Bi-Directional Rotary Actuator

Group 9

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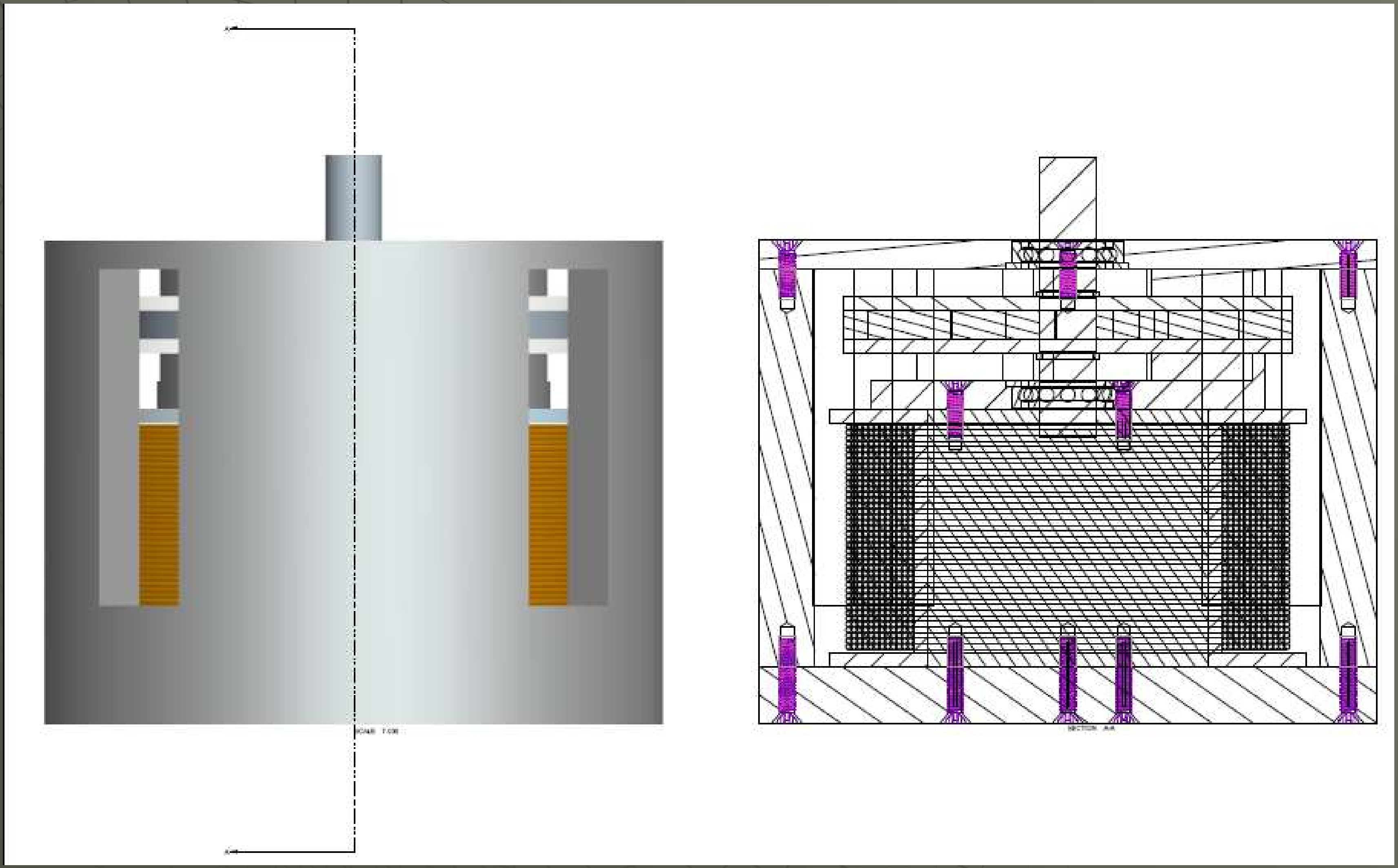
Scope

