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<u>Provisional Patent Application</u>

This document provisionally outlines several different ideas for electric machines and electric vehicle components in general.
-Individually replaceable poles
-Dynamically Balancing Rotor
-Stator lamination design for cooling
-Laminated claw pole
-BMS design
-Outrunner Ac induction motor
-Separately Excited Rotor for Synchronous Motor
-Stator form coil weld joint
-squirrel cage rotor bar connection design and clamping method

Individual Poles
More specifically individually removable poles on radial flux motors. This design can be applied to both the stator and rotor. As also, the design can be applied to inrunner and outrunner motors (whether the rotor is located inside or outside of the stator). Of course, this design would only work with a non-overlapping winding layout.

The design serves several purposes. Currently to maintain (service) a wound pole, the motor will have to be fully disassembled and the whole stator must be rewound. With this design, a coil to case short can be more directly troubleshot.

Often, one lengthy magnet wire is used to wrap the whole motor or each phase. This wire can wrap from pole to pole. There is no good way to determine where the short is located and rewrap just an individual pole. As the task of winding is both tedious and the price of copper is high, this is an unnecessary method of rewinding a motor.

The best way to troubleshoot a motor is if each pole was individually wound, the lamination stack inside the pole was not permanently constrained, and if each pole had independent terminations.

More benefits include the way laminations can be cut from a larger sheet of metal. For example, there can often be waist with the existing common designs. A large central region is cut from the steel. If the lamination design is no longer a circle, but several individual trapezoids (or whatever shape is used), then the pieces can be stamped out of steel much closer together with minimal wasted material.

Claims

1. Each pole has an independent lamination stack. This stack is designed to slide into a slot where it can be rigidly constrained, but can also be removed with ease for servicing.

2.The outer casing that holds the slot pole stacks can be extruded or also made out of stacked laminations. The optimal design would be to make this casing out of a non-conductive material that would prevent individual laminations in the pole stacks form shorting together.

3. Each pole would be independently terminated. This way poles can be individually removed as well as individually rewound.

4. Poles can be wound and replaced to for the purpose of having different inductances, torque characteristics, and rpm ranges (on DC motors)

5. Automotive tuners can have more control over a motor that used to be non-modifiable.

6. Aftermarket companies can participate in the electric vehicle industry by supplying replacement poles.

7. The automotive maintenance industry can still service vehicles without being trained in complicated winding techniques.

8. The poles could be replaced by anyone with a set of wrenches and minimal skill.

Dynamically Balancing Rotor

The idea is to create a simple device that would be permanently on the rotating section of a motor (the rotor). This device would balance the rotor to eliminate vibration. By eliminating vibration, life of the other components (such as bearings) can be extended and the motor can spin up to higher RPM limits.

By dynamically balancing the rotor, the whole rotor assembly will not need to be removed when serviced. Any individual pole can be replaced while the rest can remain in the motor. Each pole may not have a perfect weight distribution. But, the dynamic balancing assembly can be used to adjust for this.

And also for applications where poles are not replaceable this design would apply. Material can move over time do to the extreme heat and forces applied to the rotor of an electrical machine.

The dynamically balancing assembly will move 3 weights radially from the shaft. By moving these 3 weights at different distances, the assembly will be able to provide substantial balancing efforts.

Three accelerometers will sense the outward acceleration on the motor. At full balance these sensors should be equal.

While the main design purpose of this device is for electric motors, it has many useful applications. Ex, wheels, windmills, car crankshafts, and more. This patent should not be limited to dynamically balancing rotors in electric motors, but to any rotation object that has an uneven mass density.

Claims

1. An assembly to balance a rotating object while in motion (dynamically) and to be permanently mounted on the shaft.

2. The assembly will minimize or eliminate vibration without human interaction. A microcontroller will read 3 accelerometers and adjust 3 weights accordingly.

3. The weights can be adjusted in several methods.

   a. The weights will be threaded, a stepper motor will spin a leadscrew that is feed through the weight. The lead screw will be perpendicular to the rotating object’s shaft. Three leadscrews will be placed 120 degrees apart. Please refer to drawing 2.3a

   b. Three pcb motors will be placed on the same pcb. The rotating disk of the pcb motor will have a slotted hole.The weight will have a joint on this slotted hole. The slotted hole will intersect with a path radial to the rotor’s shaft. The weight will travel along this variable intersecting point.

   c.

4. The accelerometers will read radially from the rotor’s shaft. Each accelerometer only needs to be single axis. The accelerometers will be placed 120 degrees apart at the outer diameter of the rotating assembly. The accelerometers will be offset 60 degrees from the weights.

5. The device will need power. This design is intended for a powered rotor. It can also be used on a non-powered rotor where permanent magents may need to be replaced or induction poles need to be replaced. If it is being used on a non-powered rotor. This device will be inductively powered across the axis of the shaft. Please refer to patent application No..... for further details and claim 6.

6. This device can also contain the receiving coil (secondary winding) of an inductively powered rotor. Please refer to drawing 2.6. A round ferrite (often referred to as pot core) would be mounted to the device and rotate with the device. A coil would reside inside the pot core. It would receive a high frequency magnetic field from a primary winding on the stator. This frequency would remain constant no matter what the rpm of the rotor is. Mounted to the same assembly would be a rectifier and potentially a filter (consisting of capacitor and/or diodes and/or inductor).

Stator lamination design for increased surface area

The stator on an electric motor uses a significant amount of steel. As the stator is round and sheet metal is rolled into a coil with parallel edges, there is often an excess of waste material. Circular stators are stamped consecutively with the material inbetween being wasted. This material can be used to create a heatsink on the outside of the lamination stack.

Often stators are designed with a ridge in this excess material so that there is an increased surface area in 4 points around the outside of the stator. This does increase the surface area, but it is not distributed evenly. Also, it is a fairly insignificant increase in surface area. The design being proposed would provide 150% (or significantly more) surface area increase on the outside of the stator.
The design proposes creating overlap into the scrap region of the steel lamination and then offsetting those regions when stacking to create distributed fins. The fins can be designed so that the overall shape of the stator stack is still a circle. Viewable in the drawings are examples.

Another benefit would be that only one die is needed for this method as the same lamination can be offset. Some other designs use two different dies to create alternating lamination which have a larger OD. This requires not only 2 dies but also 2 different shear widths of steel and therefore twice as much material handling in manufacturing.

To increase strength of the fins, multiple laminations can be stacked at zero skew before offsetting the next set. Although, offsetting more often will provide the greatest surface area.

Claw Pole Axial Flux Rotor

The idea is a rotor for a 3 phase electric machine; both motor and generator. Applications include Wind generators, car alternators, electric vehicle drivetrains, and more not limited to these.

The claw pole is commonly used in radial flux machines such as car alternators. But do to complicated manufacturing has not been extended to axial flux motors. This design provides a method for assembling an axial flux claw pole rotor.

First thick steel end rings are created to hold the claws and attach to the shaft. Then, hundreds of lamination rings are created at the same outside dimension of the end ring. The inner dimension is determined by how thick of a tooth is desired. After stamped, thse rings are joined together inbetween the end rings. The joining process can be done by any number of well established or unique lamination joining methods (ex. welding, bolting, epoxy, etc).

Battery Management System
Provisional Patent Application for an Integrated Battery Charge System With Isolated Balancing.

Overview:

The device being invented will be a battery charger that balances parallel groups of cells and an unlimited number of series modules through isolation. The system is intended for application in the electric vehicle industry. In this situation the whole system would be on board the vehicle.

