Final Proposal Presentation

NAU CWC 2018 TEST TEAM A

SOUD ALSAHLI, AARON DELUCA, DEVON HARDY, EVAN HEILAND, KORY JOE, QIAN ZHAO

Agenda

Project introduction

Project description

Design descriptions

Design requirements

Budget

Schedule

Project Introduction

Collegiate Wind Competition (CWC)

- US Department of Energy (DOE)
- National Renewable Energy Laboratory (NREL)

Unique solution to a complex wind energy project

- Business plan
- **Build and test a wind turbine**
- Plan a wind project

Provides real-world wind energy industry workforce experience

Project Description

Build and test a wind turbine

MECHANICAL

Blades

Drive Train

Bearings

ELECTRICAL

Generator

Direct Current to Direct Current (DC-DC) Converter

Printed Circuit Board (PCB)

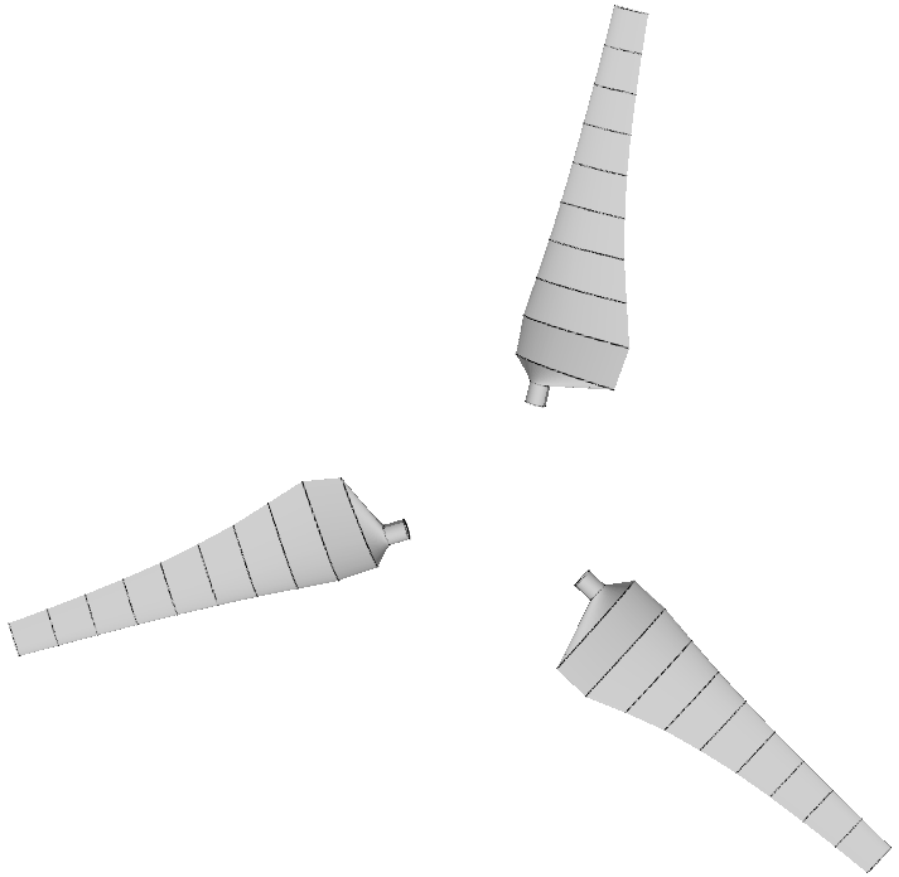
Blade Description

Materials

- Carbon fiber
- 3-D printed material

Requirements

- 20 W @ 10 m/s wind speed
- Start up @ 3-5 m/s wind speed
- Cut out @ 22 m/s wind speed