- ***Design a bi-directional rotary actuator***
  - ***Compact and easy to assemble***
  - ***Rotates either clockwise or counterclockwise with a return to a neutral position***
  - ***Electro-magnetic with a permanent magnet rotor***
  - ***Takes full advantage of maximum moment arm availability (pancake style)***
  - ***Single coil design***
  - ***Directionality is controlled by coil polarity***

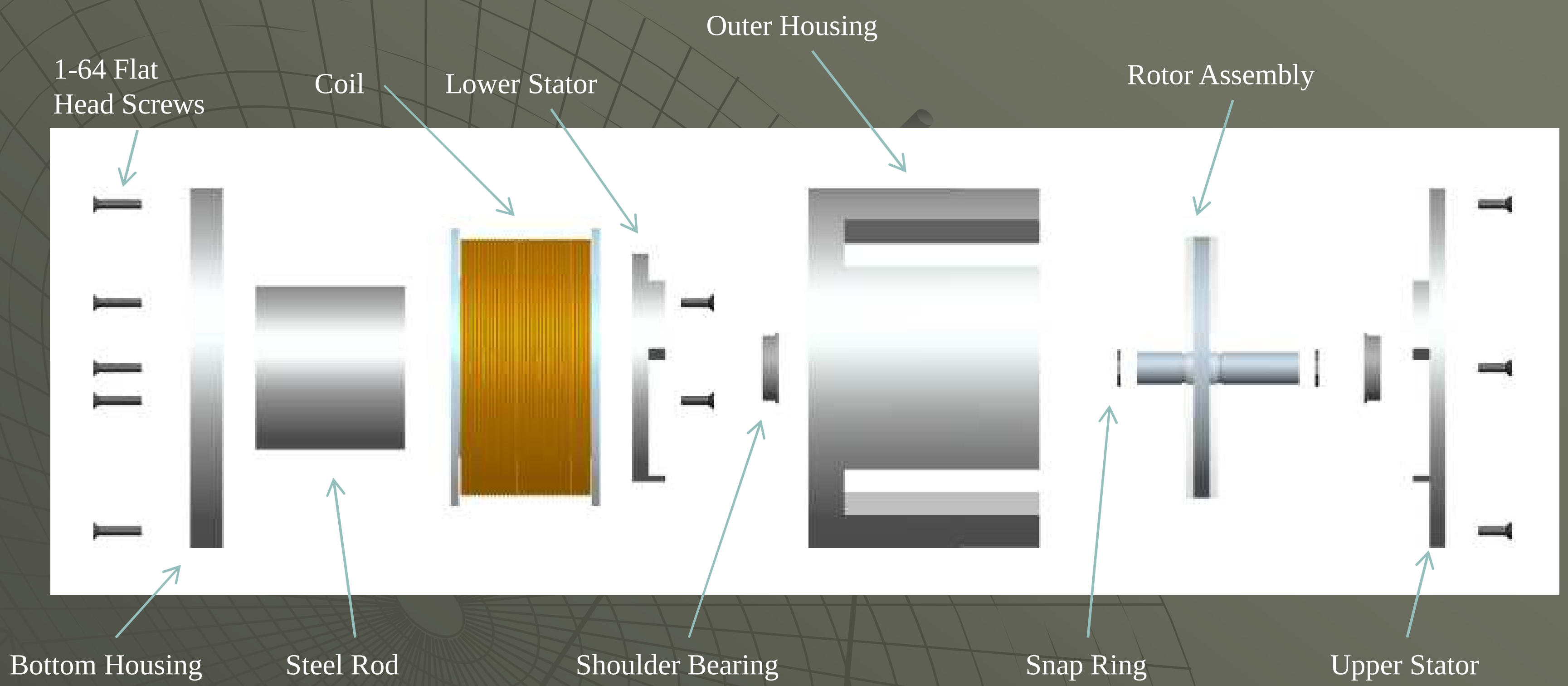
Constraints/Goals

- ***Rotor must be 2" in diameter***
- ***No springs to return to neutral position***
- ***Torque must be 0.31Nm or greater***
- ***Step size of 20° - 30°***