Electric vehicles are a platform where weight, cost, and space is very crucial. This system will integrate what previous designs required a lot more components for. It would eliminate the need for separate charging and management systems for batteries. Therefore, it would eliminate the communication required between the two systems.

By designing a modular system with isolating planar transformers and few components switched from a master alternating bus, we would accomplish the stated goals.

Description:

a. This system would have several voltage and waveform stages.
b. The first stage would be the mains input from a wall outlet or EV charge station. The system would be designed to accept any input AC or DC, with a voltage above 50 and limited by the components in the later stage. Expected maximum input voltage would be limited by the semiconductors.

c. The mains input would be rectified if AC and filtered with a large capacitor. If DC, the voltage may be filtered dependent on quality of the signal. But anyway... at the end of this stage you would have a smooth DC voltage presumably between 50 and 400 volts.
d. At the next stage the voltage would be stepped down with a buck converter **(or some other form of switching power system)** to the high current DC bus. In initial design, this is estimated to be bucked down to a max voltage of 10 times the cell voltage.
e. The high current DC bus would be feed to a single phase H bridge with four switches. Here it would be switched in an alternating square wave fashion at several hundred kilohertz.
f. An isolating planar transformer would be used to reduce the voltage to 1/10th or some other predetermined ratio.
g. The output of the transformer would be an alternating waveform. It would be rectified and filtered with a capacitor.
h. The filtered signal would charge the battery.

Secondary Scenario:

In a secondary scenario, the system would work exactly as stated above without the step down stage such as a buck converter (stage d). Instead, in stage (e) the transistors in the H bridge would also be switched at a higher frequency PWM within the alternating waveform. The duty cycle of this switching would determine the output voltage, and the primary winding in the transformer would act as the inductor does in a buck converter.

Provisional Claims:

1. Isolation between series battery modules based on a high frequency planar transformer. The secondary windings of this transformer will be rectified and filtered to the charging voltage; never to exceed the peak battery voltage.

2. The system would be modular . Any number of parallel modules of battery cells could be stacked in series and all run off the same AC square wave through isolated transformers.

3. Intended to only top balance lithium or nickel based batteries where equal state of charge is a great concern. In these battery chemistries it is important to not bring the cells below a specific voltage. By balancing the cells at their maximum voltage

4. The mains AC power will be inputed, rectified, filtered and bucked down to a standard DC bus. For example, 220vac would be rectified and bucked down to 37 volts. Then the DC bus would be switched in an AC square wave fashion to the isolation 10:1 transformers. In this case a battery with 3.7 volts charged would never exceed its maximum voltage. The same could be applied to any max voltage cell.

5. Parallel battery modules could be monitored independently for any inconsistencies. When monitoring these modules during discharge, they would not be balanced. The monitoring would turn off the pack when the lowest cell reaches the lowest potential. Furthermore, the BMS system would also be linked to the charging module and have the ability to assess the voltage of multiple cells and communicate that data either to other modules or to one main BMS controller via a serial communications protocol. Each cell could also be optionally monitored for temperature.

6. This system would not waste power as traditional bleeding balancing systems do. This system would not pull power from one battery module and place it in another module. This system eliminates the need to push pull power because it will not over charge any cell. It does not charge cells in a long series chain at a high voltage. The system charges on a cell by cell basis or charges a module of parallel cells (parallel cells will self balance).

Outrunner AC induction motor.

In-wheel motors are gaining popularity for vehicles of any kind. A direct drive motor offers many advantages. Direct drive both eliminates the inefficiency of a transmission and the costs of a transmission (initial & maintenance). Main problem with a lot of the hub motors is that these motors are heavy and add unsprung mass. Also, due to the extra vibrations of there not being any suspension, collisions can cause chipping of the permanent magnets. Another disadvantage to permanent magnets is that the top speed can be limiting in a synchronous motor.

Separately Excited Brushless DC Motor

Summary
Neodymium is the most common material use in ordinary brushless DC motors for the permanent magnet. Neodymium is a rare earth metal. It is mostly found in China and the price has doubled within the last month, steadily increasing over the past few years. China is limiting the amount they are exporting because they know it has an increasing demand.

We are eliminating neodymium or any permanent magnet from brushless motors. But, unlike an AC induction motor, this will still be a synchronous machine. Another advantage to eliminating permanent magnets is that they will demagnetize at high temperatures. This motor will be able to be smaller and have the ability to run hotter without risking damaging the materials.

The rotor will be wound and separately excited. This rotor will be similar to a rotor in a normal car alternator. But, unlike a car alternator, the rotor will not be powered by slip rings. An induction based transformer will power the rotor without any mechanical connection. When brushes are used, they reduce efficiency and require replacement. A main goal of ours is to create a zero maintenance rotor over the complete life of the motor.

This motor is not limited in its applications. For example, it could be used for electric vehicles.

Goals and Key Points
- Synchronous Motor
- No Neodymium
  - Lower Cost
  - Higher Heat Capability
- Greater Torque Control
- Brushless
  - Needs No Replacement
  - Higher Efficiency

Claims
1. A Brushless DC Motor comprising:

a. A wound rotor would be used. For example, a claw pole rotor or a bipolar radially wound rotor.

b. The motor uses no brushes or slip rings.

c. The motor uses no permanent magnets.

d. The motor uses a standard three phase stator. Either a delta or WYE configuration can be used.

e. Power is transferred to the rotor through induction using a transformer along the axis of the motor shaft. This method of power transfer to the rotor is different then any previous design.

f. A single coil will be stationary around the axis of the shaft. This coil will not be contacting the shaft and it will be part of the stator. It will be powered with a variable amplitude AC voltage. This coil will be referred to as “the excited coil.”

g. A single coil will rotate with the rotor and will be within the magnetic field of the excited coil. This coil will receive the power for the rotor. This coil will be called “the receiving coil.”

h. By varying the amplitude of the input voltage to the excited coil, the magnetic field of the rotor will be variable.This will allow simple control of the motor’s torque.

i. The motor will be a synchronous motor.

j. The power factor will be close to one because it is synchronous and due to variable strength rotor field, the motor can always run at it’s highest efficiency.

k. The control topology will be sensorless and sensored. For example, at low RPM and higher torque requirements, the motor may be sensored to prevent cogging. At higher RPM, the motor may be sensorless.

