Compact Low Voltage AC Induction Motor

Commissioned by Grainger Prototype Lab

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Department of Mechanical Engineering
University of Wisconsin - Madison
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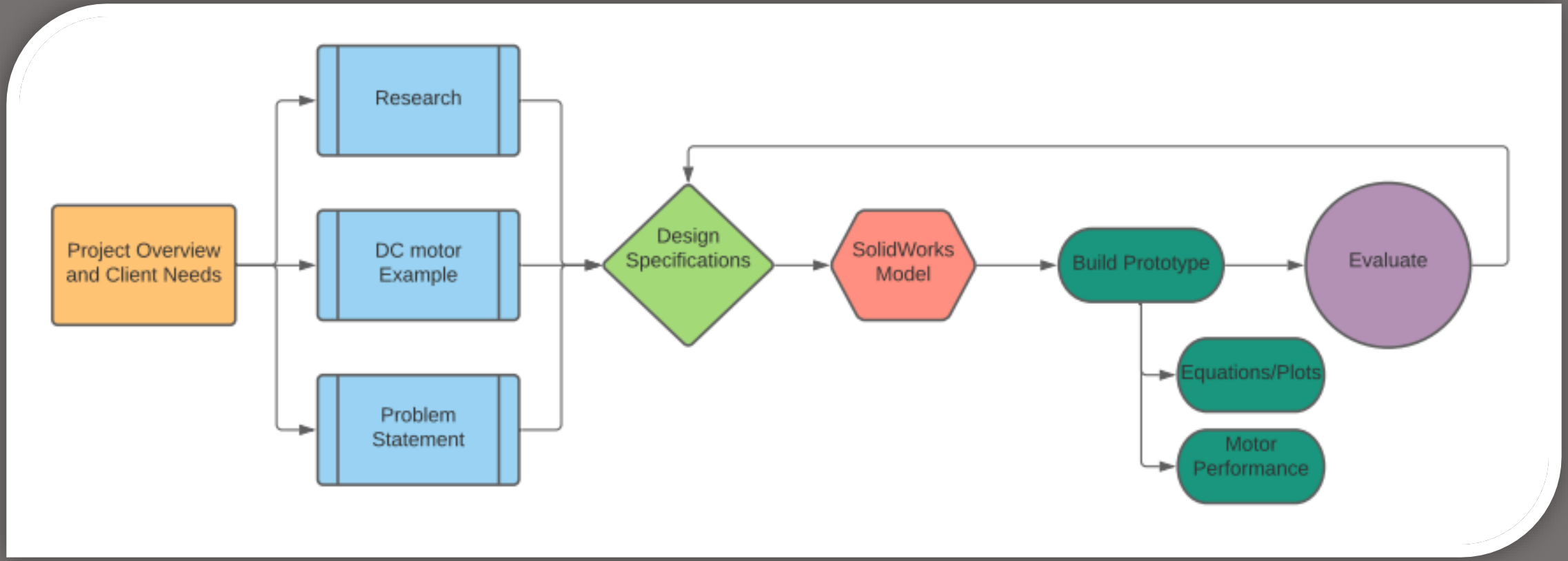
Agenda



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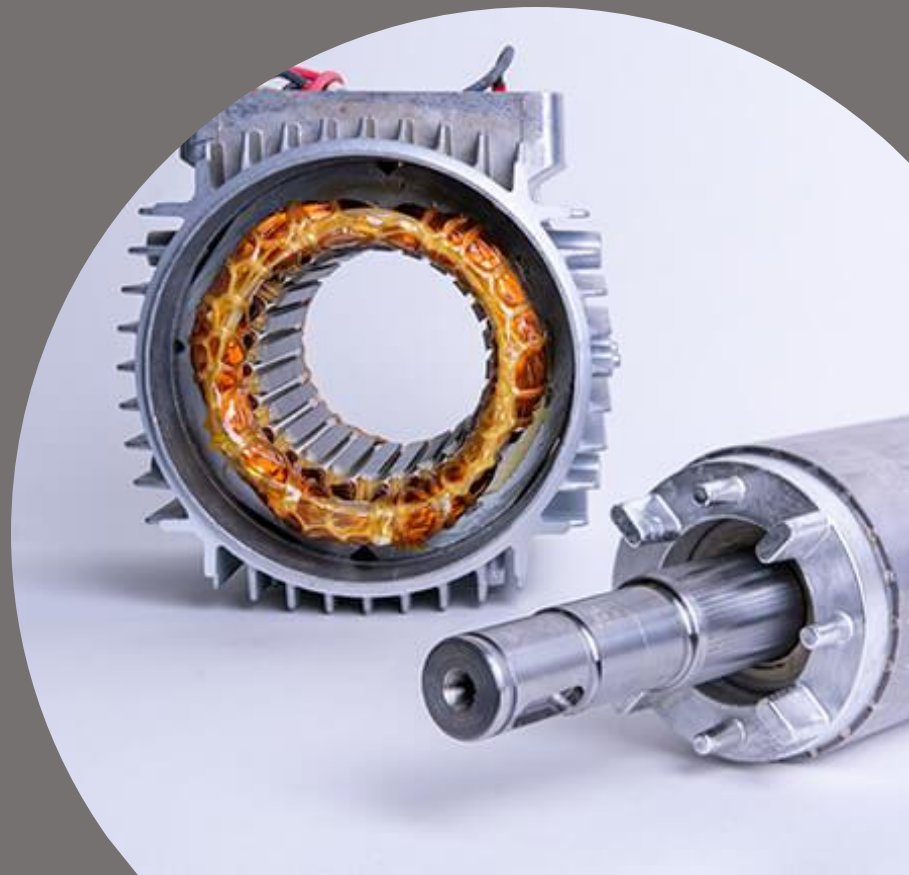
Project Overview and Client Needs