Final Design



Exploded View



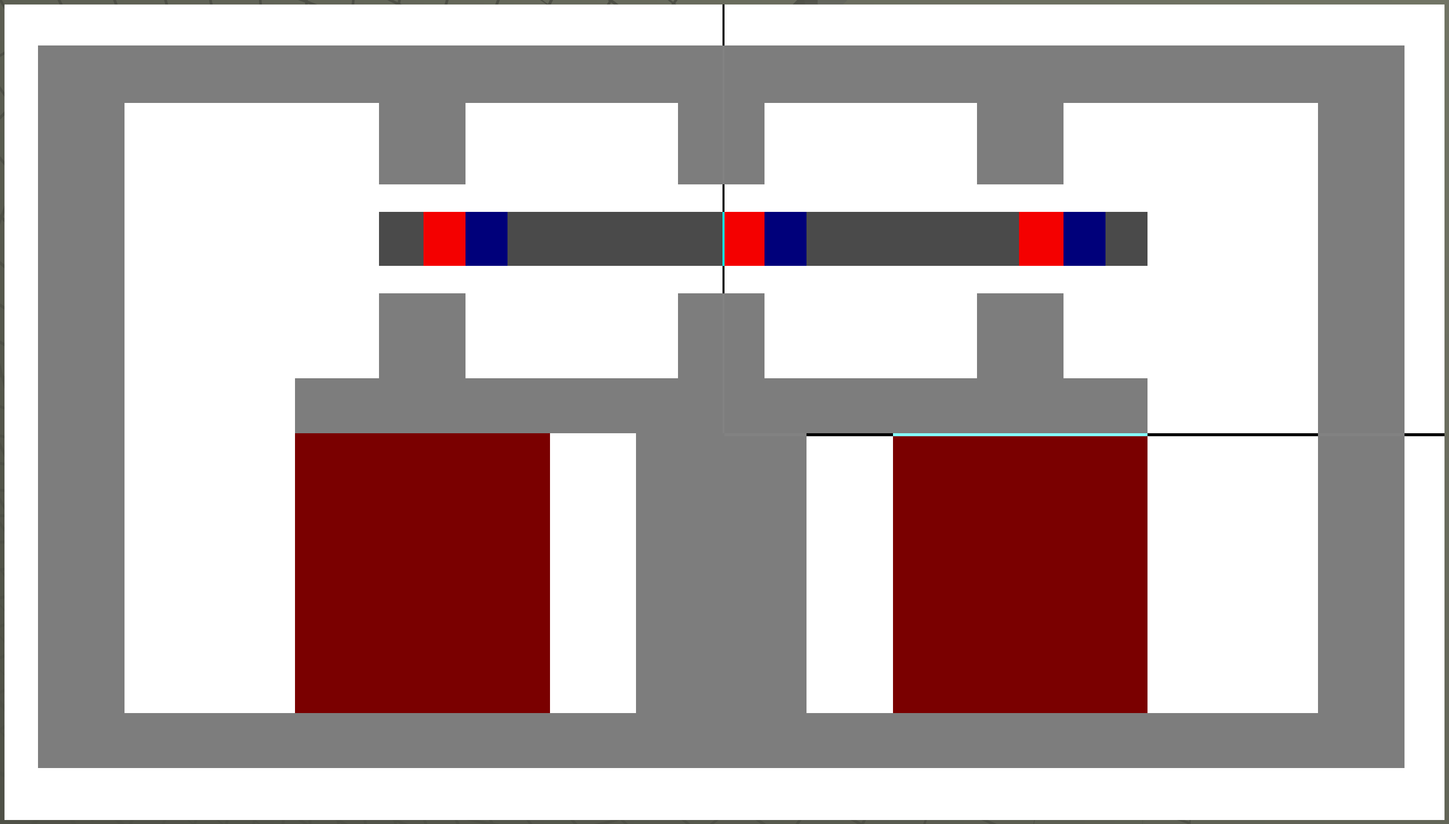
Major changes

- ***Cylindrical housing***
  - ***Uniformly distributed magnetic field***
- ***Inner magnets used.***
  - ***Helped to increase torque.***
- ***Changed from 4 poles to 3***