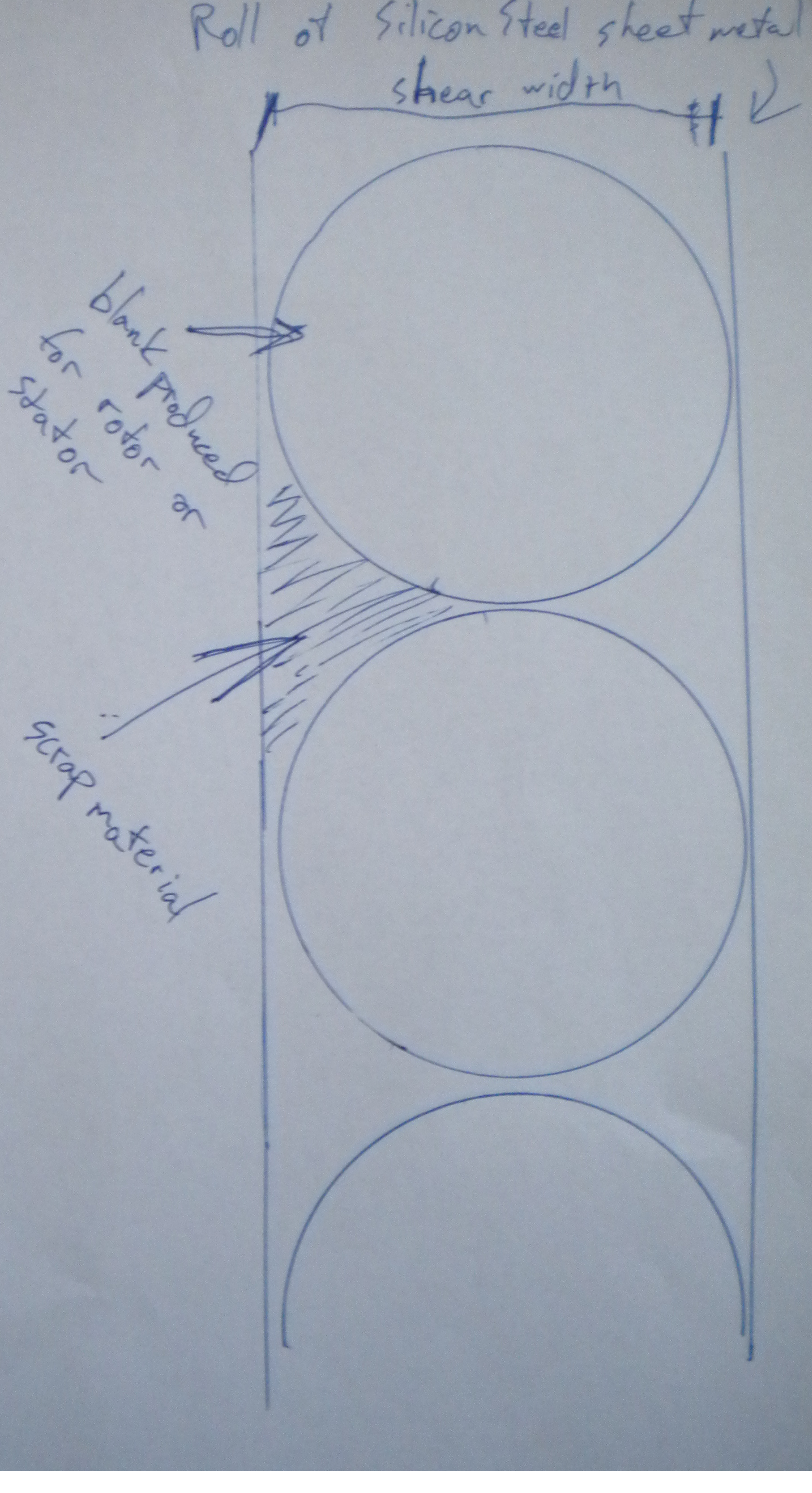
Stator Form Coil Weld joint

As pictured in the engineer drawing attached and pictured as the actual part has been made. The form coil joiner is a copper part to attach 2 stator bars. The part is made out of copper 110 or 101 for best conductivity. The part can be waterjet or even milled in low volume. But for production the part should be stamped. A separate drawing is shown of the stamp design. The stamp design has one continuos perimeter to allow for a single action die.
-The copper joiner is designed so that winding does not need to be done.
-The copper joiner is designed to accommodate off the shelf copper stator bar shape.
-Maximum slot fill is a goal of using solid copper bars. Over 90% slot fill is achievable
-By using stock copper bar and a nomex or kapton type high temperature insulation, the motor max temperature can be increased.
-Standard epoxy type insulations often only operate effectively at up to 180 degrees Celsius. Nomex can double that temp.
-By welding the joint rather than brazing, the temperature affected zone during joining can be limited.
-The three different phases are connected on different levels above the lamination stack.

-In a WYE type configuration a separate part type would be made to connect the three phases to a ground.

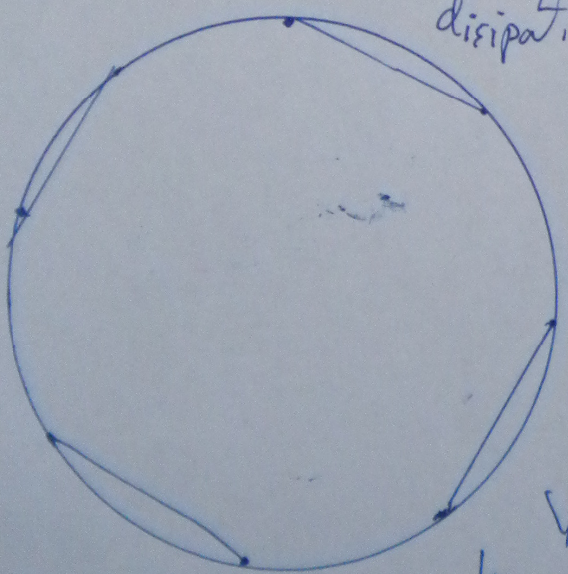
Rotor End Ring clamp down and conductor method/design

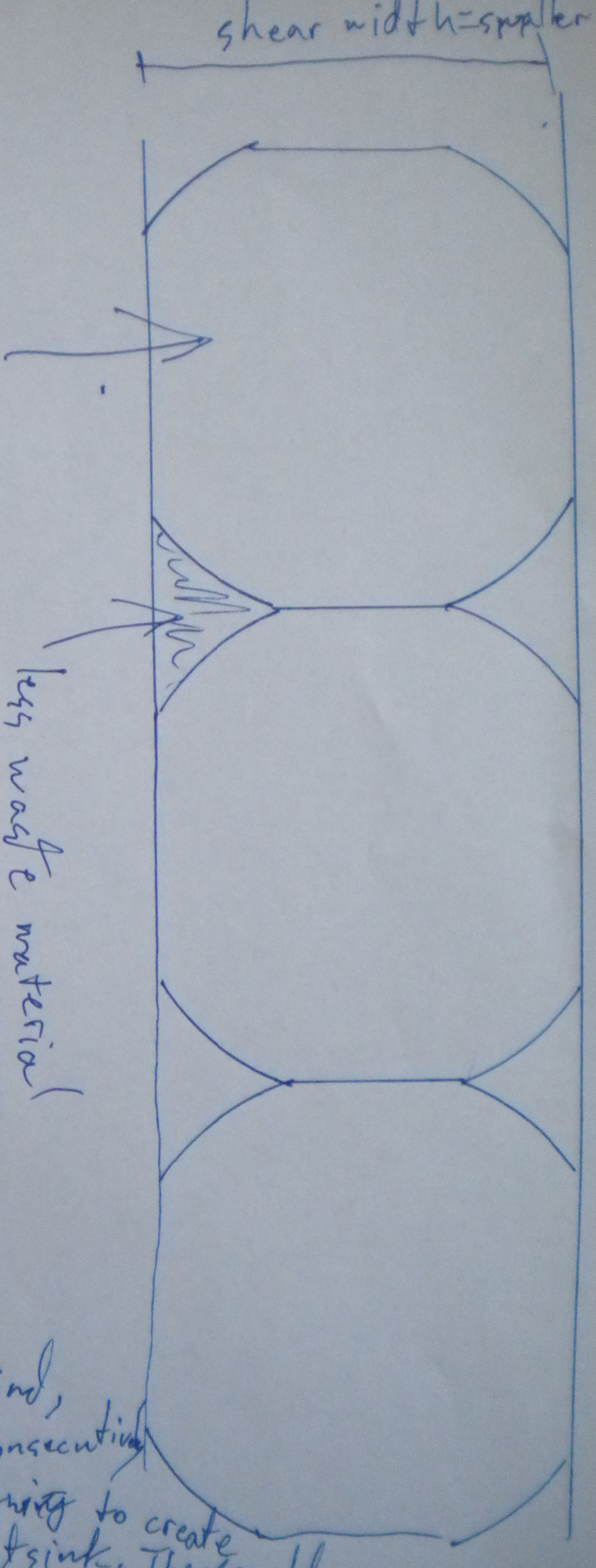
The electrical steel laminations used in motors most commonly have a coating on them good to ~1000 degrees Celsius. Often motor manufacturers also use an epoxy coating to join the laminations and to provide additional insulation between the laminations. But, this epoxy has a temperature limitation often less than 200 degrees C. So a method to form the laminations together while maintaining isolation is desired. The laminations would be held rotationally consistent with fitted copper bars through all the slots. These bars may or may not have an isolating coating. To compress the laminations together a weld would be made to join each individual bar to the ring on each end. The slots in the ring can surround the bars on all four sides or just 3 sides. It may be best to not surround the bar on the outside side. The copper material thickness will be low and during weld/braze, the material may melt away too easily and form undesired protrusions.
-It may be beneficial to have holes in the center of the rotor to assist with alignment during assembly. Dowel pins or bolts could be inserted and removed after the weld to the end ring has been placed. It would be inefficient to keep these connectors in place during motor operation if they are conductive. A conductive bar would have induced eddy currents and heat up creating losses.
-The bolts would double as a method to create a clamping force on the laminations.
-Alternatively a press could be used to create a clamping force during the weld process.


