

Included in this package are the Solidworks file of the proposed axial gap electrical hub motor, several graphical representations of the performance of a similar design, as well as, some hand written electromagnetic calculations used to choose the values of the design variables we considered. The program Maxwell3D was used to perform our dynamic, electromagnetic analysis. Due to technical issues with the program, we were unable to run the RNxpvt module within the program which allows for sophisticated hub motor design and performance analysis. However, using other 3D components we were still able to design the rotor, magnets, stator slots, and windings, and eventually run a dynamic analysis. It must be noted, however, that the Solidworks model included in this package was designed using thorough research and handwritten calculations, as the program did not have the capacity to run the simulations without crashing.

The design we used was too complex for any machine at MIT that runs Maxwell3D, and consequentially, we could not run our exact design in the simulator without a crash. However, we did run a similar, albeit simpler, model and from this we were able to produce a few graphs of the motor performance vs. time.

In addition to this, a list of our design variables, constraints, and performance criteria are included. The overall goal was to maximize our efficiency and power density while maintaining the size and weight constraints given. All of the eventual design variables were assigned values, and are representative of our Solidworks model.

#### Overall Performance Parameters:

Power Density

Efficiency

Design Variables: (Note: Due to the enormous complexity of the motor design, a vast majority of these design variables were decided upon by extensive research on similar motors and their respective performances)

Number of Poles (8)

Number of Stators Slots (18)

Inner Radius (252 mm)

Phase Number of the Motor (3 phase)

Axial Air Gap Length (1 mm)

Core Thickness (25 mm)

Winding layers (2)

Number of turns per layer (41)

Coil Pitch (4)

Slot Type 2 (Maxwell 3D defined Slot geometry, All subsequent values given by this pre-defined library)

Slot Opening Height (1 mm)

Slot Wedge Height (1 mm)

Slot Body Height (8 mm)

Slot Opening Width (2.5 mm)

Slot Wedge Maximum Width (6 mm)

Slot Body Bottom Width (6 mm)  
Slot Body Bottom Fillet (3 mm)  
Number of Winding Layers (2)  
Wire Diameter (.82 mm)

### Constraints

Voltage (96 V), subject to controller design  
RPM (750 rpm)  
Stator Diameter ( < 360 mm)  
Rotor Diameter ( < 360 mm)  
Motor Thickness ( < 150mm)  
Weight ( < 30 Kg)

As is evident from the (by no means complete) above list, there are many, many design variables involved with the design of systems of this complexity, some discrete and exclusive configurations such as pole count and core composition, some continuous attributes such as rotor diameter and supply voltage, and some that don't fit easily into either category (Hall sensor placement, for example). In order to constrain the problem a bit better while still allowing for a good design, many design variables were fixed according to empirical evidence. For example, motors built in an axial-flux configuration are known within the industry for simply having better efficiency than radial-flux motors. It was therefore possible for us to choose an axial-flux configuration without performing calculations for comparison; they have been done many times.

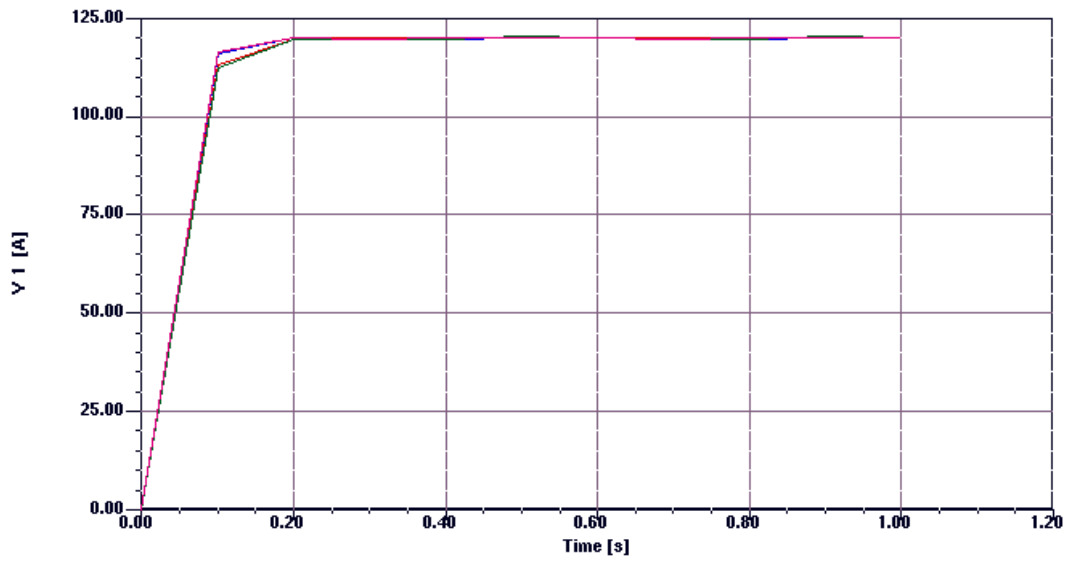
The remaining design variables were set with previous designs in mind. Many were chosen on the basis of simple principles and calculations relating to things like efficiency, impedance and airflow (e.g. at 90% efficiency, if the motor is to output 10kW of power, it must be supplied 11111W by the controller, and it will have to dissipate the difference between the two). Without a complicated computer simulation, it is nearly impossible to optimize these design variables.