- ***Taller coil***
  - ***Lowered current density***
  - ***Distributed temperature over larger area.***

2-D Simulation

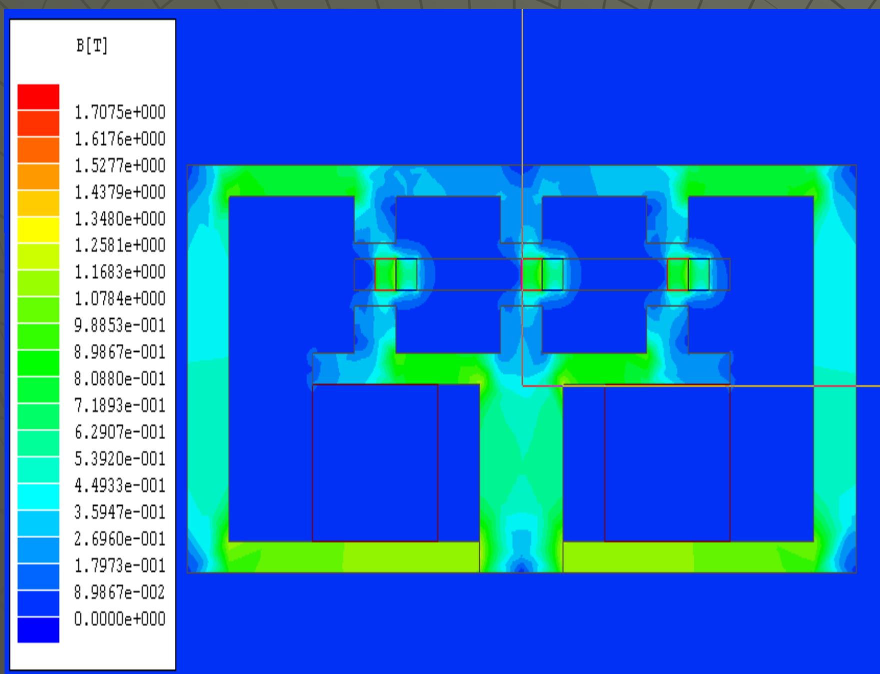
Using Maxwell 2-D SV

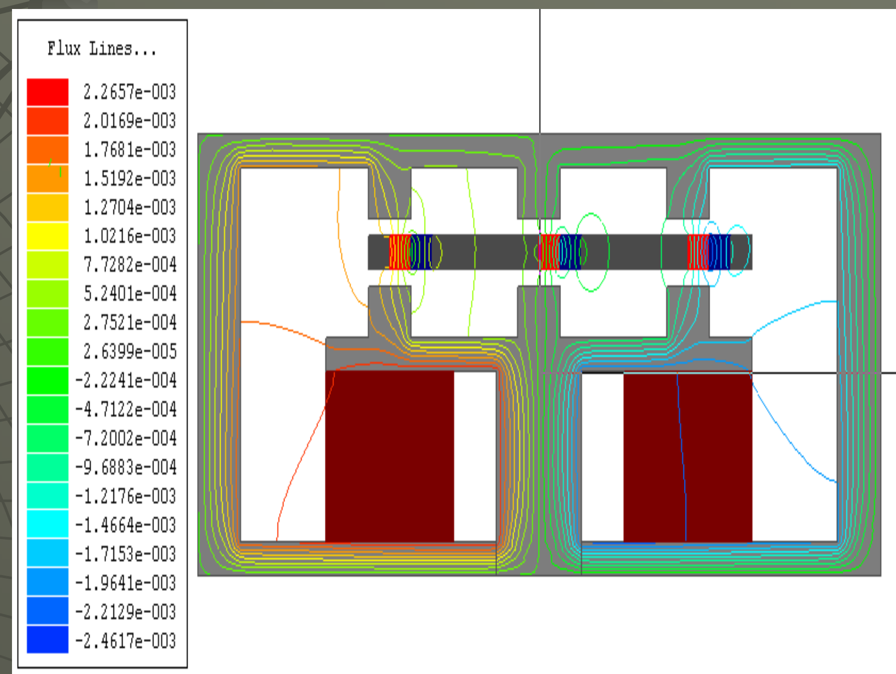
Off Position (No Current)