Roll of Silicon Steel sheet metal
shear width
blank produced for rotor or stator
scrap material

offset blanks when stacked

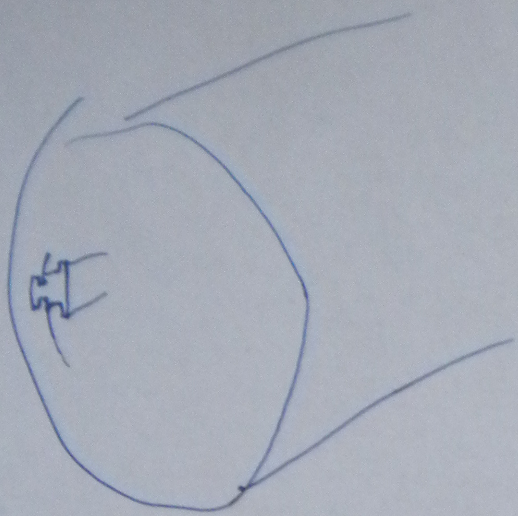
For example blanks could be offset by 45 degrees every other. This would create more surface area on outside for heat disipation

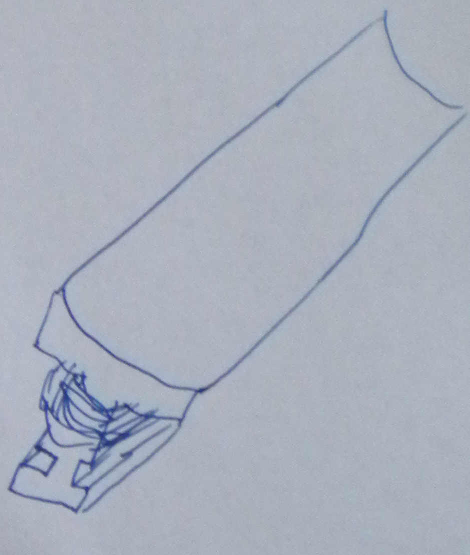




keep in mind, blanks could be consecutive stacked before offsetting to create wider fins on heatsink. They could also be offset at different angles

Individually Removable Poles





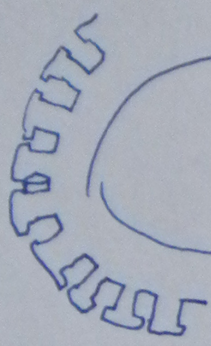
Pole can be wound outside the stator much more simply. Then pole can be slid into place and wired to the other stator poles.

Squirrell cage rotor bar connector design

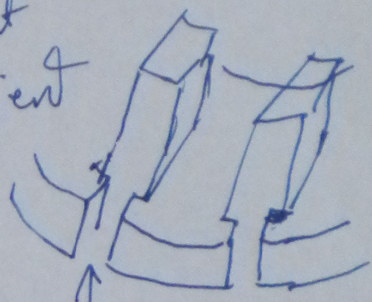
- A method to use individual rotor bars without casting

- Rotor bars can be copper or aluminum

see rendering for better image



- stamped
- laser cut
- or waterjet



could be closed as well but, open would allow for simpler stamping die

- Interior that joins to rotor bars could be coated in silver for ease of brazing

- or rotor bars could be tig welded

Dynamically Balancing Rotor

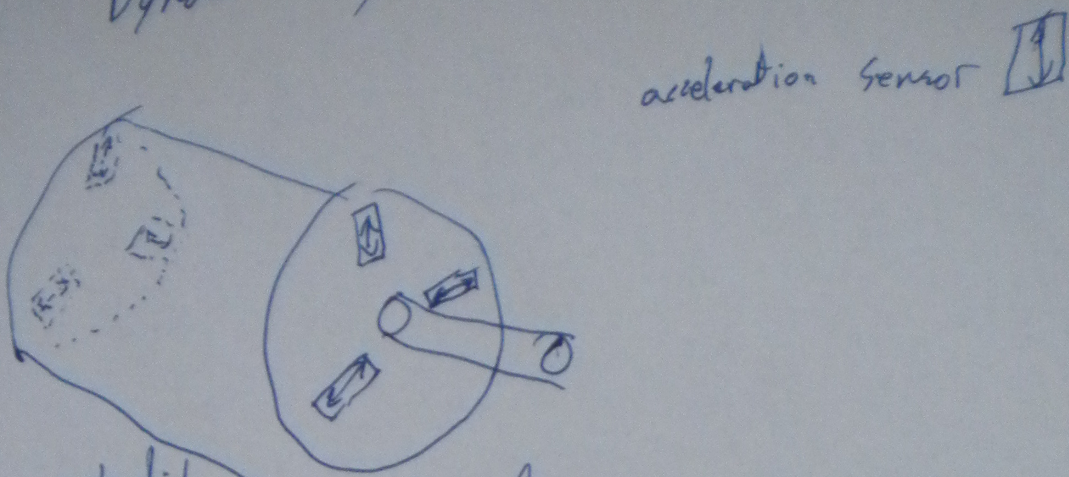
- A rotor with 3axis or more accelerometer sensing.
- The sensor is powered wirelessly off induction from the squirrel cage or a separate method of power transport
- Then weights are ajusted on linear motors to balance the rotor

Benefits

- potentially could use low cost manufacturing methods that are "sloppy" or less precise
- a rotor could be designed with individually replacable poles. Since these poles are unlikely to have matching centers of gravity
- will extend the life of the bearings