Although it would have been vastly preferable had the "Analyze All" feature in Maxwell3D been fully functional, as we could have done multiple variable analyses on several design variables at once while maintaining the integrity of our constraints, we were still able to model to a simple degree our rotating motor. In the future, the full breadth of a 3D electro-magnetic motor program would need to be functional for a proper optimization and design to occur.

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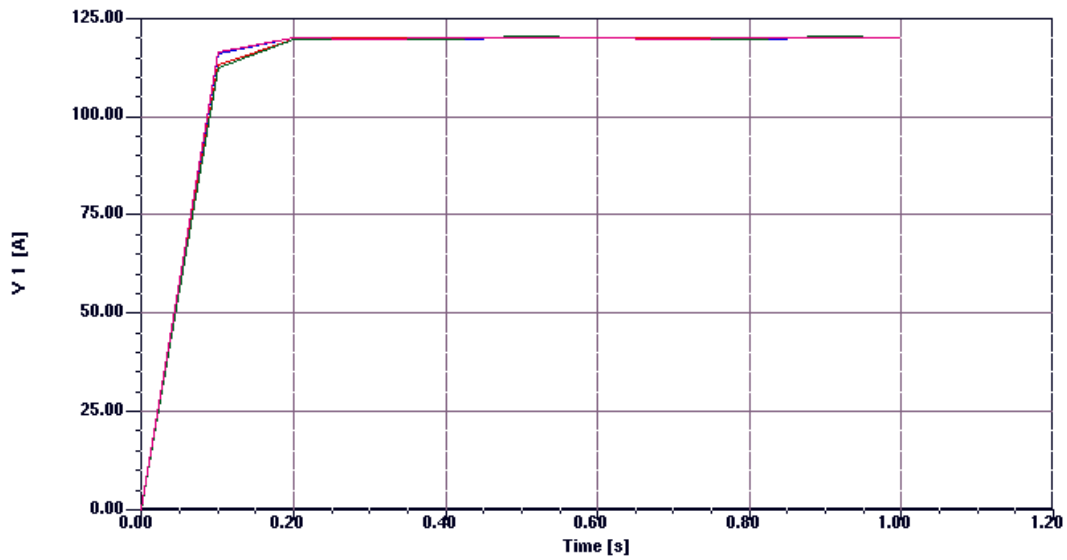


- Y1 Current Setup1 : Winding1
- Y1 Current Setup1 : Winding2
- Y1 Current Setup1 : Winding3
- Y1 Current Setup1 : Winding4

