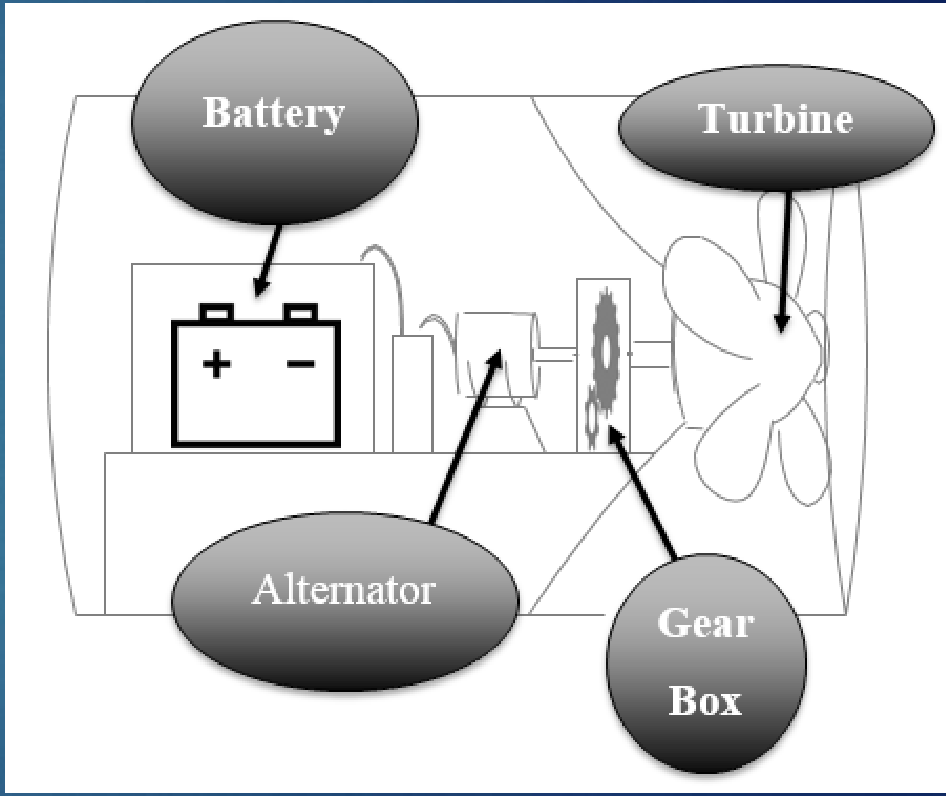


Fig. 3 – Initial Design Schematic

Final Design Concept

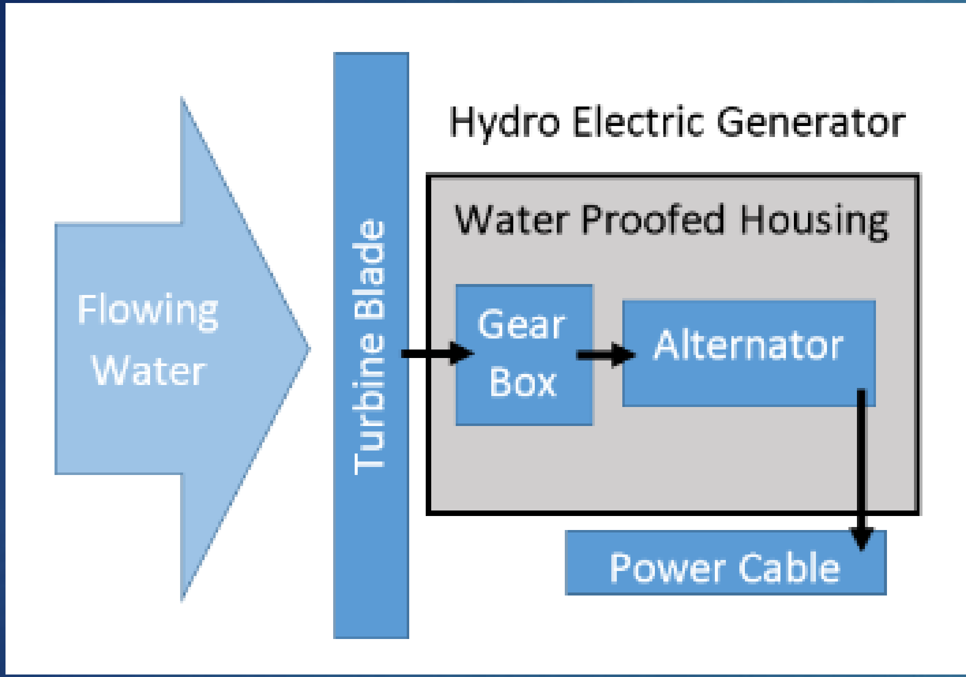


Fig. 4 – Final Design Flowchart

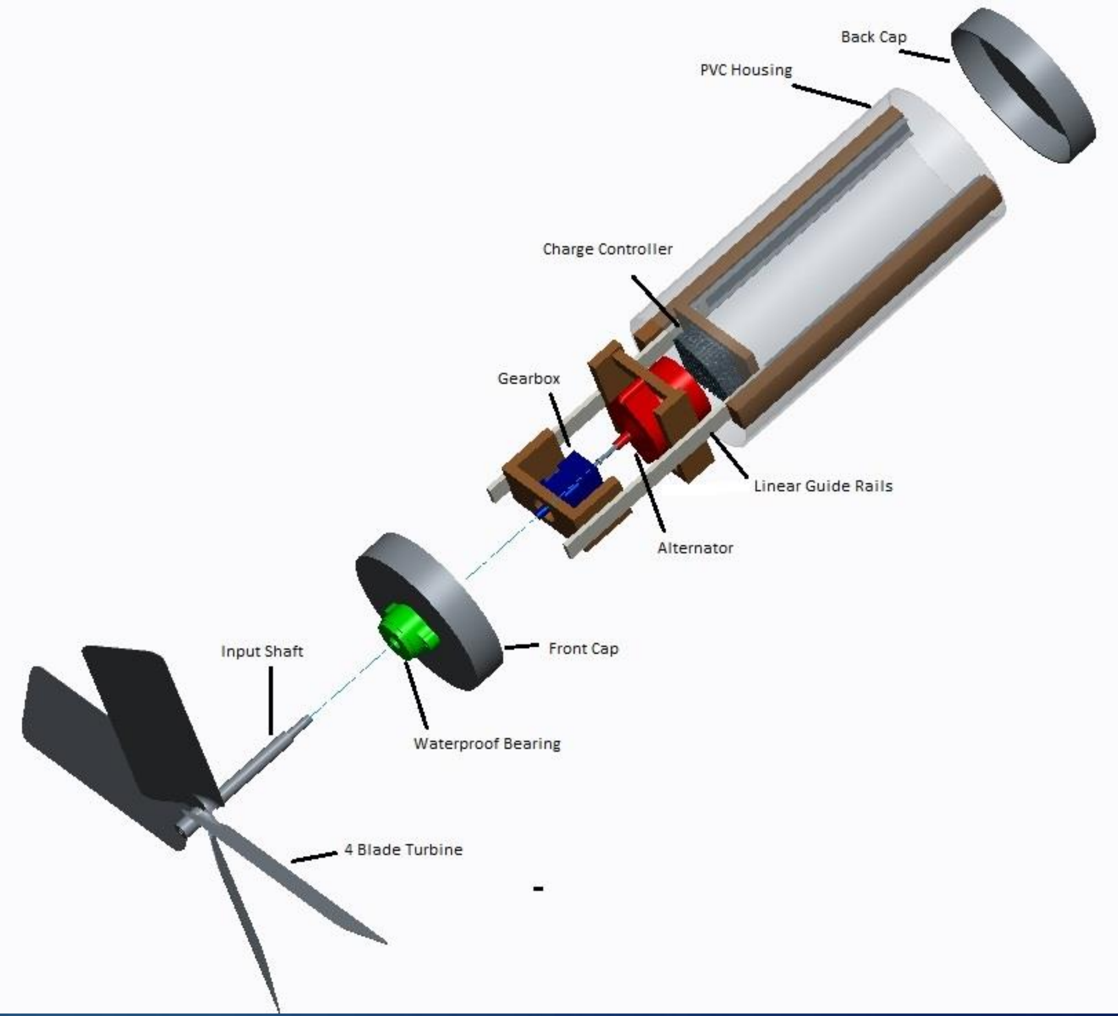


Fig. 5 – Final Design Schematic

Hydrokinetic Turbine

Selected Turbine Specifications:

- # of Blades: 4
- Diameter: 3ft
- Pitch: 35°

Tip-Speed Ratio:

$$\lambda = \frac{Tip\ speed\ of\ blade}{speed\ of\ water} = \frac{\omega R}{v_{water}}$$

For the **average 4 blade turbine**, the **tip-speed ratio is equal to 3.**

With this and an estimated average **water velocity of 3.75ft/s**, the turbine's angular velocity can be approximated:

$$\omega = \frac{\lambda v_{water}}{R} = \frac{(3)(3.75\frac{ft}{s})}{1.5ft} = 7.5\frac{rad}{s} = \mathbf{71.62\ rpm}$$

Fig. 6 - 3 ft. Diameter Aluminum Turbine

Waterproof Bearing

Waterproof Spherical Flange Bearing

- Lubrication using grease inserted by a zerc fitting
- Heat Tolerance ranges from -22 to +212 °F
- Designed for a 1” shaft diameter