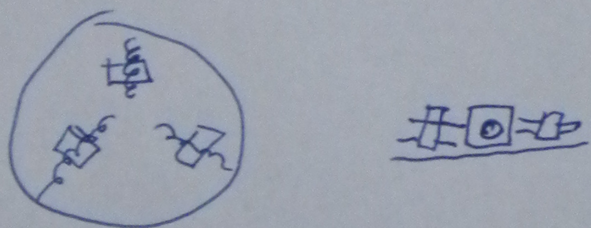
Dynamically Balancing Rotor

acceleration sensor



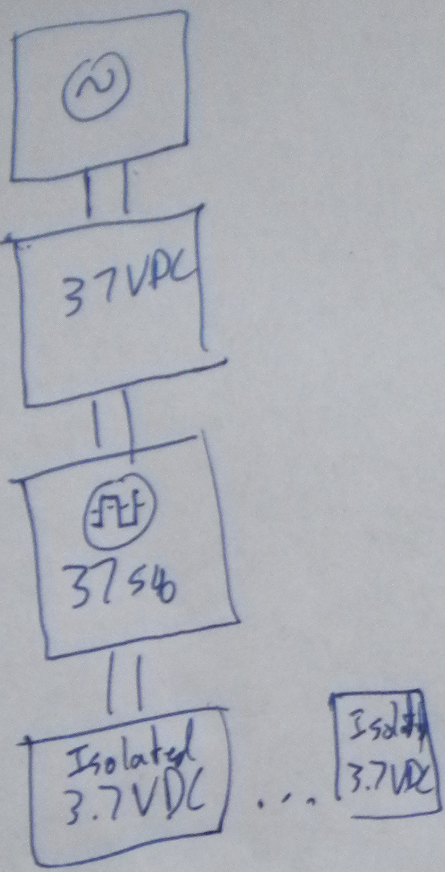
potential sensor placement locations

weightsetup



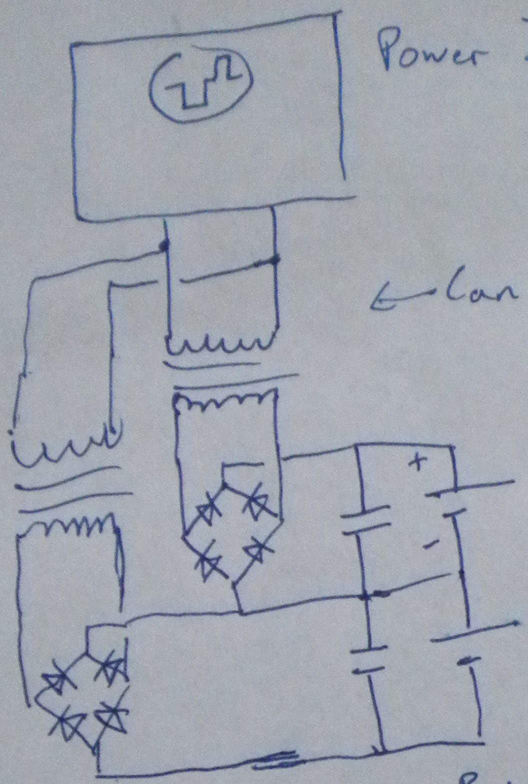
- 3 weights are moved in and out independently on screws
- Triangulation would be used to calculate and adjust an imbalance off-axis

Battery Charge System Overview



Isolated Battery Charger

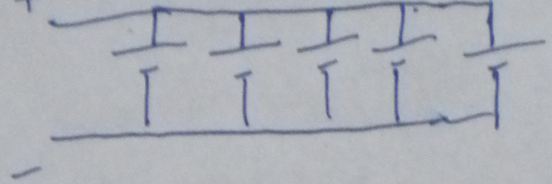
Power Input



← Can be duplicated continously

Batteries in series with isolated charge

"Parallel Battery Module"

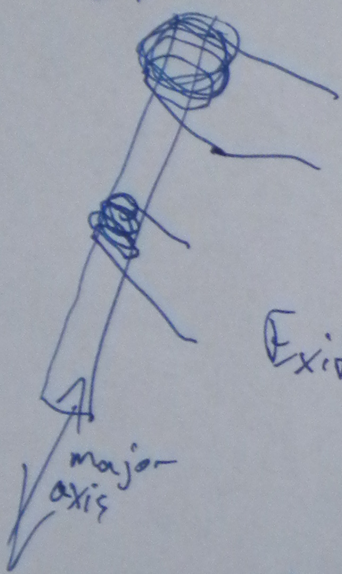


separately Excited Brushless Induction Rotor

- Rotor is Bipolarly wound or - Claw Pole Wound

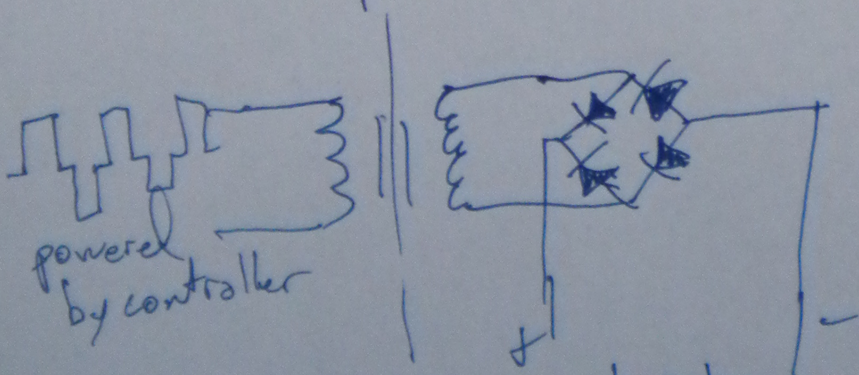
wound around shaft

- shaft has induction across its major axis



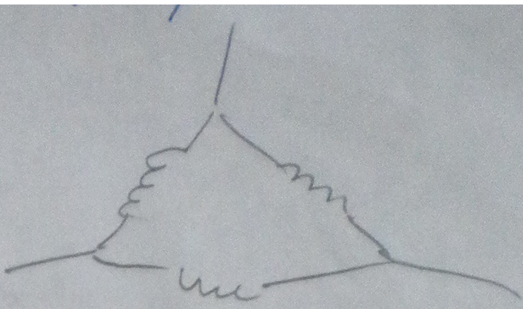
Exiting Coil (Primary Winding)
- Stationary
- Powered by controller

Exited Coil (Secondary Winding)
- rotates with shaft
- powers rotor

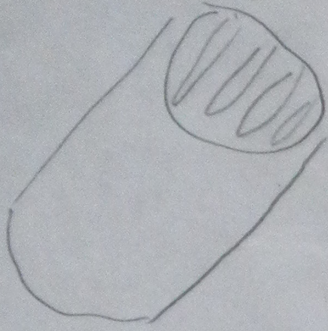


(also may include filter... capacitor or inductor)