Blade Design

Airfoils

- Single surface
- High camber

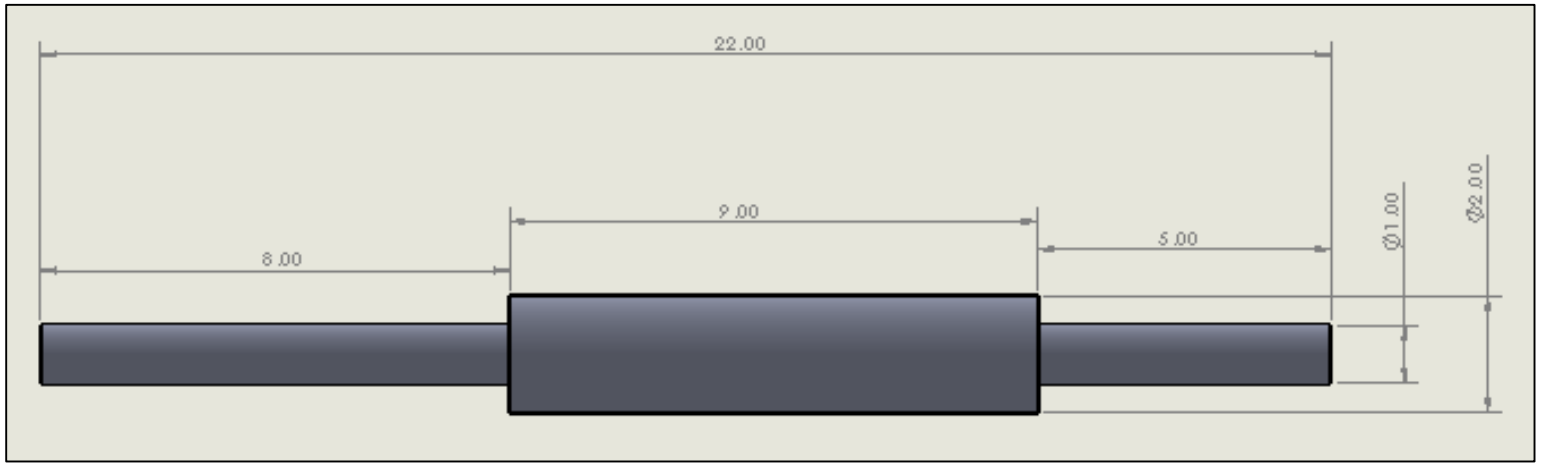
Dimensions

- Connection to hub
  - 1cm
- Length
  - 19.5 cm

Shaft Design Description

Shaft

- Direct drive shaft
- Material
  - Aluminum
  - Grade TBD
- Initial Size and Diameter
  - Length = 22cm
  - Diameter[1] = 2 cm
  - Diameter[2] 1 cm



Shaft Design Requirements

Pros and Cons of aluminum

- Pros
  - Light weight
  - Easy to machine
  - Low cost
- Cons
  - Hard to repair

Different aluminum grades comparison [x]

Material	Yield strength (psi)	Tensile strength (psi)	Cost of 2 ft ($)
7075 Aluminum	62,000	83,000	30.09
6063 Aluminum	16,000	28,000	18.56
6061 Aluminum	35,000	42,000	14.89
6020 Aluminum	39,000	45,000	34.72

Bearings Design Description

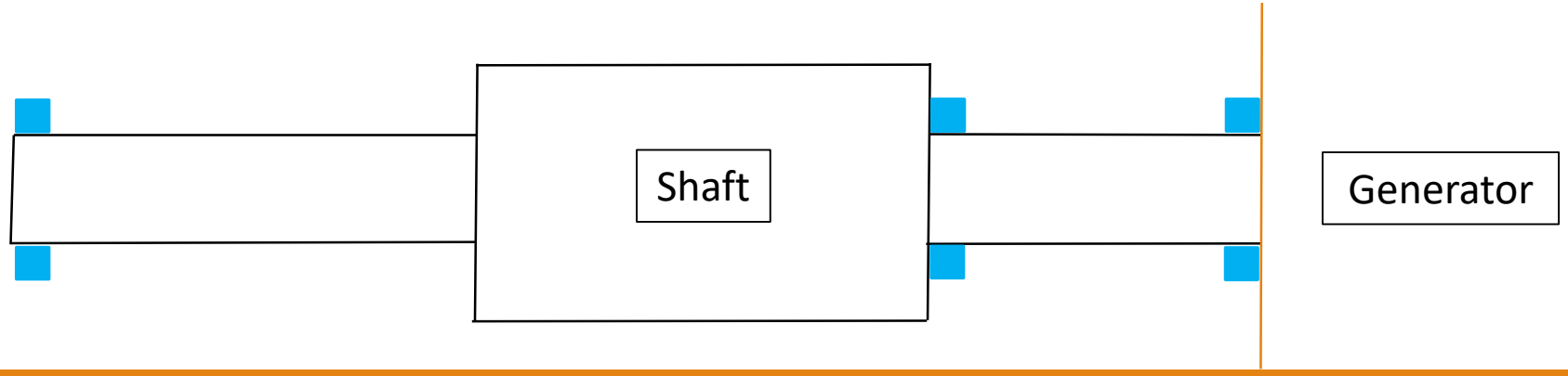
Need to keep shaft rotating while in statically in position