Project Overview and Client Needs

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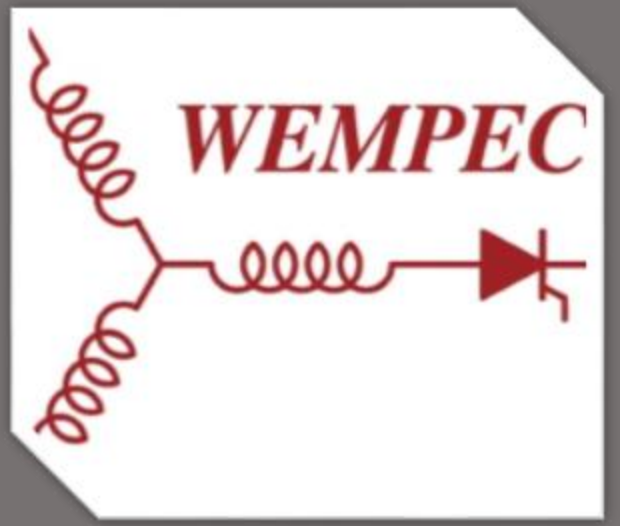
Stakeholders

Induction Team

Client
(Grainger Teaching Studio)



Professors

Students

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Problem Statement

Typical Induction Motor

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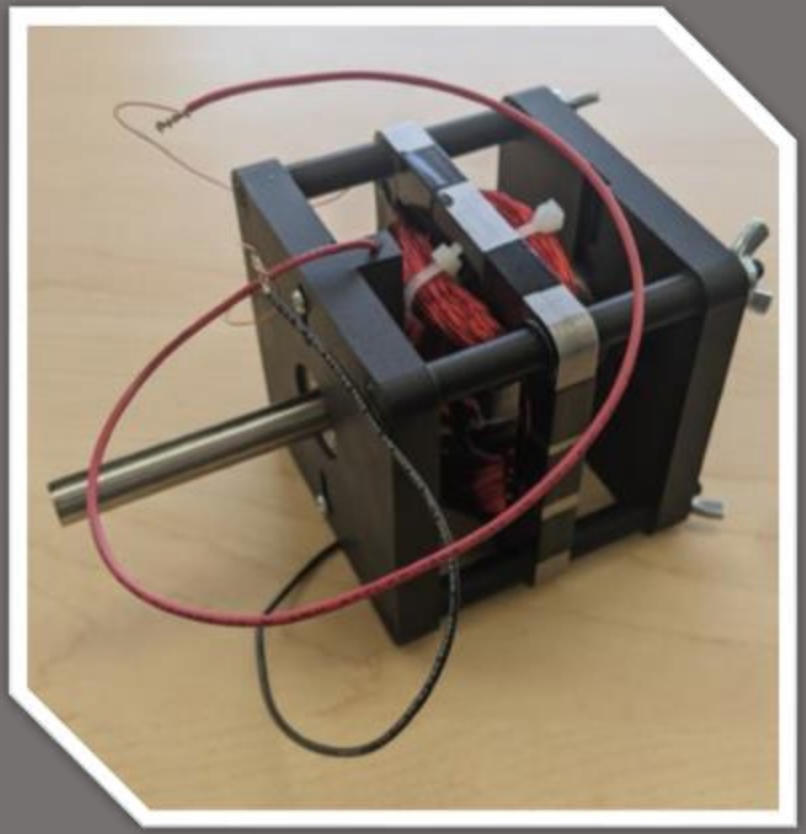
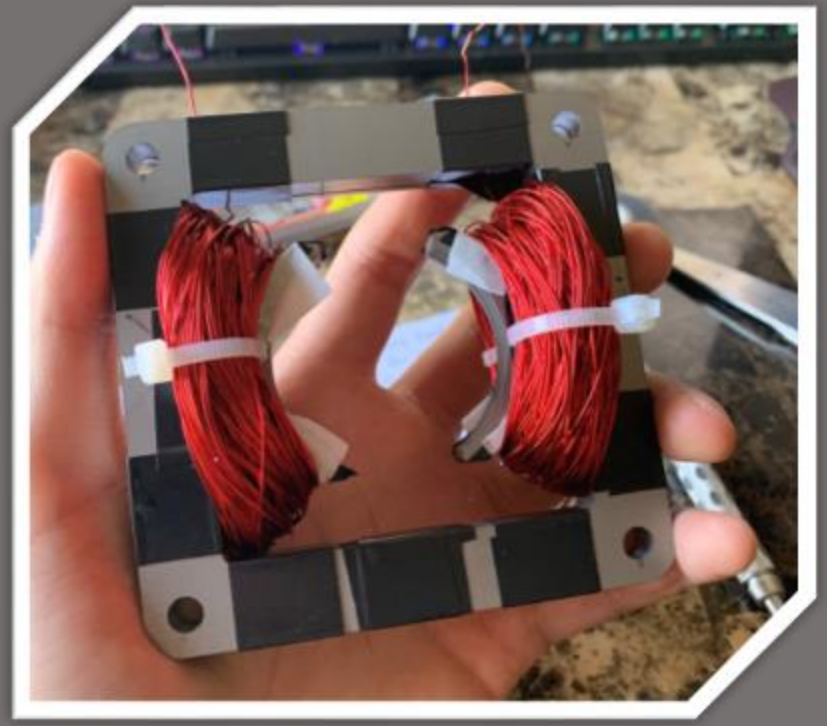
DC Motor Example