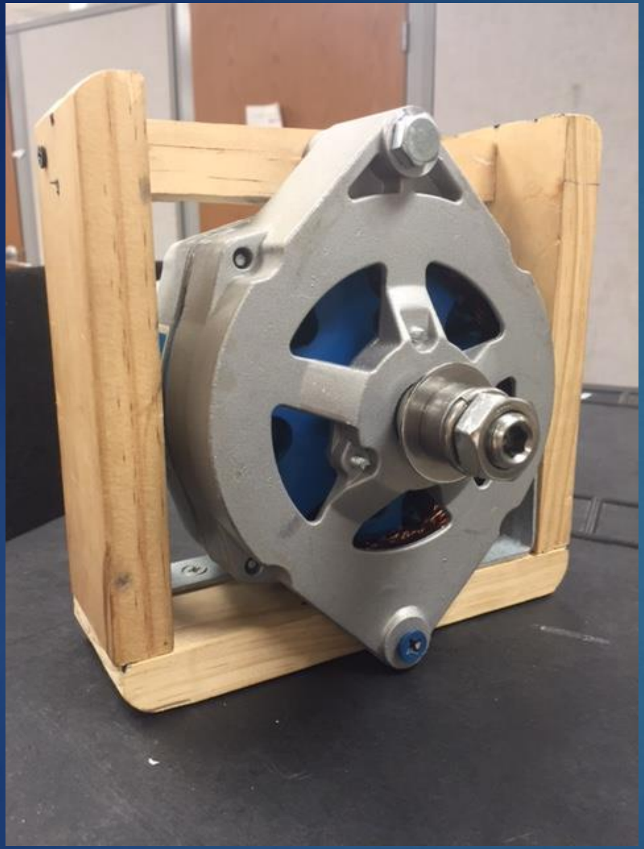
Fig. 7 – Spherical Flange Bearing

Gearbox

- The gearbox increases the RPM output of the turbine shaft to the desired input angular velocity for the alternator
- Gearbox Ratio 10:1
- Ratio increases an estimated input speed of 71.62 rpm to an output speed of 716.2 rpm into the alternator

Fig. 8 - Anaheim Automation Gearbox

Alternator



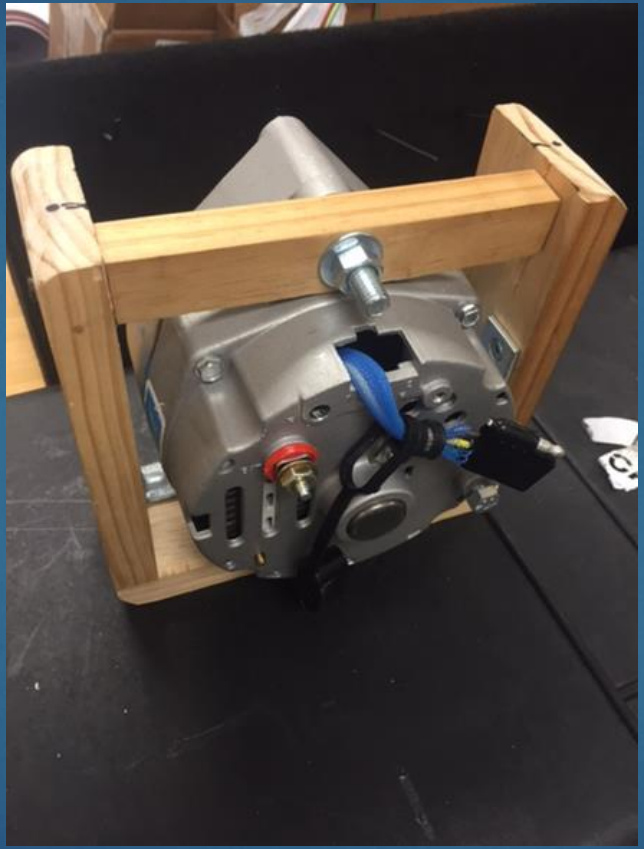


Fig. 9 - The WindBlue DC-540 Low Wind Permanent Magnet Alternator

These pictures show the alternator secured in its custom caging, which is to be secured to the housing's linear guide rails.