- Maximize energy transfer between rotor and generator

3 Bearing Locations on Shaft (**see figure**)

- Experience random variable radial and axial (thrust) loads
- Static outer ring (with housing)
- Rolling Inner ring (balls or rolling elements)

Supplier – Applied Industrial Technologies®



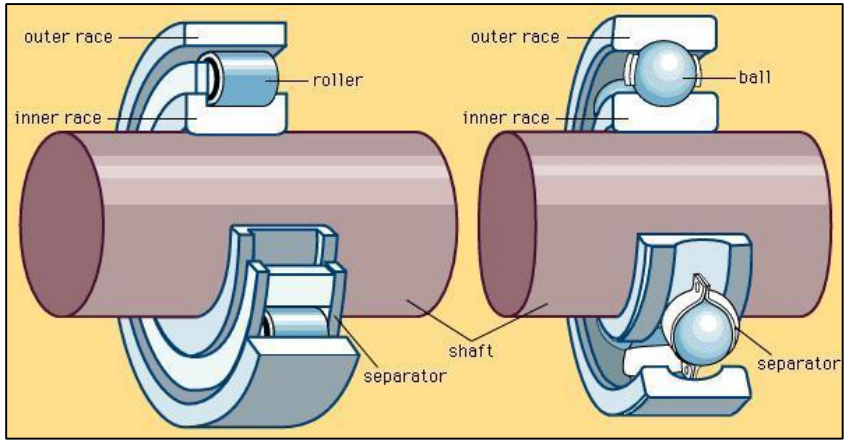
Bearings Design Requirements

Single-Row Deep-Groove Ball Bearings

- Handles radial loads
- Handles some axial loads

Needle Roller Bearings

- Handles radial loads
- Handles axial loads very well



GlobalSpec

10 mm ID Cost Comparison from Applied Industrial Technologies®:

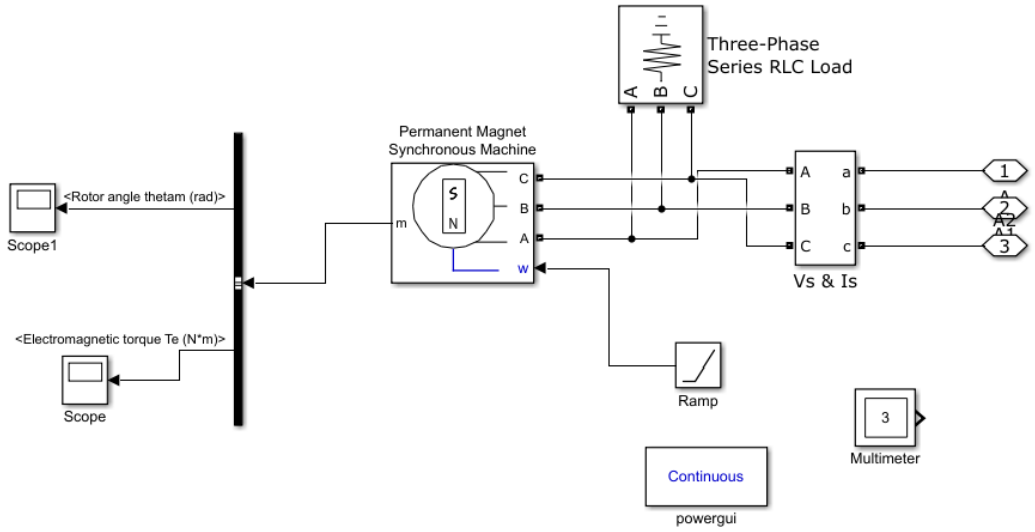
Bearing Type (Item Number)	Cost per Bearing
Timken Single-Row Deep-Groove Ball Bearings (#112307781)	$8.82
SKF Needle Roller Bearing (#101492344)	$7.51