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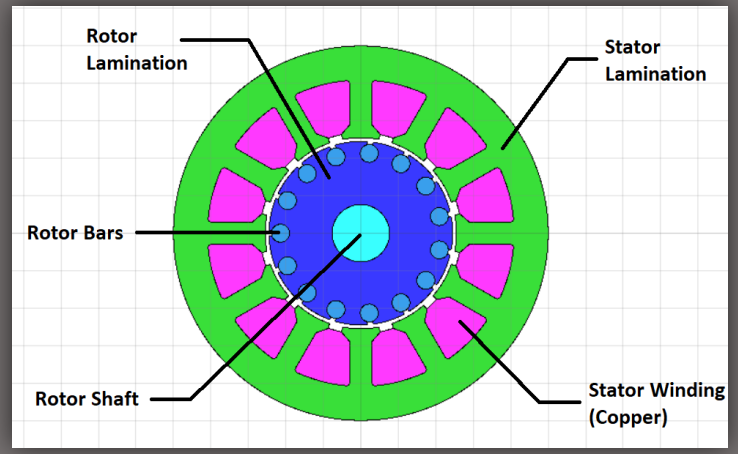
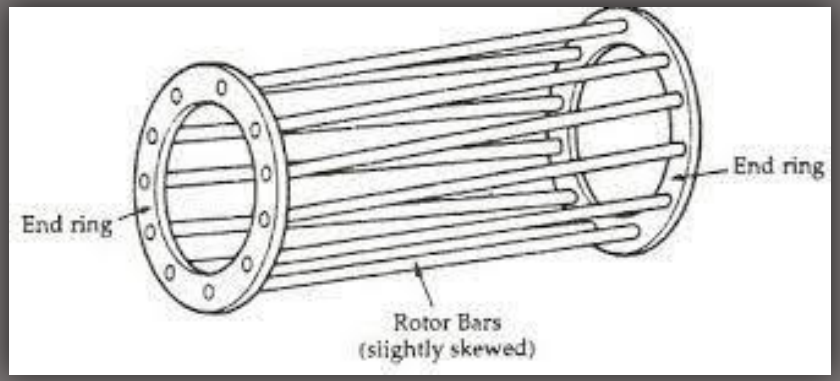
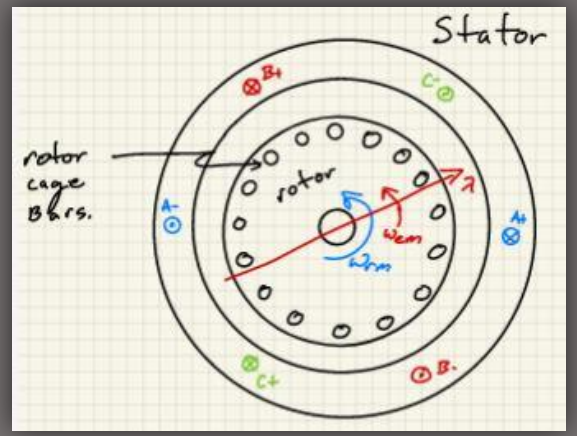
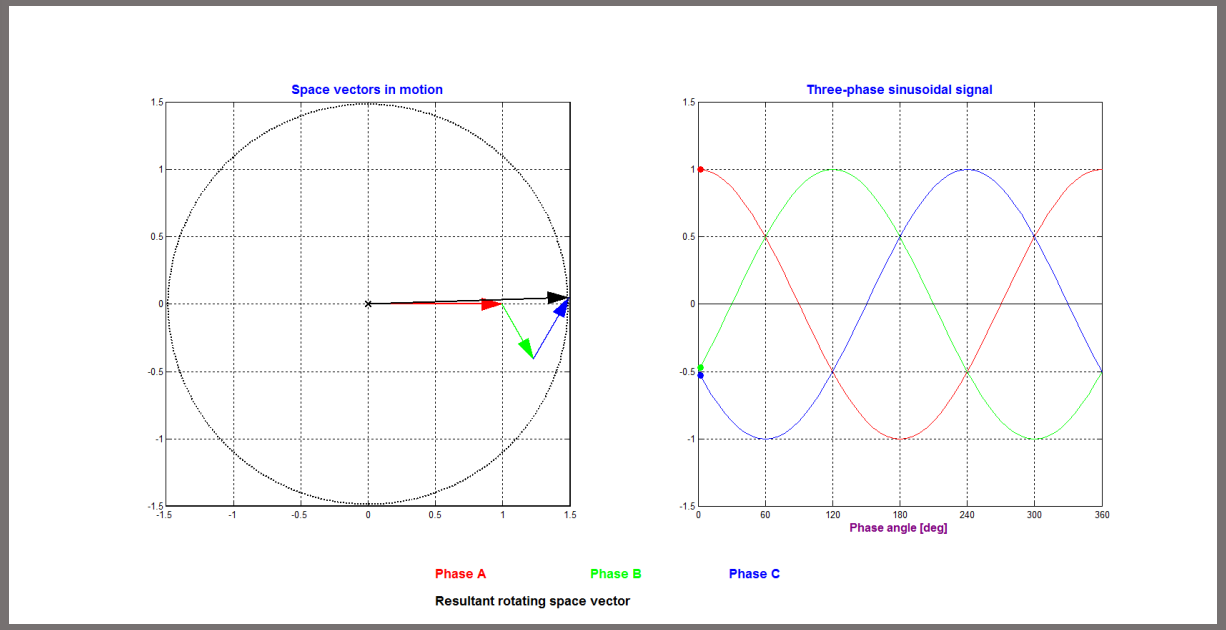
Research