Electronic Components – Circuit Schematic

Fig. 10 – Charge Controller

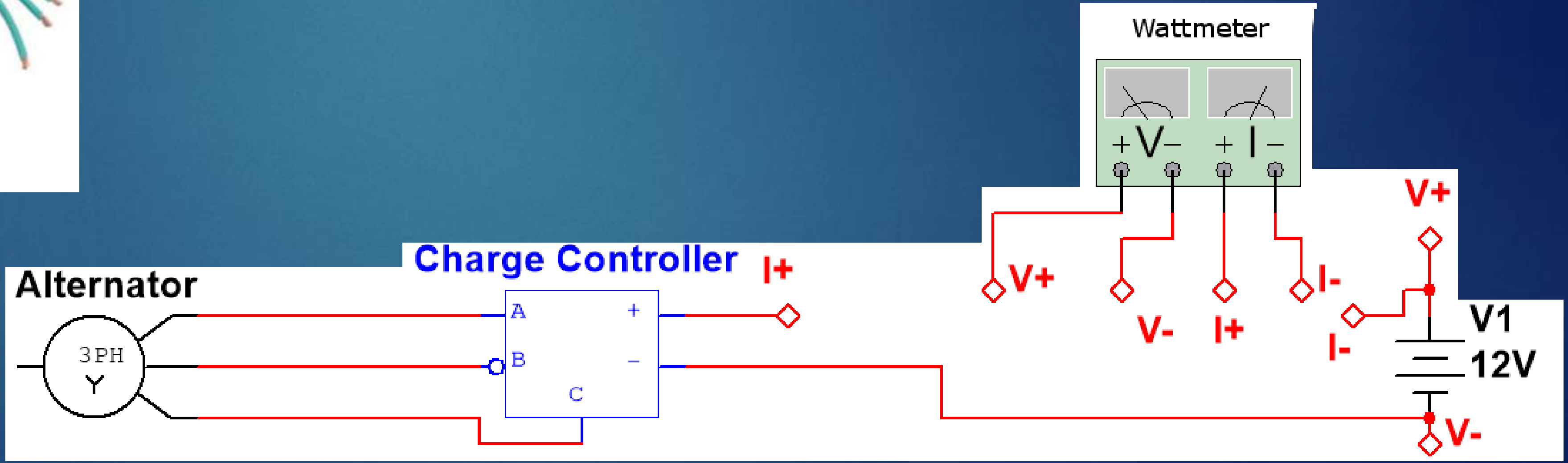


Fig. 11 - Circuit Schematic

External PVC Housing

Fig. 12 – Profile of outer PVC housing

Fig. 13 – Inside of outer PVC housing and railing

Fig. 14 – Railing system fully extended

Detachable linear guide rails were fixed to the inside of the PVC housing to serve as anchor spots for the gearbox and alternator cages as well as the charge controller. Implementing these rails allows for **easy access to the internal components** of the system without fully disassembling it.

Assembled Prototype

Fig. 15 – Assembled Prototype

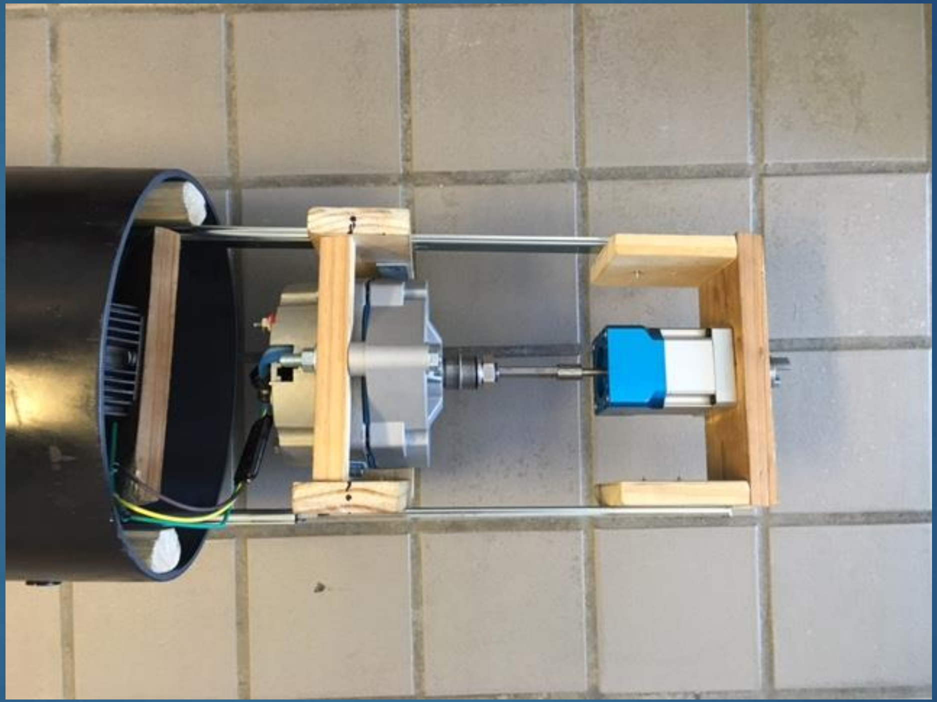


Fig. 16 – Internal Components

Fig. 17 – Video of Working Prototype

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Waterproof Testing and Results