Design Description

Generator connected to resistive load to determine voltage values

Generator block can be used as a motor or generator (negative torque = generator)

Measuring torque, angle, and voltage



Generator Selection

Chosen Generator: Permanent Magnet Synchronous Generator

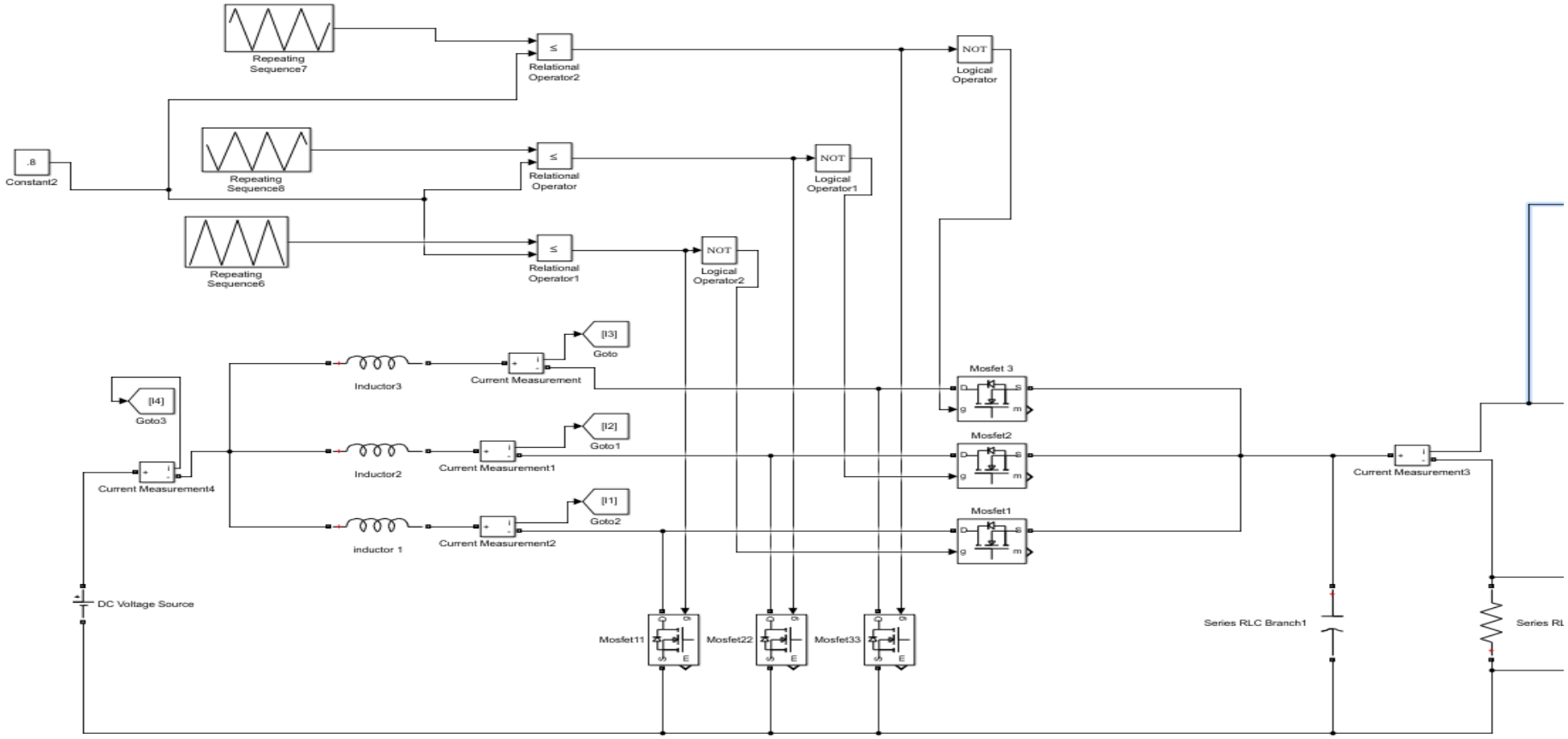