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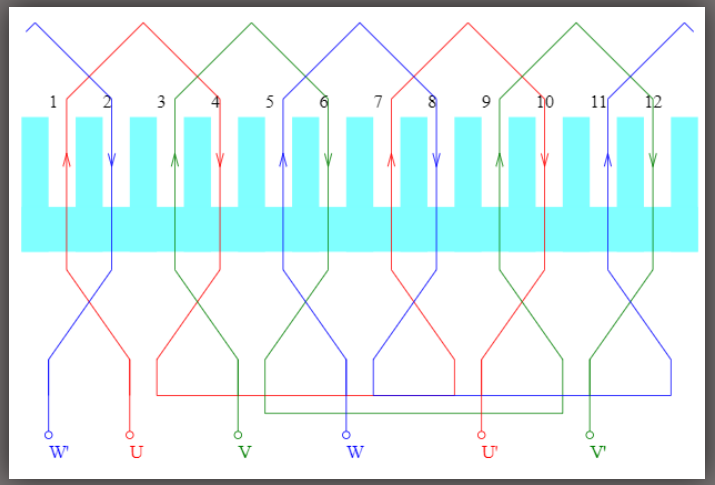
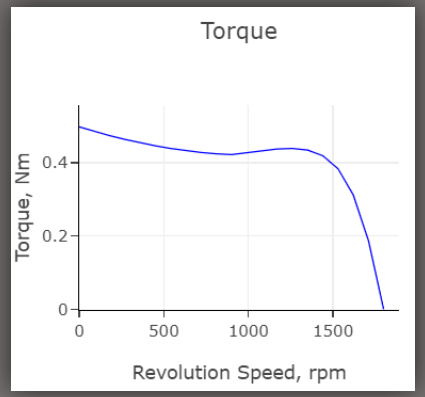
JMAG Design Process

Targeted Value	
☑ Rated Power, kW	0.1
☐ Maximum Torque, Nm	
☑ Rated Revolution Speed, rpm	1700
☐ Maximum Revolution Speed, rpm	
Sizing Parameter	
☑ Number of Poles	4
☑ Number of Slots	12
☑ Number of Bars	13
☐ Power Supply Voltage(RMS), V	
☑ Maximum Current(RMS), A	
☑ Maximum Outer Diameter of Motor, mm	
☑ Maximum Motor Height, mm	
☑ Cage	Copper

Input Design Parameters



Configure Windings



Evaluate Results

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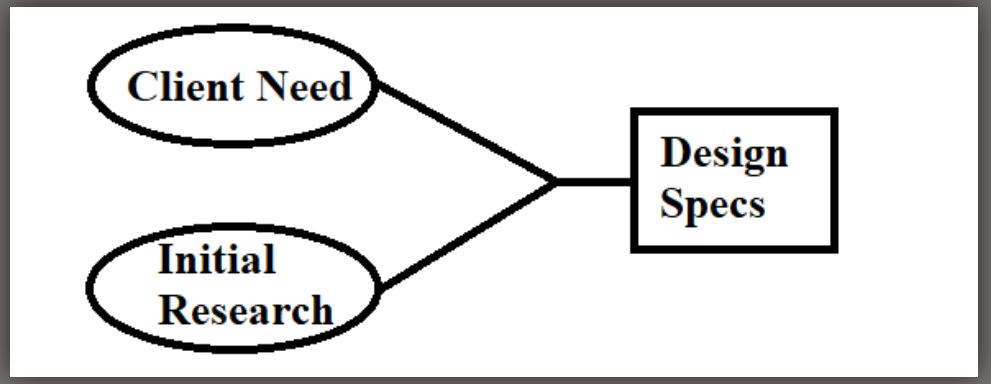
Design Specifications

- Top Priority Specifications
  - Easy to Manufacture
  - 3 Phase AC Supply
  - <$100 / motor
  - Mountable on Existing Dyno
  - Spins



Design Matrices – Overall Design

Design Spec:	Levels:	Design A
Winding Layer Type	Single	**Single**
	Double	
Number of Poles	2 [3600 rpm]	**4**
	4 [1800rpm]	
Consideration:	**Relative Importance:**	**Design A**
Manufacturability	30	**0.25**
Cost	25	**0.8**
Learning Potential	35	**0.95**
Efficiency	10	**0.8**
Rating (Highest Most Favorable)	(/100)	**68.75**

First Prototype

Design Spec:	Levels:	Baseline - Kit	Design A	Design B	Design C
Winding Layer Type	Single	Single or Double	**Single**	Double	Single
	Double				
Number of Poles	2 [3600 rpm]	4	**4**	2	2
	4 [1800rpm]				
Consideration:	**Relative Importance:**	**Baseline - Kit**	**Design A**	**Design B**	**Design C**
Manufacturability	30	1	**0.25**	0.3	0.3
Cost	25	0.1	**0.8**	0.8	0.8
Learning Potential	35	0.25	**0.95**	0.9	0.9
Efficiency	10	1	**0.8**	0.6	0.65
Rating (Highest Most Favorable)	(/100)	51.25	**68.75**	66.5	67
*Design A (in bold) was used for the first prototype.					