2-D Simulation

On Position (1500A)



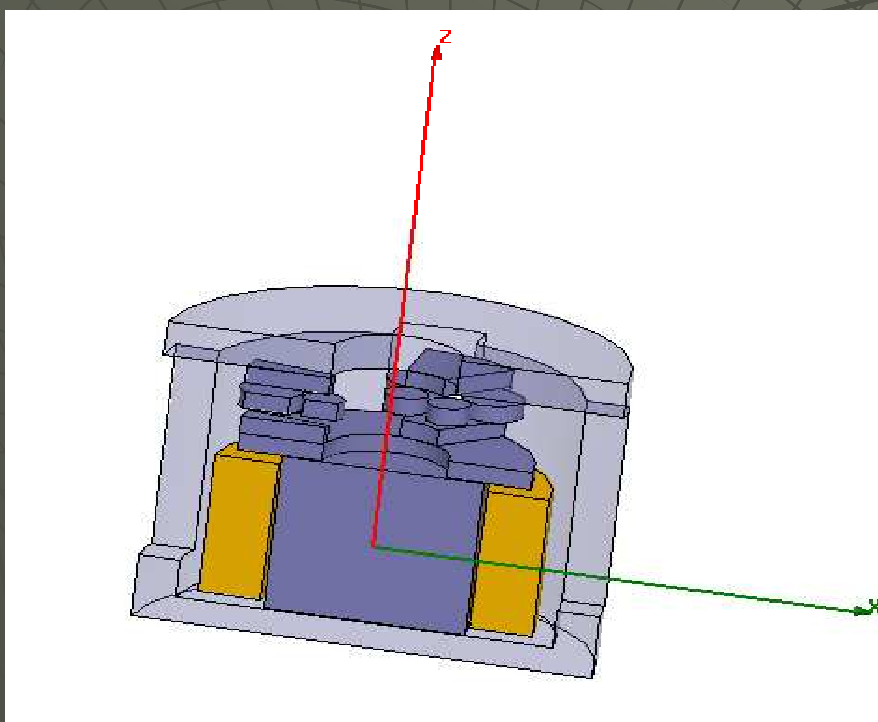


Shading in above figure represents magnetic field, lines represent magnetic flux

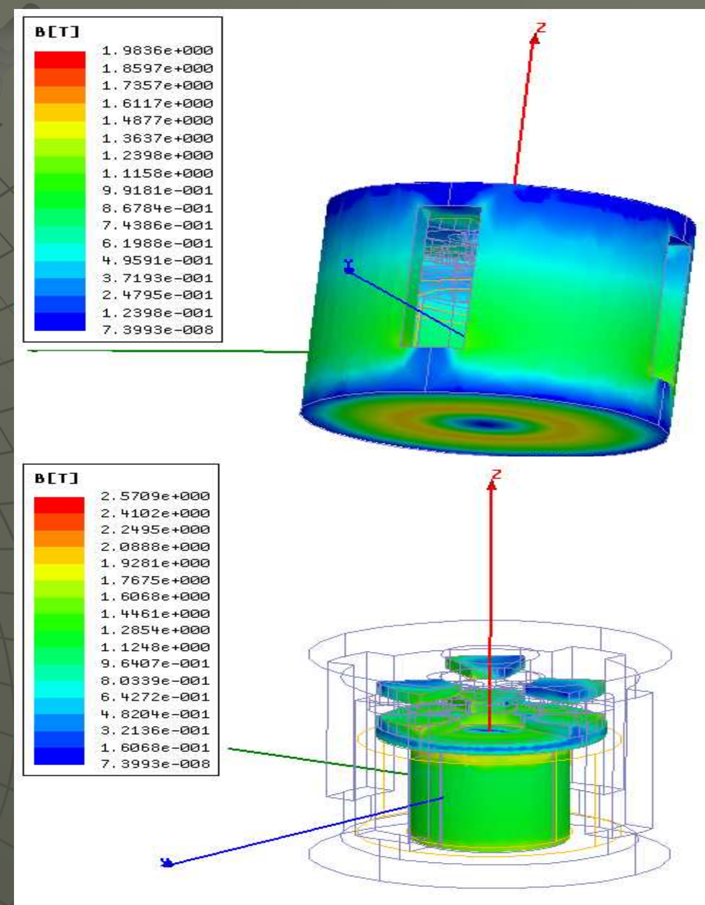
3-D Simulation