380 KV rating

Puts out an acceptable voltage range depending on wind speed

Boost converter

3 Channel Interleaved Boost Converter

Size components for our voltage system



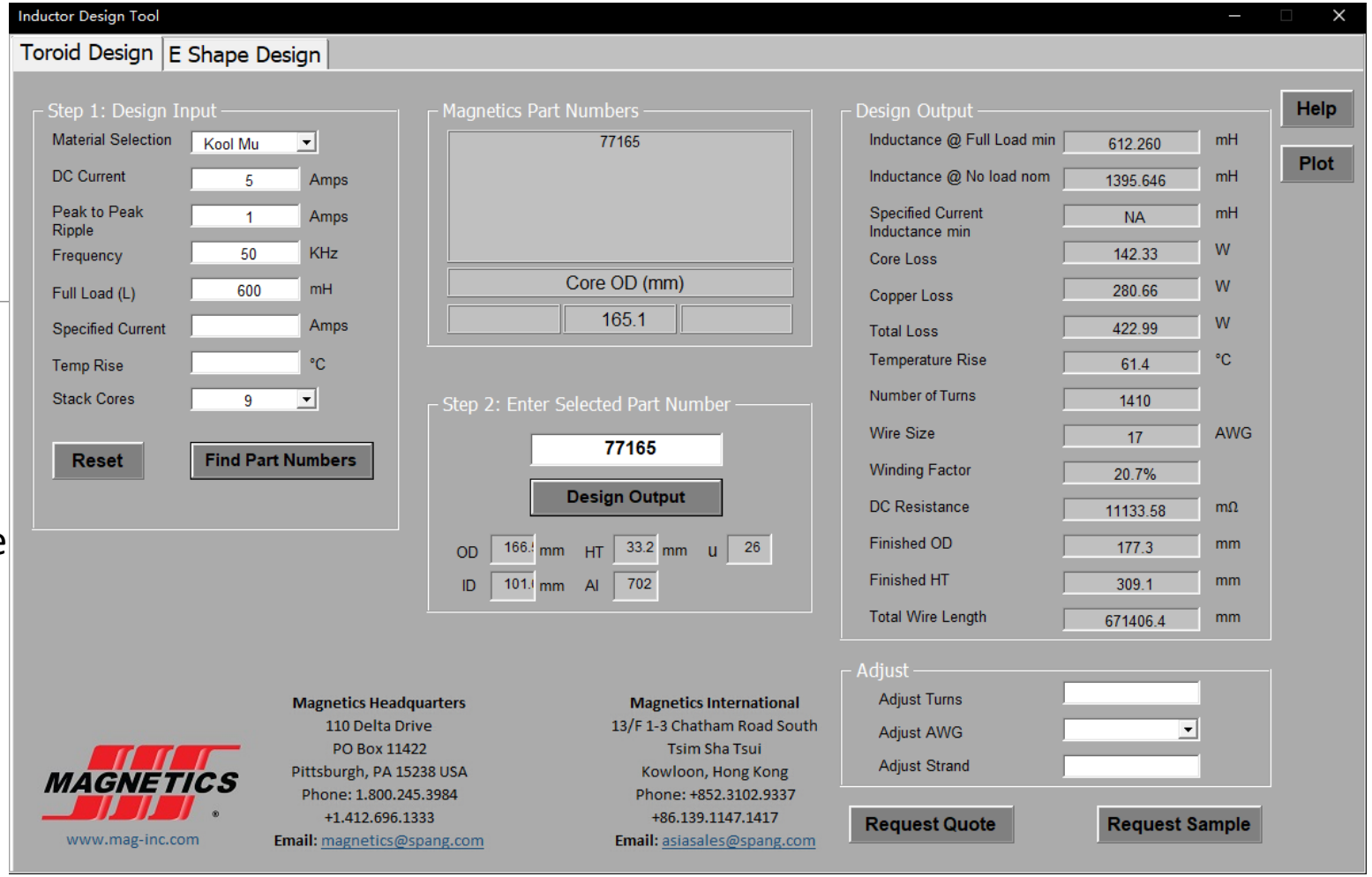
Design Description in PCB

Components selection is an another important part in PCB board.