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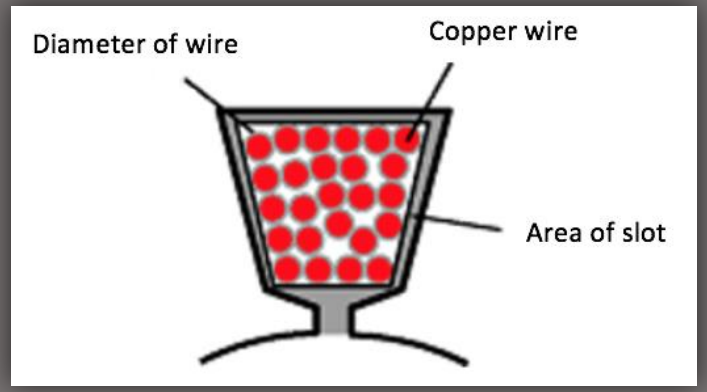
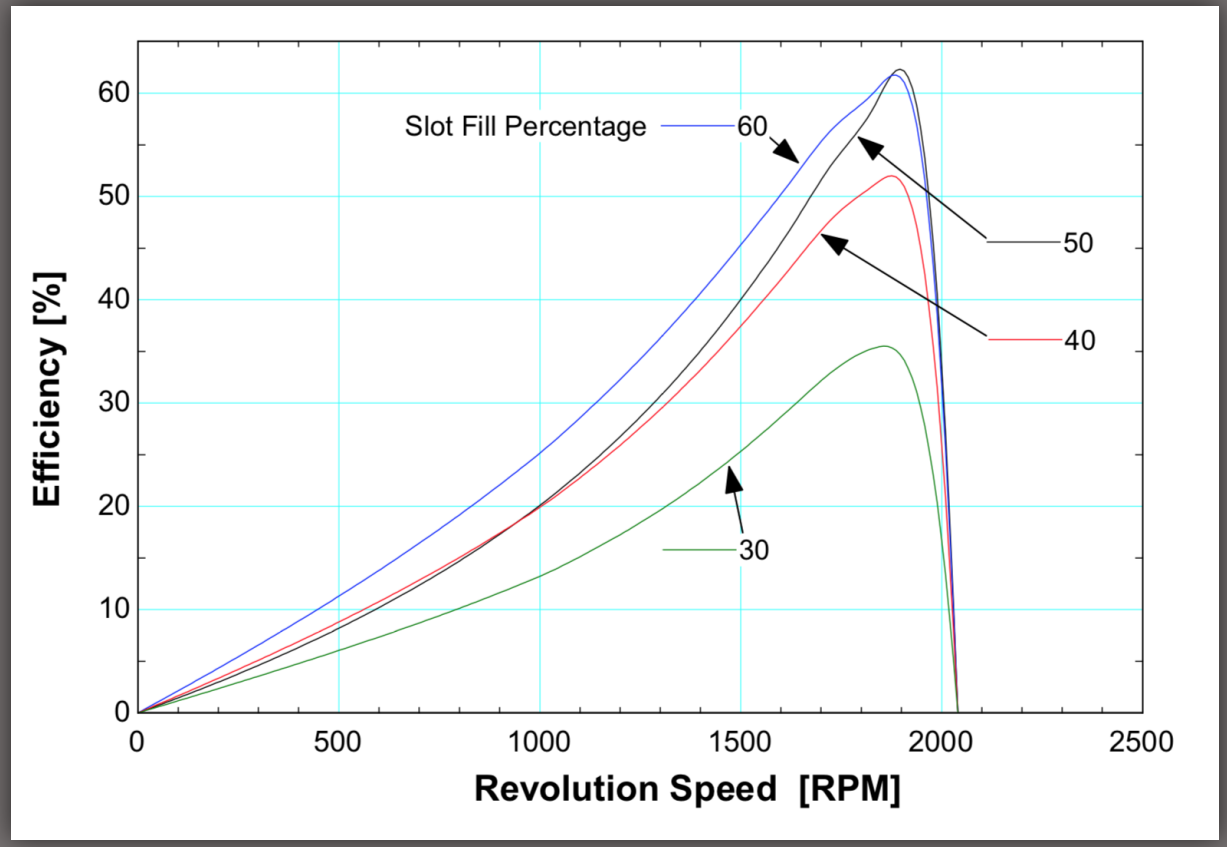
Equations/Plots

$$Fill_{Factor} = \frac{2 \cdot \pi \cdot \left[\frac{d_{wire}}{2}\right]^2 \cdot N}{A_{slot}}$$