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Current Quick Report 2  
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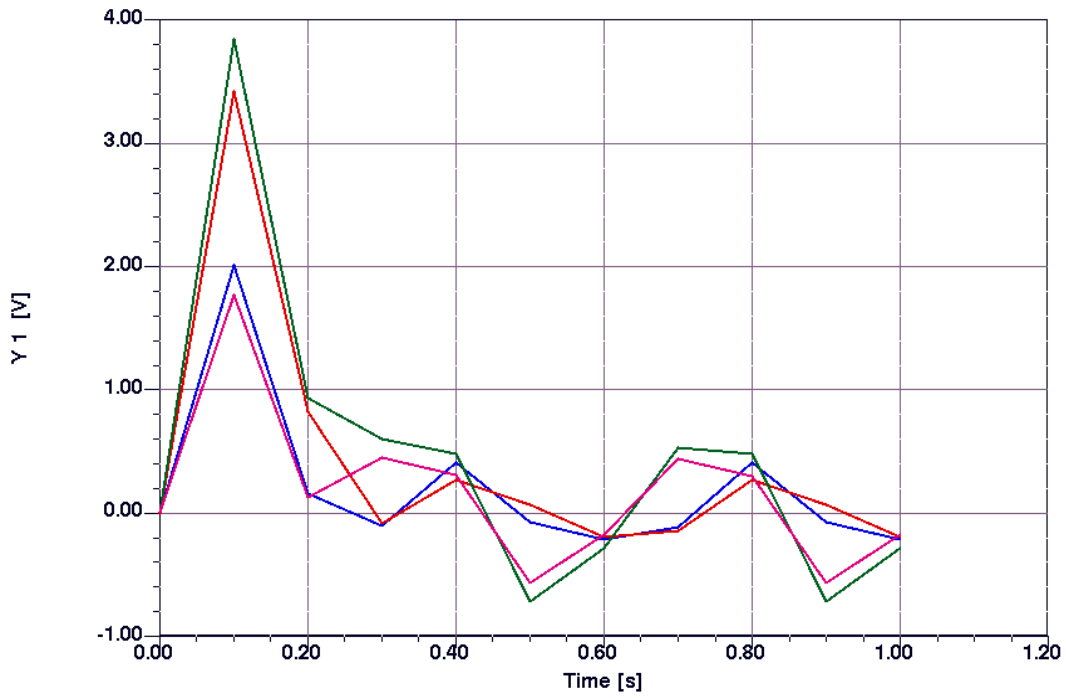


- Y1 Current Setup1 : Winding1
- Y1 Current Setup1 : Winding2
- Y1 Current Setup1 : Winding3
- Y1 Current Setup1 : Winding4

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InducedVoltage Quick Report 1  
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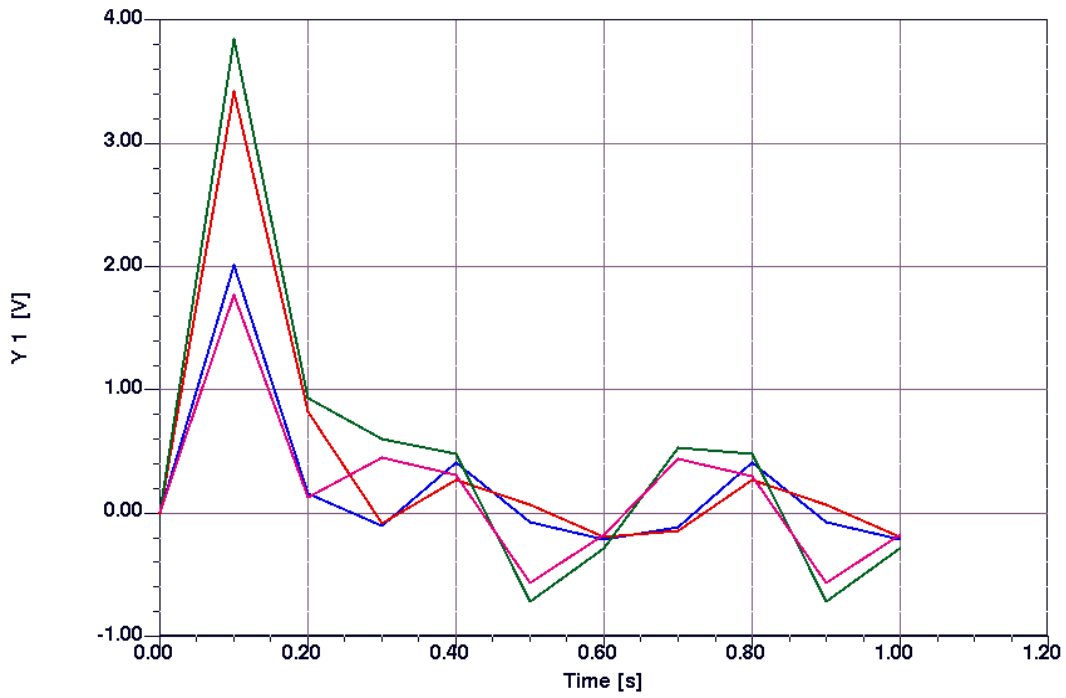


- Y1—○— InducedVoltage Setup1 : Winding
- Y1—+— InducedVoltage Setup1 : Winding
- Y1—□— InducedVoltage Setup1 : Winding
- Y1—\*— InducedVoltage Setup1 : Winding

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