- Inductor selection
- MOSFET selection

Inductor selection

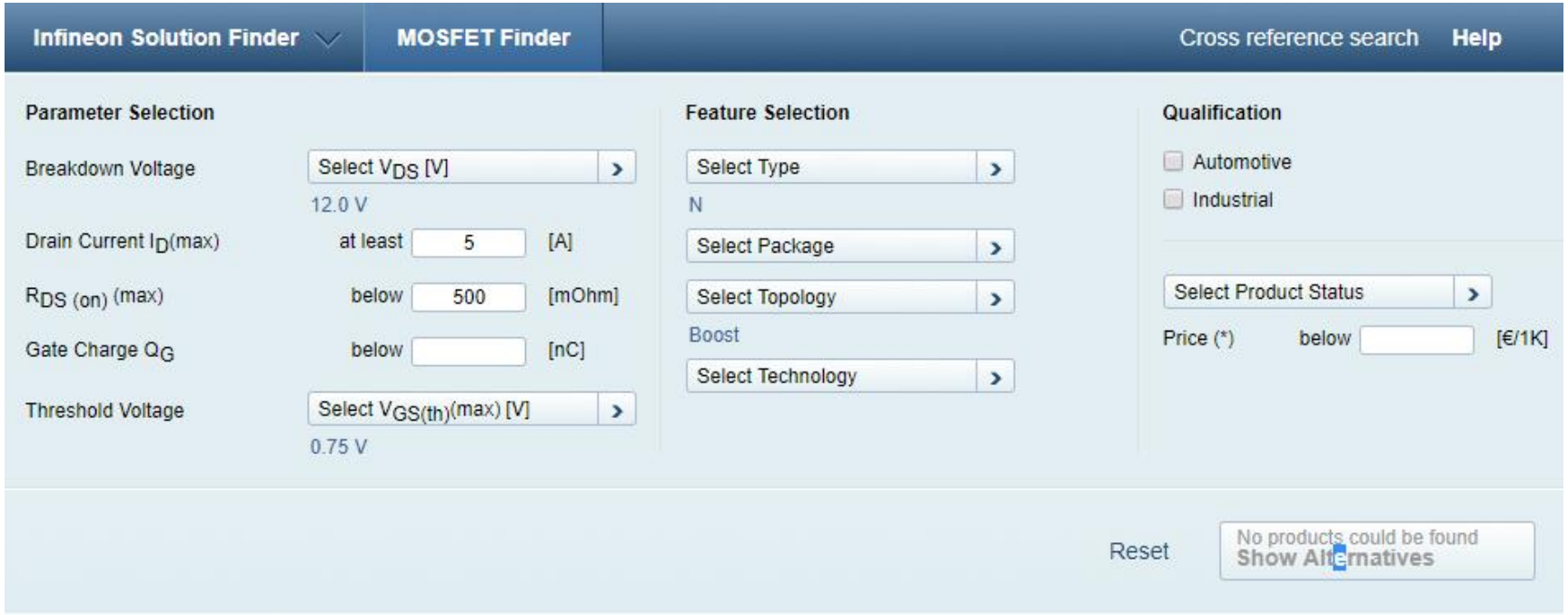
- Magnetics Power Cores
  - Pros
    - Low Temperature
    - DC bias better
    - Switching circuit
  - Cons
    - cost more expensive



- Magnetics Ferrite Cores
  - Pros
    - low core losses at high frequencies
  - Cons
    - Needing to add air gaps to improve efficiency

MOSFET selection

- Material
  - Silicon carbide
    - Benefits
      - Highest efficiency for reduced cooling effort
      - Higher frequency operation
  - Gallium Nitrite
    - Benefits
      - Low gate voltage
      - Can be switch to a high switching frequency



Budget

HIGHEST EXPECTED COSTS (NO CURRENT)

Material	Cost
6020 Aluminum Shaft	$34.72
3:1 Two Part Thin Epoxy Resin Blades (plus fabric)	$90.00
Timkem Single-Row Deep-Groove Ball Bearings (2)	$17.64
Inductors (6 total)	$6.00
Mosfets (12 total)	$8.00
Generator	$30.00
TOTAL	$186.36