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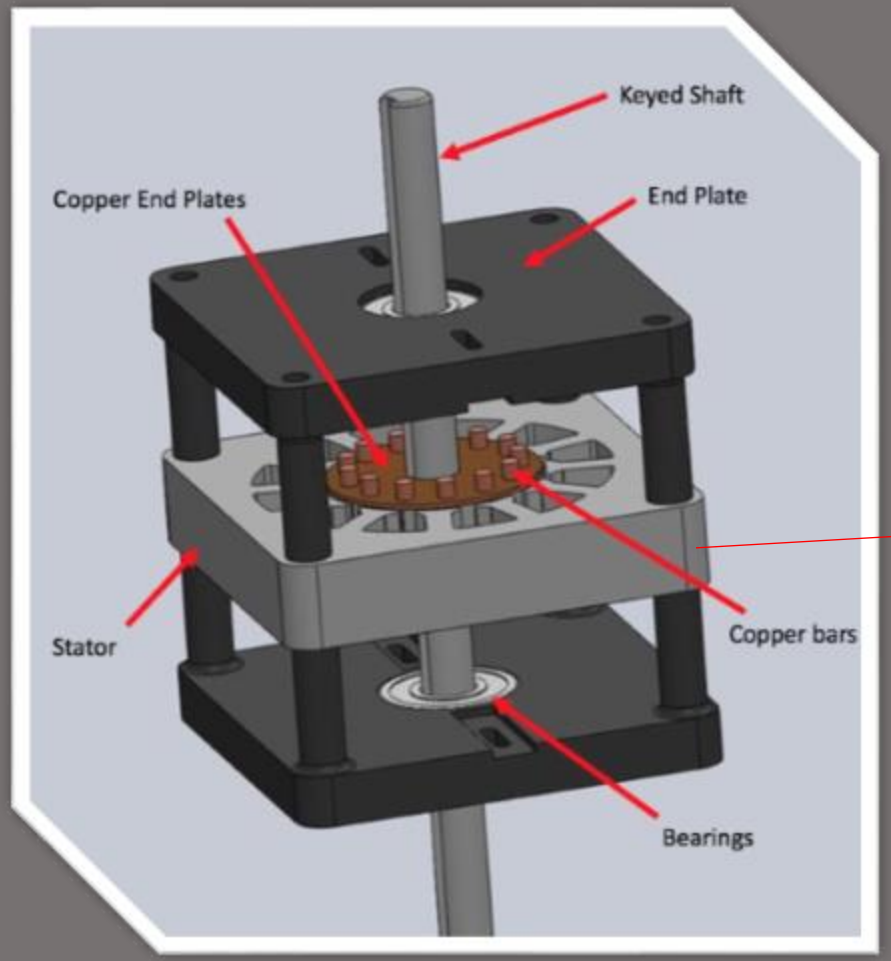
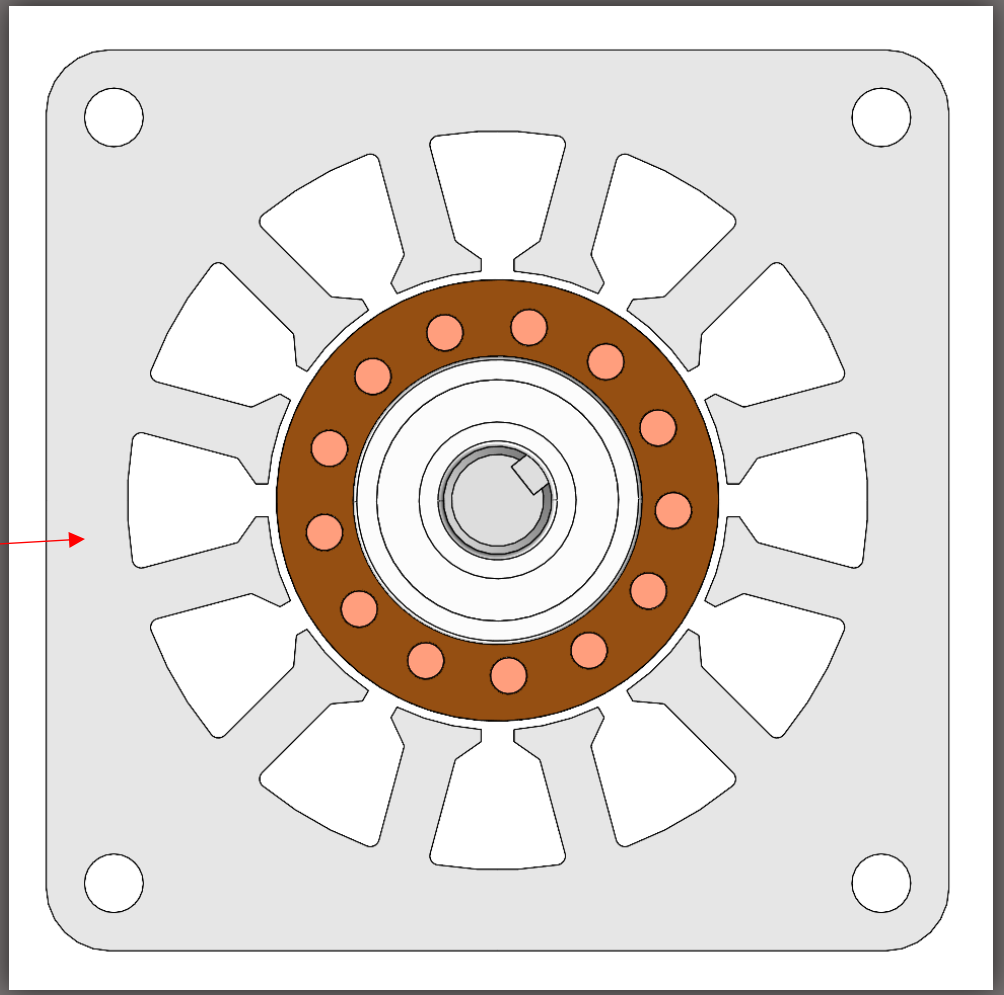
SolidWorks Model





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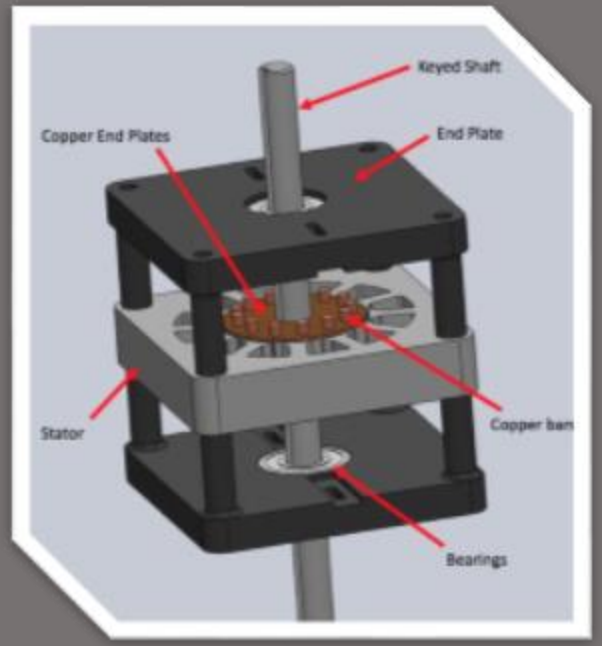
Fabricate Prototype

- Laser Cut Laminations
- Water Jet Copper End Plates
- 3D Print End Plates
- Band Saw Copper Bars