- Experiment #1
  - Filled the housing end caps with water to check for leaks through the seams and the bearing
    - Results: Water leaked through the seams but not the bearing
    - Conclusion: Marine grade epoxy was applied to the inside of the cap seams
- Experiment #2
  - Submerged entire sealed housing into the Florida State University diving pool
    - Results: No leaks were detected

Heat Dispersion Testing and Results

- Experimental Procedure:
  - Placed the alternator within housing
  - Attached electric drill with socket and extension to the alternator’s input shaft
  - Spun the drill to reach desired voltages and took temperature with a temperature gun every 30 seconds for five minutes to observe temperature change

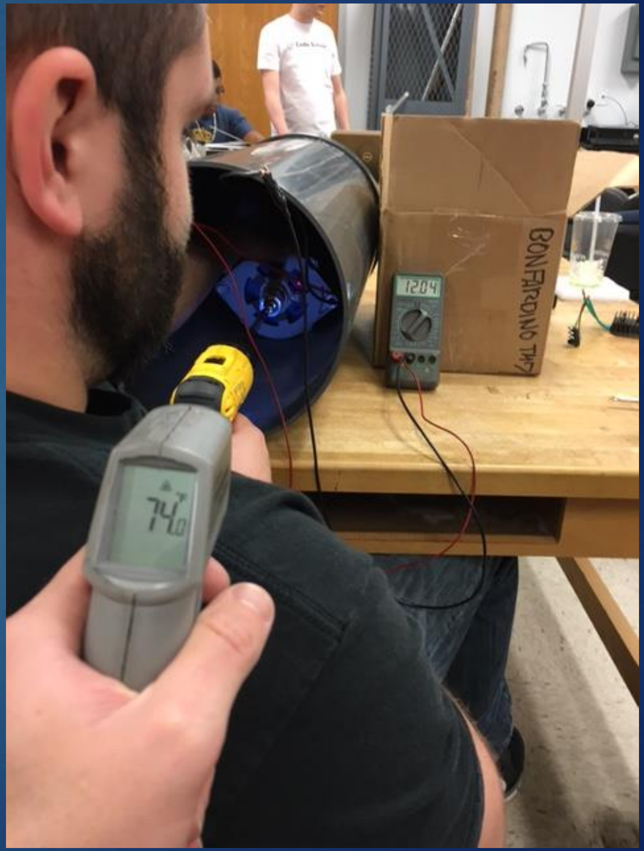

Fig. 18 – Heat Testing of Alternator

Heat Dispersion Testing and Results

- Conclusion:
  - Heat should **not** be a problem
  - The heat had a max plateau of 76°F at 40V
  - The apparatus will be operating at 12V