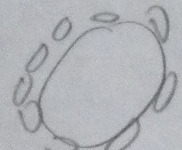
Narmal "WYE" Stator



Angle



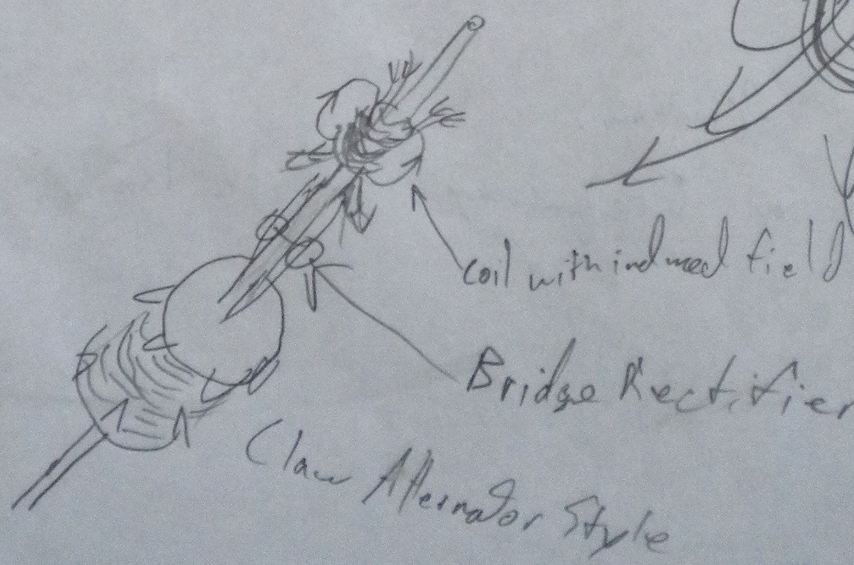
Above



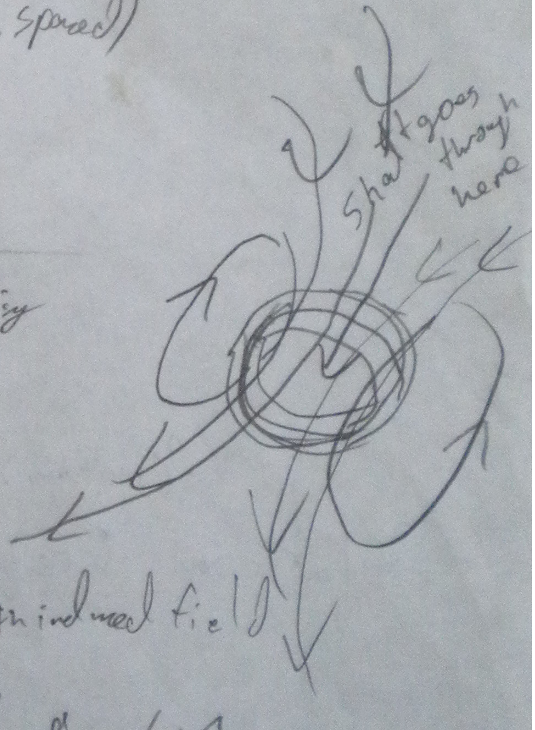
(They would be evenly spaced)

Stator Seperately Excited

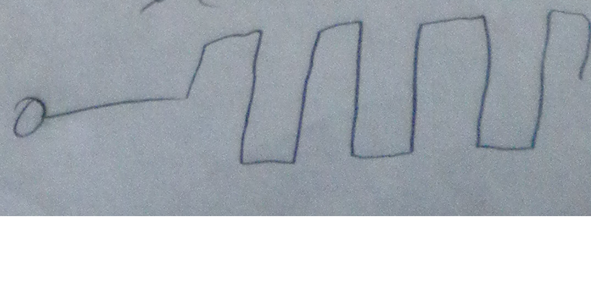
All Rotating



Claw Alternator Style



Signal



- A normal stator is used.

- A rotor similar to an alternator is used.

- The slip rings are replaced with an inductive transformer across the axis of the shaft.

- The Inductive transformer is the only method of transferring power to the rotor

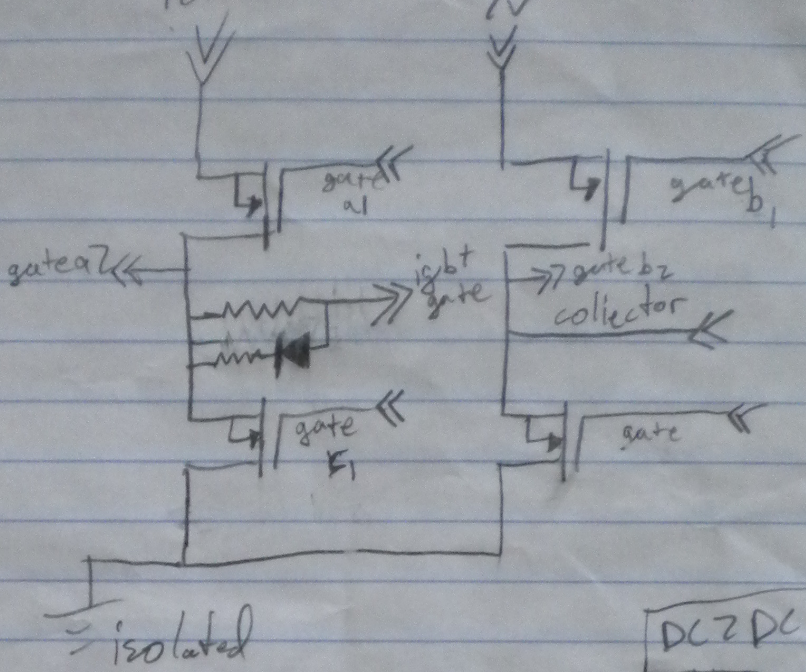
- An AC square wave is feed to the stationary coil.

- The Amplitude is variable on the waveform for variable torque.

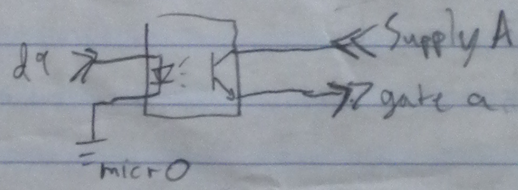
- Frequency (switching) will be 20khz or higher

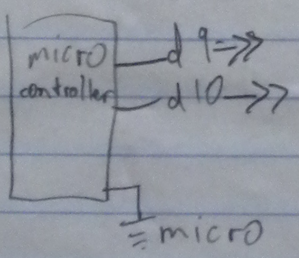
- Rotational Frequency will be lower: 0-500hz