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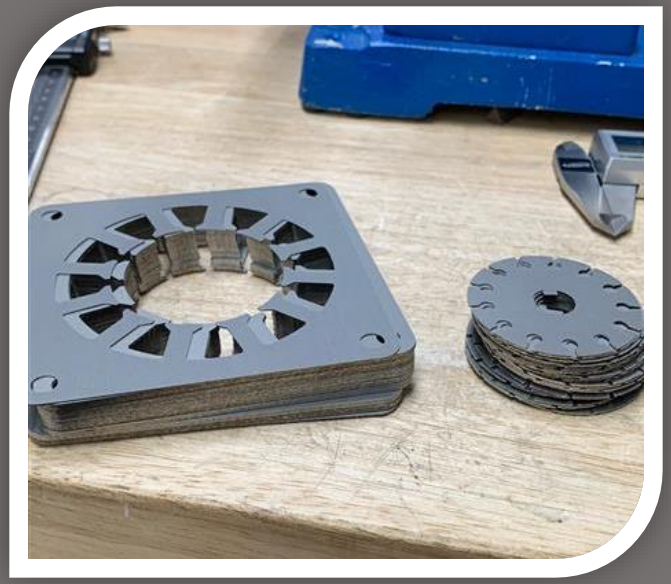
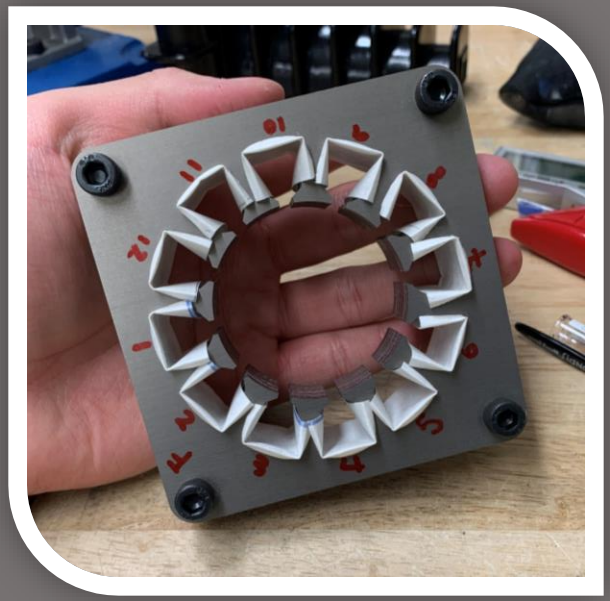
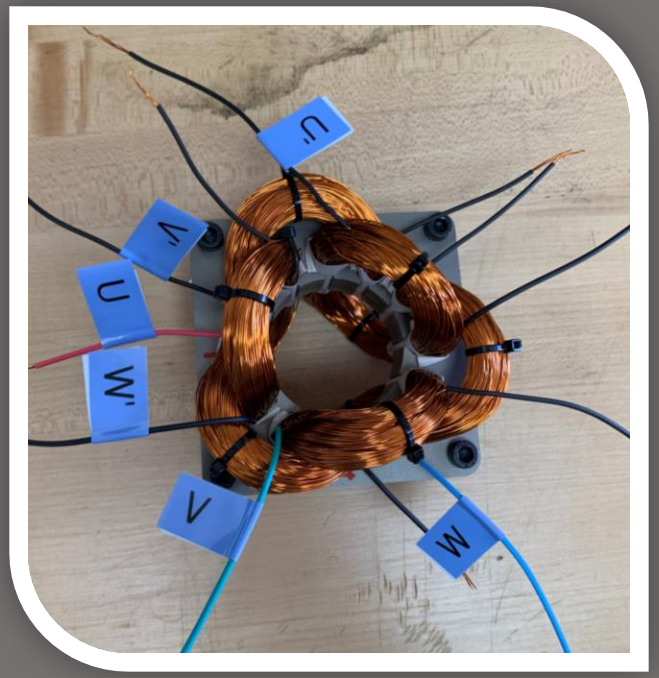
Assemble Stator





Assemble Windings



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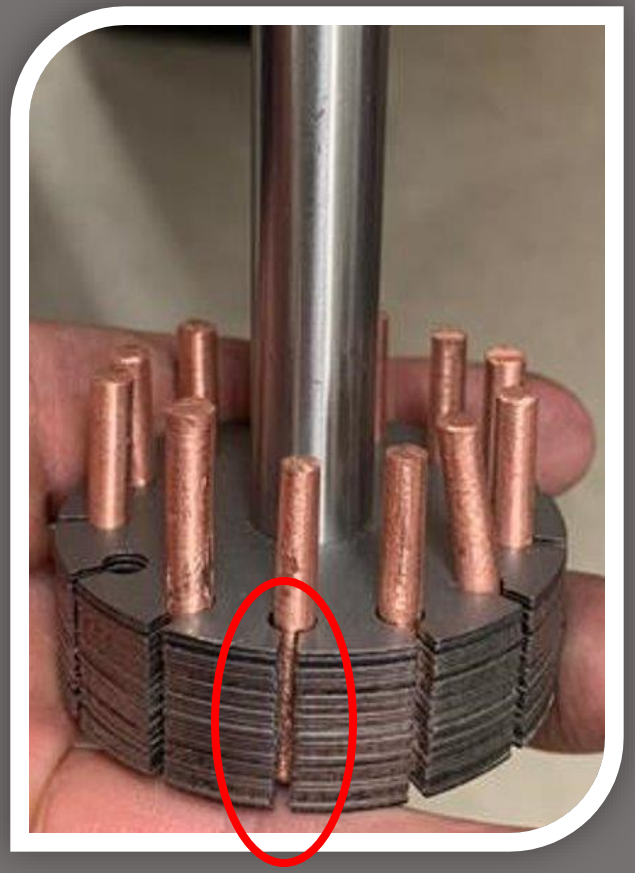
Assemble Rotor