Using Maxwell 3-D

De-Energized



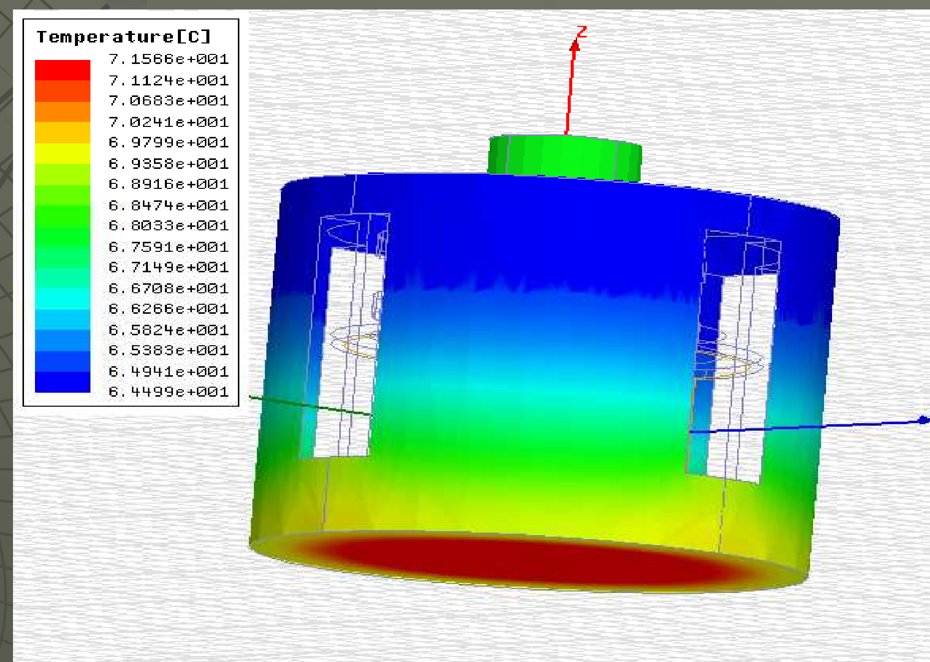
Energized



Thermal Modeling

- ***Surface Temperature***
  - ***Surrounding objects.***
  - ***Safety.***
  - ***Determined materials used for coil.***

