Final Proposal Presentation

NAU CWC 2018 TEST TEAM A

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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
 - Diameter¹ = 2 cm
 - Diameter² 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



<u>GlobalSpec</u>

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 Design Tool	-	· 🗆 🗙
	Toroid Design E Shape Design		
 Magnetics Power Cores Pros Low Temperature DC bias better 	Magnetics Part Numbers Material Selection Kool Mu Image: Magnetics Part Numbers DC Current 5 Amps Peak to Peak 1 Amps Frequency 50 KHz Full Load (L) 600 mH Specified Current Amps Temp Rise °C	Design Output Inductance @ Full Load min 612.260 mH Inductance @ No load nom 1395.646 mH Specified Current NA mH Inductance min 142.33 W Core Loss 280.66 W Total Loss 422.99 W Temperature Rise 61.4 °C	Plot
 Switching circuit 	Stack Cores 9 Step 2: Enter Selected Part Number	Number of Turns 1410	
 Cons cost more expensive 	Find Part Numbers 77165 Design Output OD 166.1 mm HT 33.2 mm U 26 ID 101.1 mm AI 702	Wire Size 17 AW Winding Factor 20.7% DC Resistance 11133.58 mΩ Finished OD 177.3 mm Finished HT 309.1 mm Total Wire Length 671406.4 mm	G
 Magnetics Ferrite Cores Pros 	Magnetics HeadquartersMagnetics International110 Delta Drive13/F 1-3 Chatham Road SouthPO Box 11422Tsim Sha TsuiPittsburgh, PA 15238 USAKowloon, Hong KongPhone: 1.800.245.3984Phone: +852.3102.9337+1.412.696.1333+86.139.1147.1417www.mag-inc.comEmail: magnetics@spang.com	Adjust Adjust Turns Adjust AWG Adjust Strand Request Quote Request Sampl	e

- low core losses at high frequencies
- Cons
 - Needing to add air gaps to improve efficiency

MOSFET selection

- Material ٠
 - Silicon carbide •
 - Benefits
 - Highest efficiency for reduced cooling effort

Infineon Solution Finder \sim

• Higher frequency operation

- **Gallium Nitrite** •
 - Benefits •
 - Low gate voltage ٠
 - Can be switch to a high switching • frequency

	F				C Automation
Breakdown Voltage	Select VDS [V]	>	Select Type	>	Automotive
	12.0 V		N		Industrial
Drain Current ID(max)	at least 5	[A]	Select Package	>	
R _{DS (on)} (max)	below 500	[mOhm]	Select Topology	>	Select Product Status
Gate Charge Qo	below	[nC]	Boost	Price (*) below	
			Select Technology >		
Threshold Voltage	Select VGS(th)(max) [V] >			
	0.75 V				
					No products co

MOSFET Finder



Cross reference search

No products could be found Show Alternatives

Help

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[€/1K]

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

Amount
\$1,300.00*
TBD
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)

	Fri 1	1/3/17 Today											5at 4/21/18
Sep 24, '17 Oct 8, '17	Oct 22, 11	Nov 5, '17	Nov 19, 17	c 3, '17 Dec 17,	'17 Dec 31, '17	Jan 14, 18	Jan 28, '18	Feb 11, '18	Feb 25, '18	Mar 11, '18	Mar 25, '18	Apr 8, '18	Apr 22, '18
· ·				Δ	dd tasks with date	s to the timeline		•					Finish Map 4/20/1
													MI011 4/ 30/ 10
ask Name 👻	Duration		Finish - Predecessors	ovember 2017 3 8 13 1	December 8 23 28 3	2017 8 13 18 23	January 20 28 2 7	18 / 12 17 1	Februar 22 27 1	y 2018 6 11 16 1	March 201 21 26 3	8 13 18	April 2018 23 28 2 7 12
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	_ r									
⊿ 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										
	75 days	Mon 1/1/18	Fri 4/13/18				· · · · ·						1
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				· · · · ·						1
▲ Generator	75 days	Mon 1/1/18	Fri 4/13/18										1
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										1
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	6 days	Fri 4/6/18	Fri 4/13/18										

Devon/Kory - 18

References

- [1] Office of Energy Efficiency & Renewable Energy. (2017). *Collegiate Wind Competition*. <u>https://energy.gov/eere/collegiatewindcompetition/collegiate-wind-competition</u>
- [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 neurostimulation device compatible with MRI," in Electronics Letters, vol. 52, no. 15, pp. 1292-1293, 7 21 2016.
- [4] <u>www.mag-inc.com/Design/Design-Guides</u>
- [5] <u>https://www.infineon.com/cms/en/product/power/sicarbide-</u> <u>sic/channel.html?channel=ff80808112ab681d0112ab6a50b304a0</u>
- [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:<u>https://www.mcmaster.com/#standard-aluminum-rods/=1a4mp9e</u>. [Accessed: 05-Nov-2017