TOTAL INCOME THUS FAR

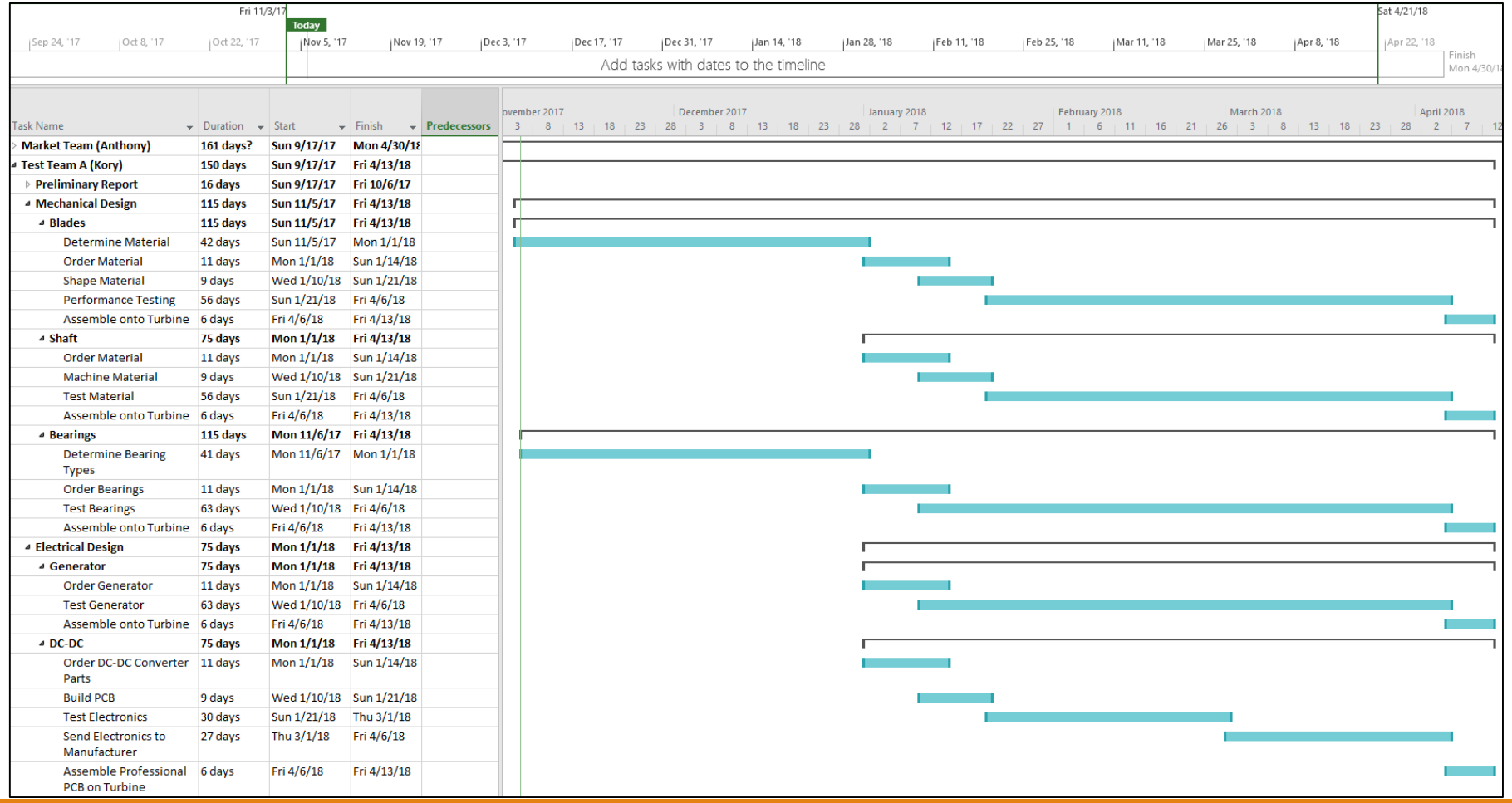
Income Source	Amount
Gore	$1,300.00*
TBD	TBD
TOTAL	TBD

*Percentage of total Gore donation

RESULTING BALANCE THUS FAR:

Total Income/Expense	Amount
Income	$1,300.00
Expense	$160.00
RESULTING BALANCE	$1,113.64

Schedule (2018)



Task Name	Duration	Start	Finish	Predecessors
Market Team (Anthony)	**161 days?**	**Sun 9/17/17**	**Mon 4/30/18**	
Test Team A (Kory)	**150 days**	**Sun 9/17/17**	**Fri 4/13/18**	
Preliminary Report	**16 days**	**Sun 9/17/17**	**Fri 10/6/17**	
Mechanical Design	**115 days**	**Sun 11/5/17**	**Fri 4/13/18**	
Blades	**115 days**	**Sun 11/5/17**	**Fri 4/13/18**	
Determine Material	42 days	Sun 11/5/17	Mon 1/1/18	
Order Material	11 days	Mon 1/1/18	Sun 1/14/18	
Shape Material	9 days	Wed 1/10/18	Sun 1/21/18	
Performance Testing	56 days	Sun 1/21/18	Fri 4/6/18	
Assemble onto Turbine	6 days	Fri 4/6/18	Fri 4/13/18	
Shaft	**75 days**	**Mon 1/1/18**	**Fri 4/13/18**	
Order Material	11 days	Mon 1/1/18	Sun 1/14/18	
Machine Material	9 days	Wed 1/10/18	Sun 1/21/18	
Test Material	56 days	Sun 1/21/18	Fri 4/6/18	
Assemble onto Turbine	6 days	Fri 4/6/18	Fri 4/13/18	
Bearings	**115 days**	**Mon 11/6/17**	**Fri 4/13/18**	
Determine Bearing Types	41 days	Mon 11/6/17	Mon 1/1/18	
Order Bearings	11 days	Mon 1/1/18	Sun 1/14/18	
Test Bearings	63 days	Wed 1/10/18	Fri 4/6/18	
Assemble onto Turbine	6 days	Fri 4/6/18	Fri 4/13/18	
Electrical Design	**75 days**	**Mon 1/1/18**	**Fri 4/13/18**	
Generator	**75 days**	**Mon 1/1/18**	**Fri 4/13/18**	
Order Generator	11 days	Mon 1/1/18	Sun 1/14/18	
Test Generator	63 days	Wed 1/10/18	Fri 4/6/18	
Assemble onto Turbine	6 days	Fri 4/6/18	Fri 4/13/18	
DC-DC	**75 days**	**Mon 1/1/18**	**Fri 4/13/18**	
Order DC-DC Converter Parts	11 days	Mon 1/1/18	Sun 1/14/18	
Build PCB	9 days	Wed 1/10/18	Sun 1/21/18	
Test Electronics	30 days	Sun 1/21/18	Thu 3/1/18	
Send Electronics to Manufacturer	27 days	Thu 3/1/18	Fri 4/6/18	
Assemble Professional PCB on Turbine	6 days	Fri 4/6/18	Fri 4/13/18	

References

[1] Office of Energy Efficiency & Renewable Energy. (2017). *Collegiate Wind Competition*. https://energy.gov/eere/collegiatewindcompetition/collegiate-wind-competition

[2] . W. M. Chew, P. D. Evans and W. J. Heffernan, "High frequency inductor design concepts," Power Electronics Specialists Conference, 1991. PESC '91 Record., 22nd Annual IEEE, Cambridge, MA, 1991, pp. 673-678.

[3] B. Bai, C. Jiang, F. Zhang and L. Li, "DC–DC converter design with ferrite core inductor for implantable neuro-stimulation device compatible with MRI," in Electronics Letters, vol. 52, no. 15, pp. 1292-1293, 7 21 2016.

[4] www.mag-inc.com/Design/Design-Guides

[5] https://www.infineon.com/cms/en/product/power/sicarbide-sic/channel.html?channel=ff80808112ab681d0112ab6a50b304a0

[6] B.N. Aditya, Navneet Gupta, Material selection methodology for gate dielectric material in metal–oxide–semiconductor devices, In Materials & Design, Vol. 35, 2012, pp 696-700, Mar 2012

[7] “McMaster-Carr,” McMaster-Carr. [Online]. Available:https://www.mcmaster.com/#standard-aluminum-rods/=1a4mp9e. [Accessed: 05-Nov-2017