E-Physics



Thermal Calculations

$L(t) := [2\cdot\pi\cdot(0.70 + 0.0251\cdot t)]in$ $\quad L = 231.594\ ft$

Current in the coil (Ampere turns)	$I_{coil} := 1500A$	
Resistivity of Copper	$\rho := 1.67\cdot 10^{-8}\Omega\cdot m$	
Current Density is given by	$J := \frac{I_{coil}}{A_{cross}}$	$J = 6.2\frac{A}{mm^2}$

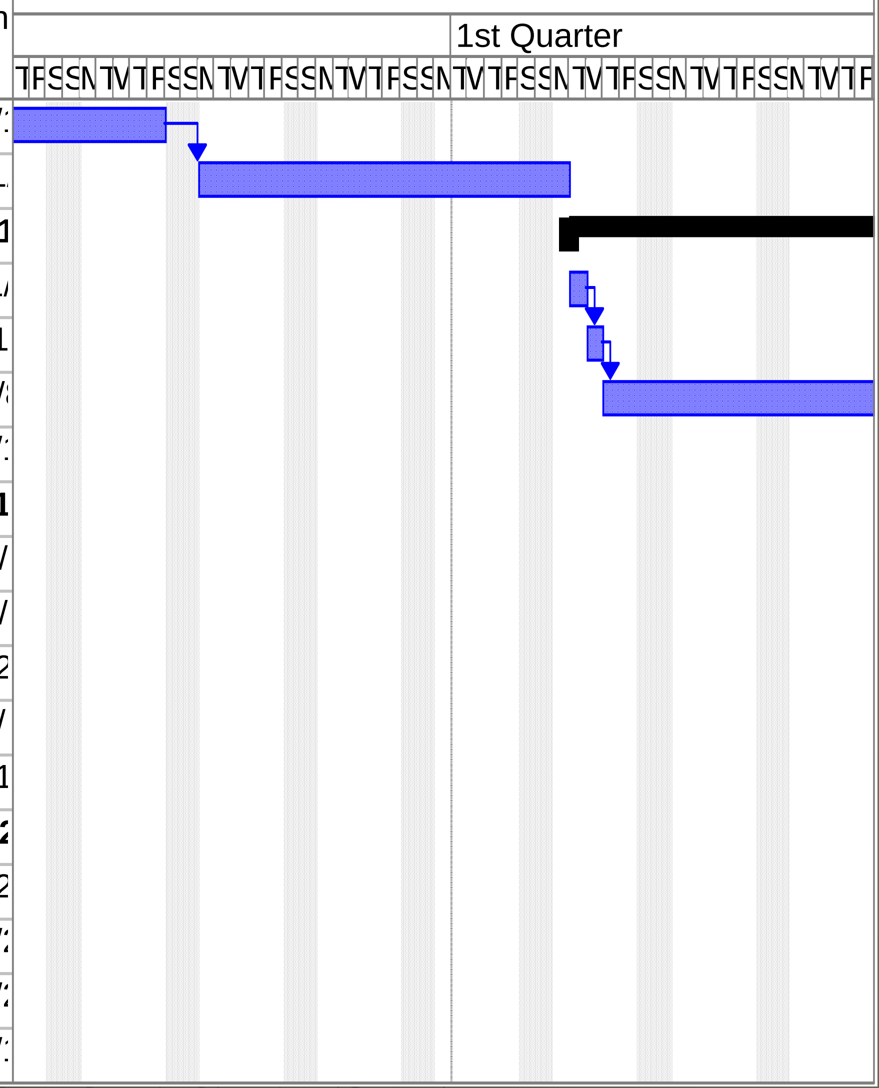
Resistance of wire	$R := \frac{\rho\cdot L}{A_{wire}}$	$R = 3.722\ \Omega$
Power Supply current required	$I_{supply} := \frac{J\cdot A_{wire}}{\frac{\pi}{4}}$	$I_{supply} = 2.5\ A$
Power Supply voltage required	$V := I_{supply}\cdot R$	$V = 9.306\ V$
Heat Generated by Coil	$P := I_{supply}^{2}\cdot R$	$P = 23.265\ W$