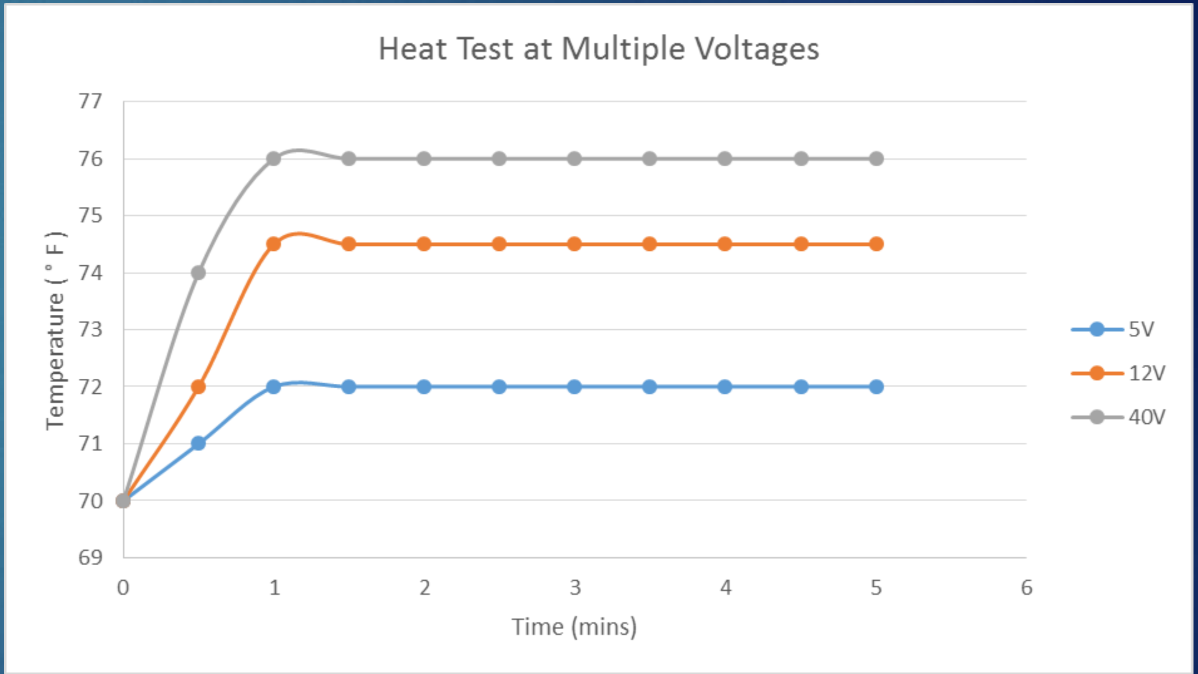

Fig. 19 – Heat Testing Results

Electrical Power Output

Table 2. WindBlue DC-540 Power Output Results

ω (rpm)	Resistance (Ω)	Voltage (V)	Current (A)	Power (W)
117	28.0	8.15	0.28	2.282
117	7.0	5.87	0.80	4.696
209	28.0	15.46	0.52	8.039
209	10.5	12.64	1.16	14.662
365	28.0	27.47	0.96	26.371
365	10.5	22.16	2.08	46.093
490	28.0	36.98	1.28	47.334
490	10.5	29.54	2.76	81.530
650	28.0	48.30	1.72	83.076
650	11.5	38.90	3.32	129.148
870	28.0	64.10	2.24	143.584
870	14.0	54.30	3.80	206.340

- The final prototype was tested by spinning the turbine manually at a constant angular velocity
- 7 watts was produced at 18 rpm (180 rpm to the alternator) with a small resistive load of the LED strips
- Higher rpm was not tested due a gearbox manufacturing defect

Torque Testing


Fig. 23 – Top View of Prototype

A torque test was performed by measuring the force required to initiate rotation

This force was about 1kg*g at 16.5in from the center of shaft: $\tau_{start\ up}$ = 4.11Nm

Considering the 10:1 gearbox, the gathered torque data matches that provided by the vendor

$$P_{water@3.75ft/s} = \frac{1}{2}\rho A V^3 = \frac{1}{2}\left(1000\frac{kg}{m^3}\right)\left(\frac{\pi 3ft^2}{4}\right)\left(3.75\frac{ft}{s}\right) = 490\ W$$

$$\omega = P_{water@3.75ft/s}/\tau_{start\ up} = 119.2 \text{ rad/s} = 227.7 \text{ rpm}$$

System Buoyancy

- In order to achieve maximum energy transfer from water to alternator, the entire turbine blade needs to be submerged.
- When completely submerged, the device will displace a specific volume of water.
- If the device weighs more than the weight of this volume of displaced water, the device will sink.
- At current design specifications, the device would need to weigh 82.39 pounds to be neutrally buoyant.
- The current total weight of our apparatus is 40.4 lbs.

$$W_{fluid} = \rho_{fluid} * V_{fluid}$$

$$\rho_{water} = 1000\ \frac{kg}{m^3}$$

$$V_{water} = 0.03737\ m^3$$

$$\boxed{W_{water} = 37.37\ kg = 82.39\ lb}$$

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Bill of Materials

Team 7				
Personal Hydroelectric Generator				
Date: 04/08/2016				
Item(s)	**Vendor**	**Quantity**	**Price per Unit ($)**	**Total ($)**
DC 540 Alternator	WindBlue Power	1	239	239
12V/25A Charge Controller	WindBlue Power	1	44	44
60V/100A Watt Meter	WindBlue Power	1	24	24
5' of 11" PVC Pipe	Commercial Ind. Supply	1	170	170
External PVC End-Caps	Commercial Ind. Supply	3	74.8	224.4
Water-Proof Bearing	TNN-JEROS	1	101.36	101.36
Turbine Blade	Lowes	1	235.43	235.43
1' Aluminum Shaft	Grainger	1	16.17	16.17
Linear Guide Rails	HomeDepot	1	21.76	21.76
Assembly Hardware	HomeDepot	1	65.61	44.23
Assembly Hardware	HomeDepot	1	15.72	15.72
Windblue Shipping		1	17.16	17.16
Bearing Shipping		1	15.88	15.88
Pipe Shipping		1	25.97	25.97
Gearbox	Anaheim Automation	1	330	330
Gearbox shipping		1	43.39	43.39
Input Shaft Coupling	Grainger	1	20.16	20.16
Gearbox-Alternator Coupling	Lowes	1	6.24	6.24
LED Lighting	AutoZone	1	21.49	21.49
			Total	1616.36
			Amount Over Initial Budget	116.36
			Available Budget - Total	383.64