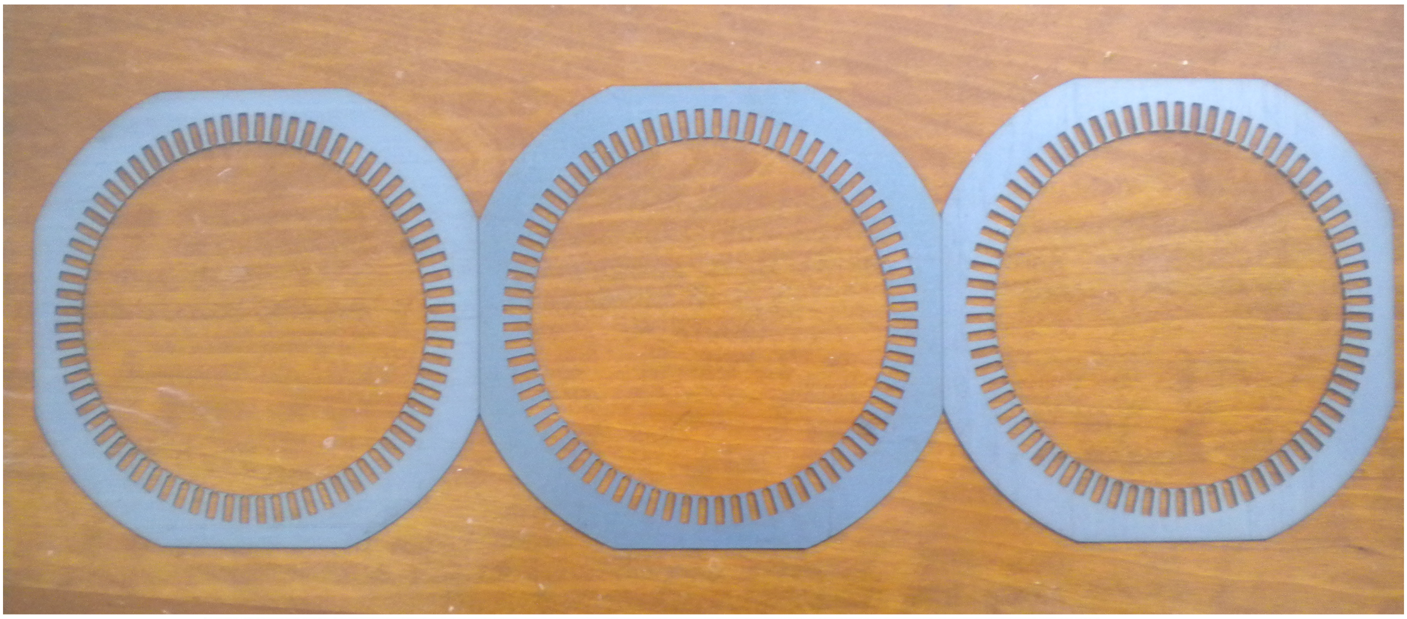
Igbt drives

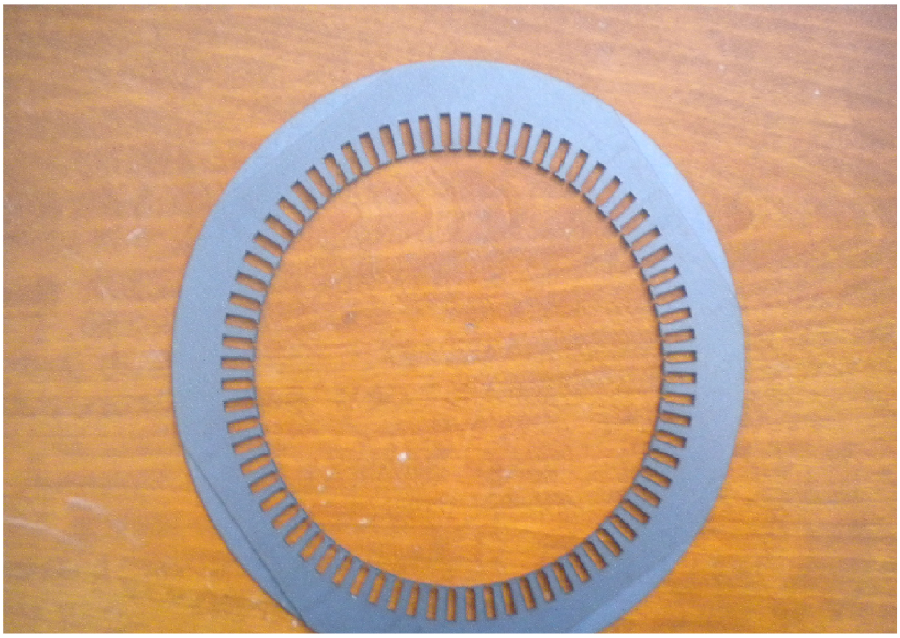

12v
7v
gate a1
gate b1
gatea2
igbt gate
gate b2
collector
gate
gate
isolated


DC2DC

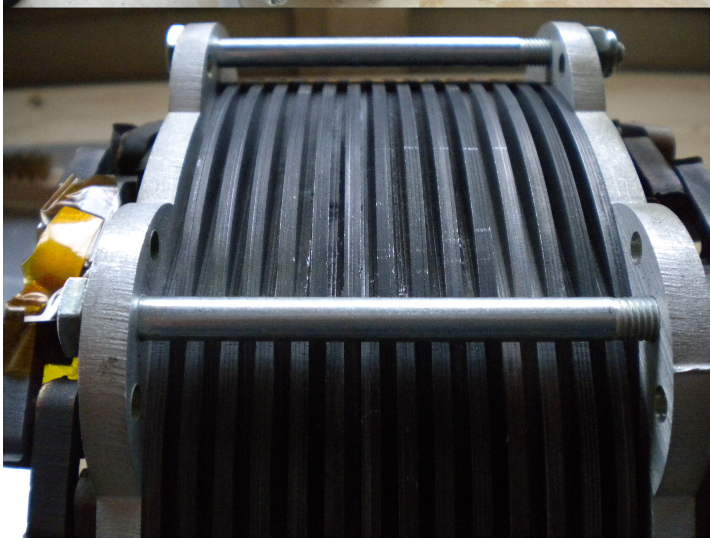

d9
Supply A
gate a
micro

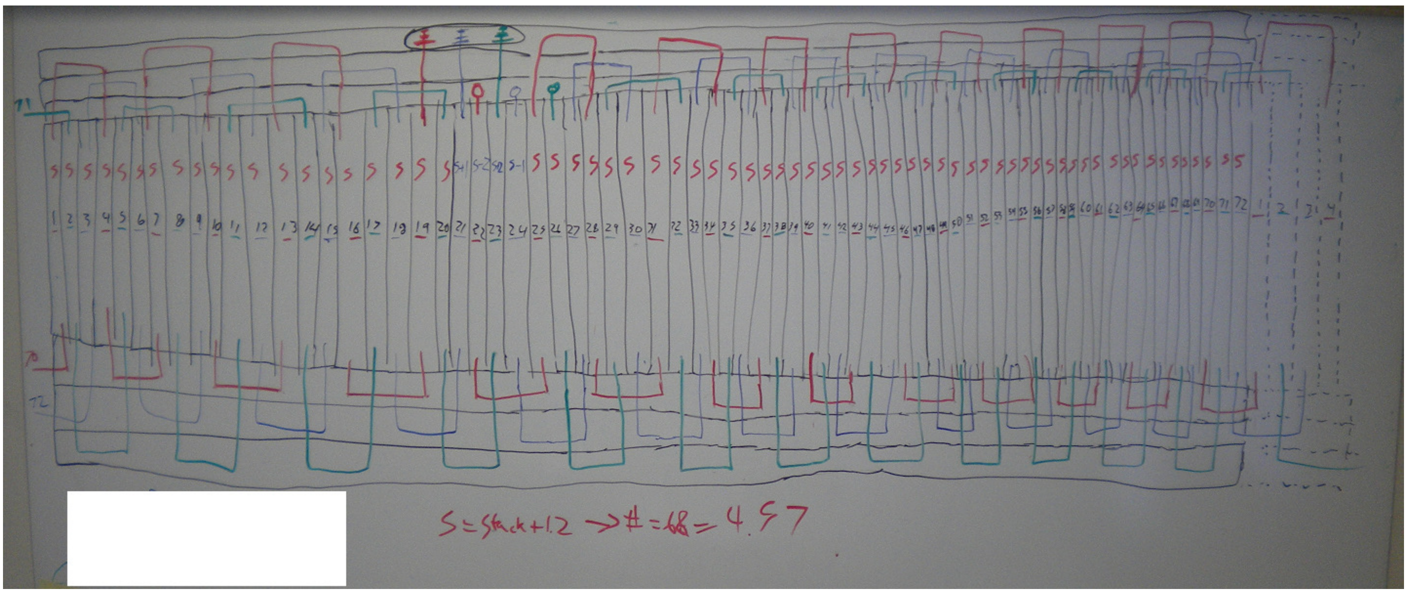