Budget

Part	Part No.	Description	Quantity	Unit Price	Total Price	Supplier
Bottom Housing Outer Structure Lower Stator Upper Stator	8279T221	1045 Medium Carbon Steel 2-3/4" x 12" Rod	1	$54.23	$54.23	McMaster-Carr
Steel Rod	8924K311	1045 Medium Carbon Steel 1-1/4" x 12" Rod	1	$10.74	$10.74	McMaster-Carr
Rotor Core	9042K1	Aluminum 6062 2" x 1" Disc	1	$6.84	$6.84	McMaster-Carr
Rotor Caps	8589K21	Cast Acrylic 12" x 12" Sheet	1	$2.54	$2.54	McMaster-Carr
Coil Spool	7662K14	Polyetherimide 2.5" x 3" Rod	1	$38.95	$38.95	McMaster-Carr
Copper Wire	8873K19	22AWG Insulated Copper Wire	2	$9.65	$19.30	http://www.action-electronics.com/magnetwire.htm
Shoulder Bearing	4259T15	SS Flanged Ball Bearing ID 0.25", OD 0.50"	2	$14.12	$28.24	McMaster-Carr
Snap Ring	91590A113	SS Snap Ring 0.25" x 0.025" 10 Pack	1	$7.50	$7.50	McMaster-Carr
Flat Head Screw	91771A068	1-64 UNC x 0.375" 100 Pack	1	$12.29	$12.29	McMaster-Carr
Flat Head Screw	91771A066	1-64 UNC x 0.25" 100 Pack	1	$11.48	$11.48	McMaster-Carr
Magnets		Neodymium 0.25" x 0.125"	6	$30.00	$30.00	magnetmasters.com
		Neodymium 0.375" x 0.125"	6	$30.00	$30.00	magnetmasters.com
Power Supply	14604 PS	0-30VDC @ 0-10A Constant Voltage or Current	1	$169.99	$169.99	powersupplydepot.com
JB Weld High Temp	8265-S	Metal to Acrylic Adhesive	2	$5.53	$11.06	McMaster-Carr
Fan	S35-1090	120mm Case Fans	4	$9.99	$39.96	tigerdirect.com
Machining	-	Possible CNC work	1	$500.00	$500.00	
Shipping	-	Shipping Charges	1	$200.00	$200.00	
Total	-	-	-	-	$1,173.12	

Plan for Spring '08

ID		Task Name	Durat	Start	Finish
1		Order Parts	7 da	Thu 12	Fri 12/
2		Winter Break	16 d	Mon 12/	Mon 1
3		**Fabrication**	**26 d**	**Tue 1/**	**Tue 2/1**
4		Prepare Detailed Drawi	1 d	Tue 1/	Tue 1/
5		Begin Machining	1 d	Wed 1	Wed 1
6		Machine Time	22 d	Thu 1/	Fri 2/
7		Final Assembly	2 da	Mon 2/	Tue 2/
8		**Testing**	**23 d**	**Wed 2/**	**Fri 3/1**
9		Initial Test (Assuming P	1 d	Wed 2/	Wed 2/
10		Analysis of Tests	5 da	Thu 2/	Wed 2/
11		Modify Testing	7 da	Thu 2/	Fri 2/2
12		Spring Break	6 da	Mon 3	Mon 3/
13		Re-Test	4 da	Tue 3/	Fri 3/1
14		**Reporting**	**9 da**	**Mon 3/**	**Thu 3/**
15		Final Testing Analysis	5 da	Mon 3/	Fri 3/2
16		Final Reports	4 da	Mon 3/	Thu 3/
17		Operations Manual	4 da	Mon 3/	Thu 3/
18		Final Presentations and O	13 d	Tue 3/	Thu 4/



Questions?