Total Budget – $2000

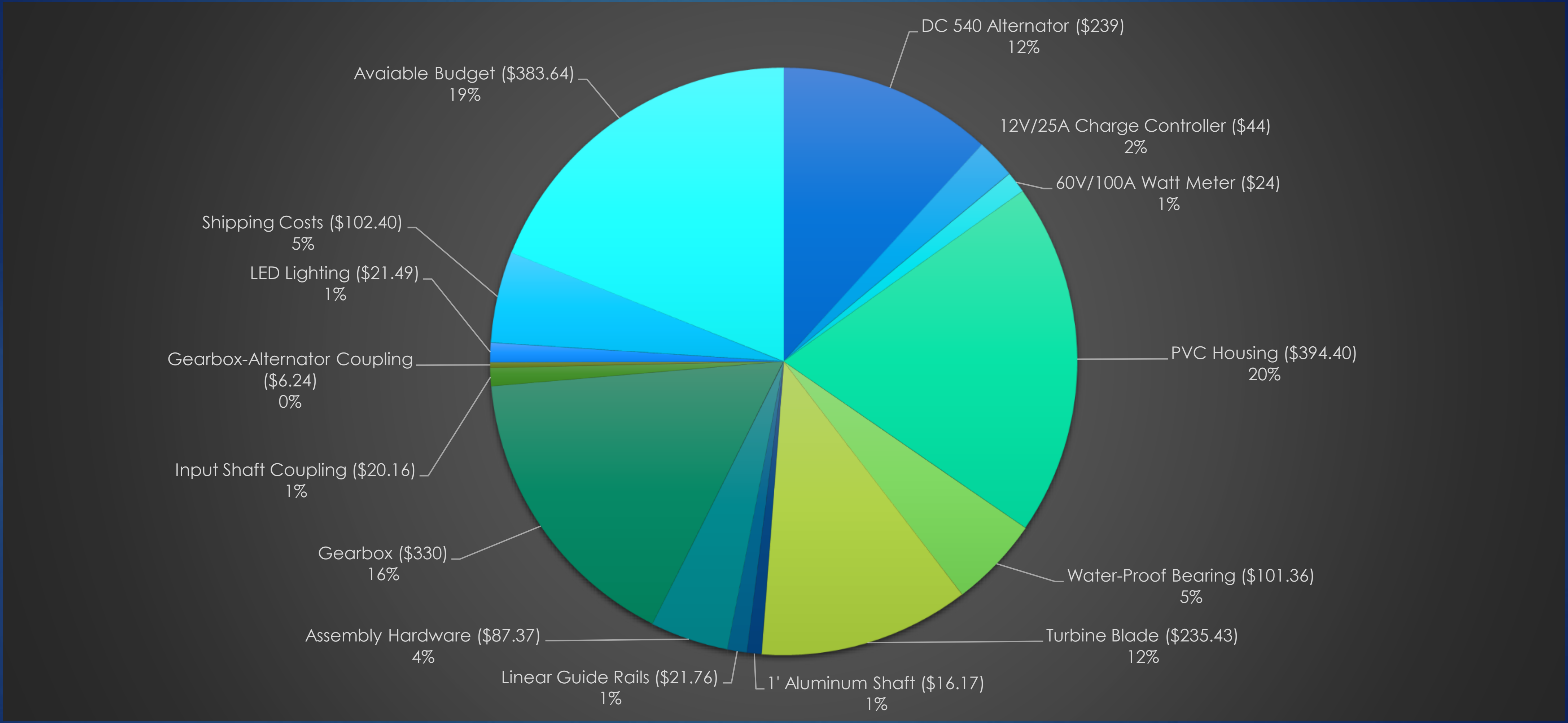

Fig. 24 – Budget report

Scheduling

Task Name	Duration	Start	Finish
Part Acquisition	**15 days**	**Mon 2/29/16**	**Fri 3/18/16**
Gearbox	15 days	Mon 2/29/16	Fri 3/18/16
Shafts/Couplings	5 days	Mon 3/14/16	Fri 3/18/16
Wiring	3 days	Mon 3/14/16	Wed 3/16/16
Assembly	**15 days**	**Mon 3/14/16**	**Fri 4/1/16**
Rail System	5 days	Mon 3/14/16	Fri 3/18/16
Gearbox Housing	6 days	Sat 3/19/16	Fri 3/25/16
Shafts/Couplings	3 days	Sat 3/26/16	Tue 3/29/16
Turbine	4 days	Tue 3/29/16	Fri 4/1/16
Wiring	6 days	Sat 3/26/16	Fri 4/1/16
Complete Assembly	4 days	Tue 3/29/16	Fri 4/1/16
Testing	**13 days**	**Mon 3/28/16**	**Wed 4/13/16**
Alternator Testing	5 days	Tue 3/29/16	Mon 4/4/16
Heat Testing	4 days	Sun 4/3/16	Wed 4/6/16
Waterproofing	3 days	Thu 4/7/16	Mon 4/11/16
RPM & Torque	3 days	Sun 4/10/16	Tue 4/12/16
Power Output	3 days	Mon 4/11/16	Wed 4/13/16