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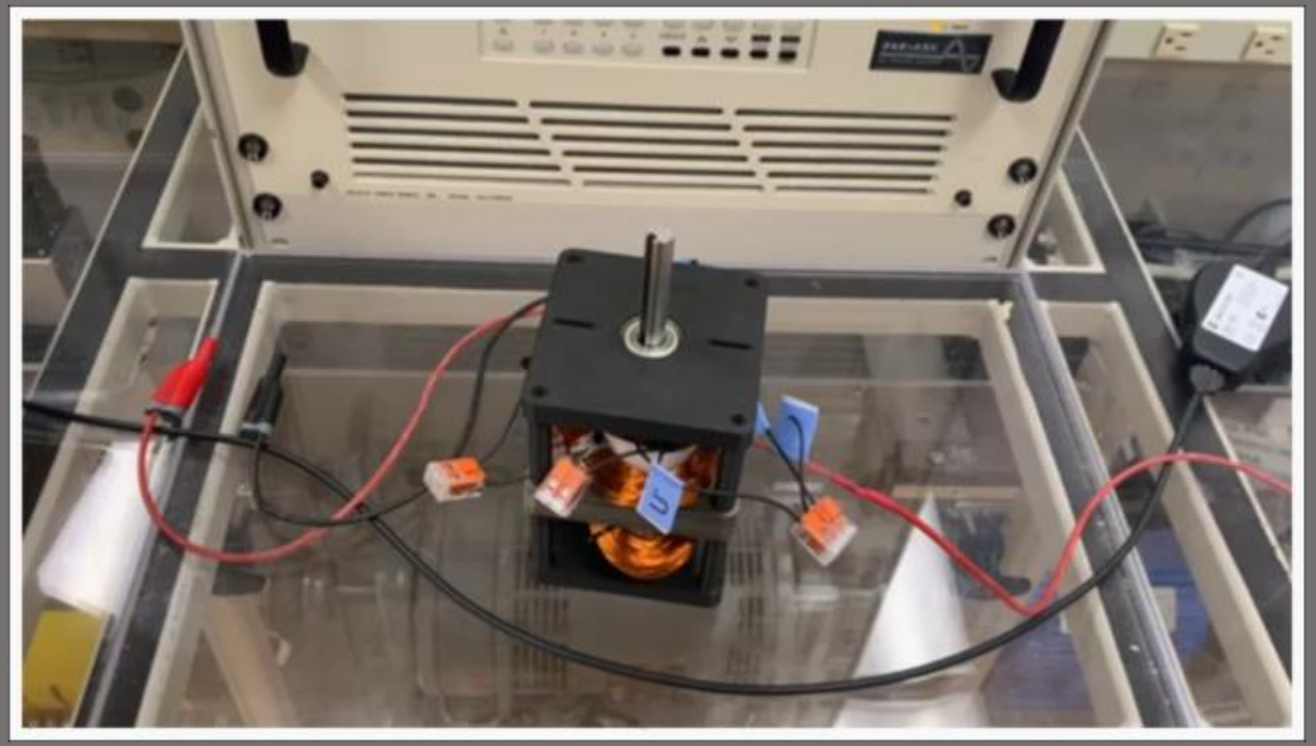
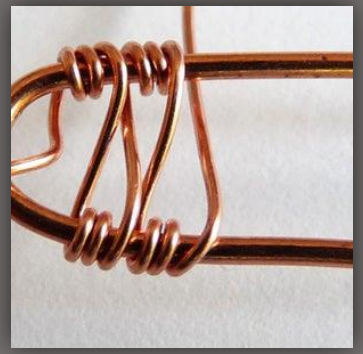
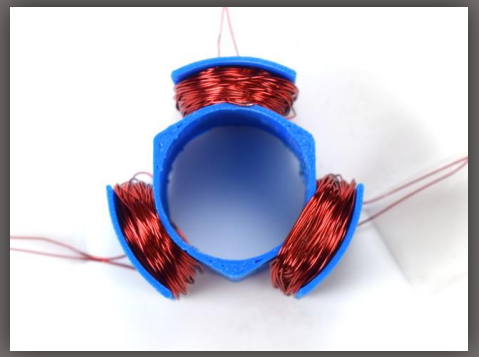
Full Assembly/Testing



Future Iterations

Improve Manufacturability





Decrease Cost

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Design Matrices - Windings

First Prototype

Design Spec:	Levels:	Baseline	Design A	Design B
Stator Winding Configuration	1) 24 AWG | N Loops 2) 24 AWG | <N Loops 3) >24 AWG | >N Loops	1	2	3
Consideration:	**Relative Importance:**	**Baseline**	**Design A**	**Design B**
Manufacturability	30	0.25	0.6	0.5
Cost	25	0.8	0.9	0.9
Learning Potential	35	0.95	0.95	0.95
Efficiency	10	0.8	0.6	0.6
Rating (Highest Most Favorable)	(/100)	68.75	79.75	76.75
*Baseline is First Prototype Built. N=Loops in First Prototype				

First Prototype

Design Spec:	Levels:	Baseline	Design A	Design B
Squirrel Cage Design	1) Bars + End Plates 2) Continuous Wire 3) Alum. Fasteners	1	2	3
Consideration:	**Relative Importance:**	**Baseline**	**Design A**	**Design B**
Manufacturability	30	0.25	0.5	0.35
Cost	25	0.8	0.95	0.85
Learning Potential	35	0.95	0.95	0.95
Efficiency	10	0.8	0.7	0.7
Rating (Highest Most Favorable)	(/100)	68.75	79	72
*Baseline is First Prototype Built				

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Questions?