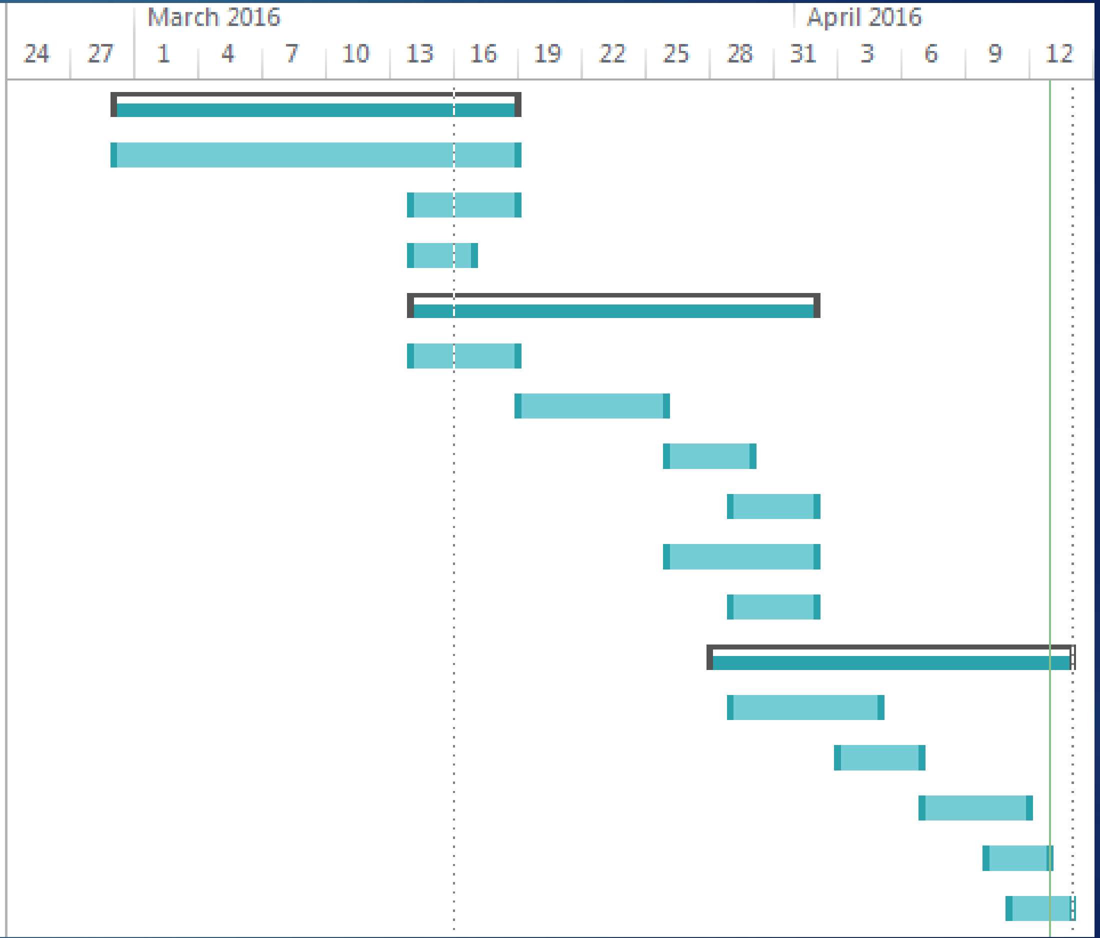

Fig. 25 – Gantt Chart

Entrepreneurial Aspects

- InNolevation Challenge
  - Develop business model canvas
  - Made Stage 4 among top 20 contestants
- ACC Challenge
  - 3 minute quick business pitch + 7 minutes of questions
  - Finished as a top 3 finalist for FSU
- DigiTech
- Engineering Shark Tank

Future Work

Potential ideas:

- Anchoring
  - Create an effective way of offsetting the lack of weight in the system to make the system neutrally buoyant
- Power display
  - Design a small platform to mount the wattmeter and battery for land based monitoring and connection
- Performance optimization
  - All designs always have room for improvement in performance and ergonomics

Acknowledgments

On behalf of Team 7 we would like to thank the FAMU-FSU College of Engineering for presenting us the opportunity to participate in the 2015-2016 Senior Design.

We would like to personally thank Dr. Devine and Dr. Hahn for their guidance in entrepreneurial engineering and electrical engineering concepts.

Also, much appreciation is given to Dr. Gupta for providing the team with supervision and direction on our project progress.