micro controller
d9
d10
micro







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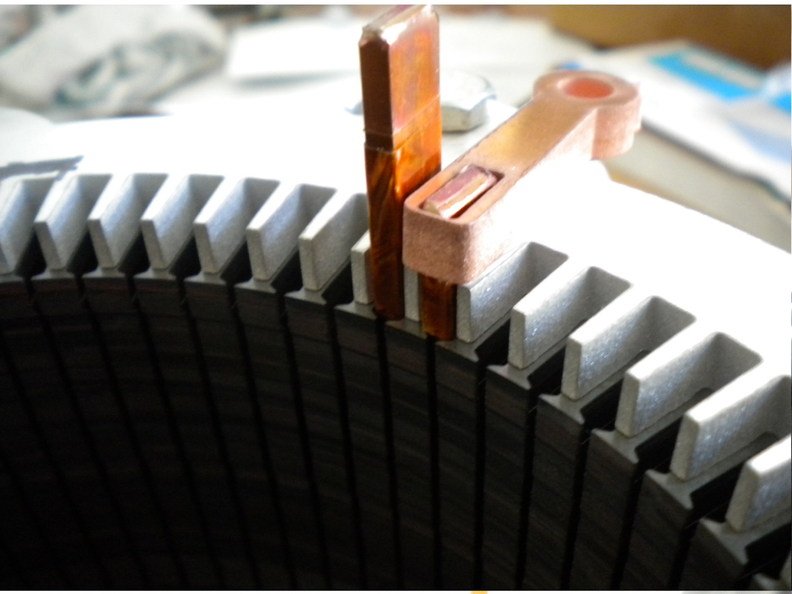
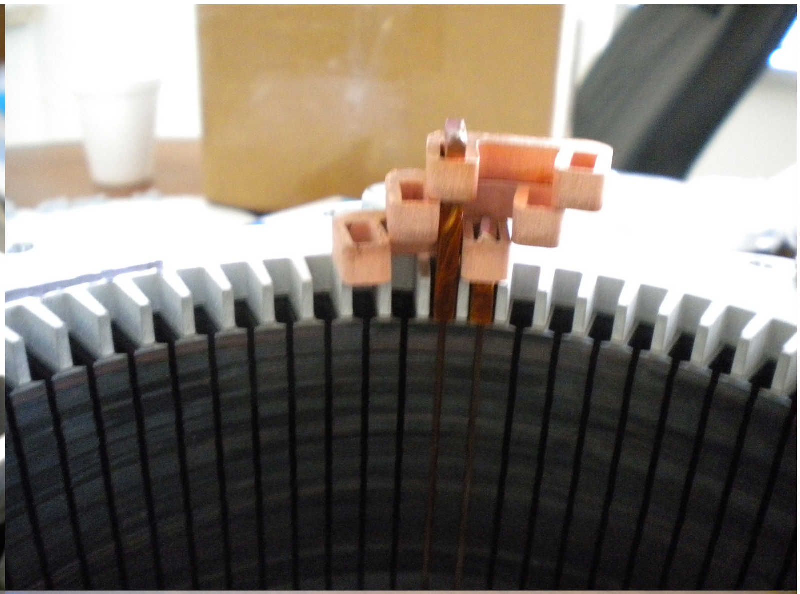
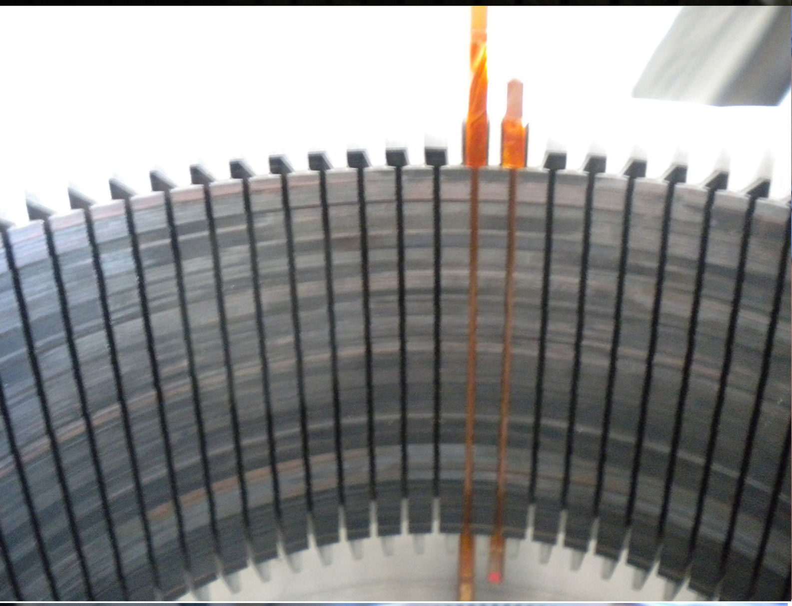

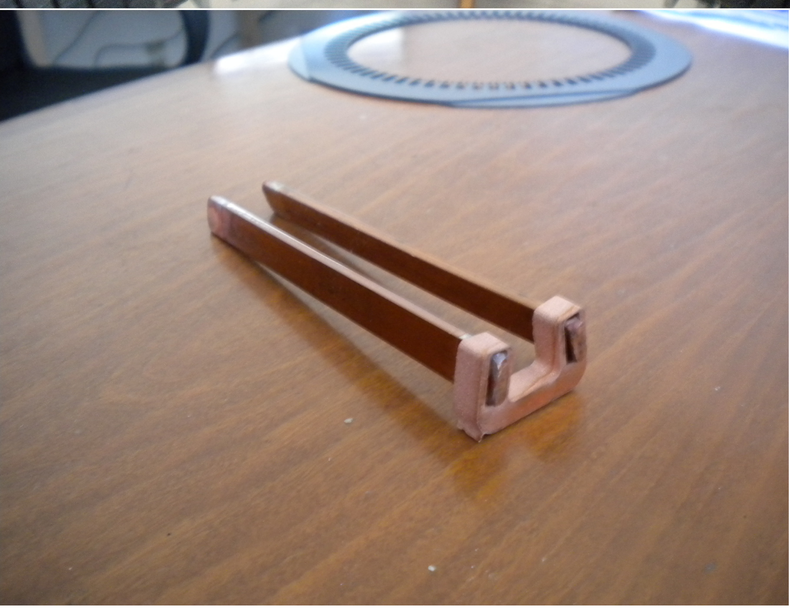


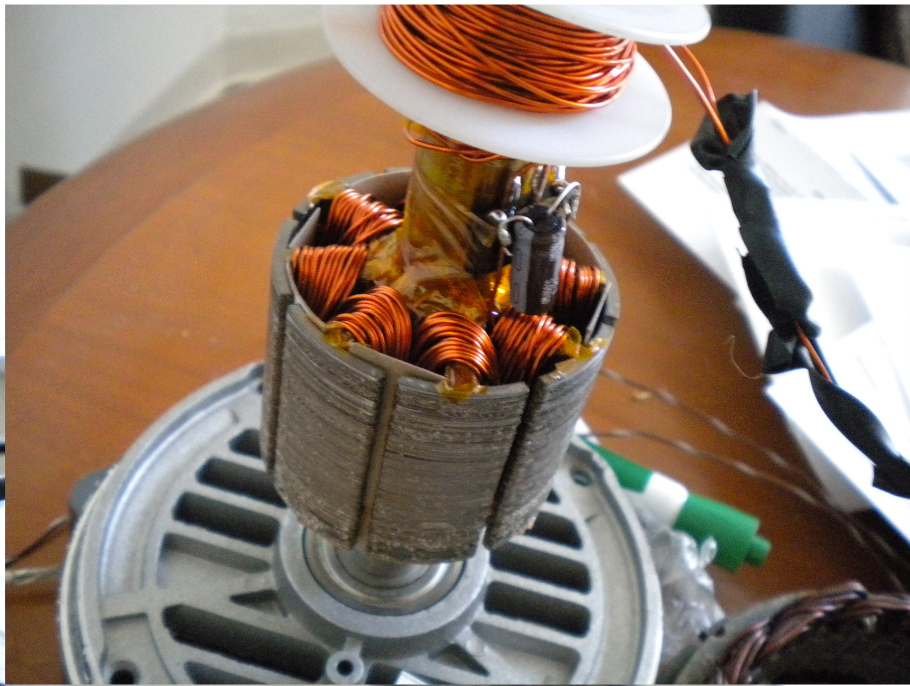

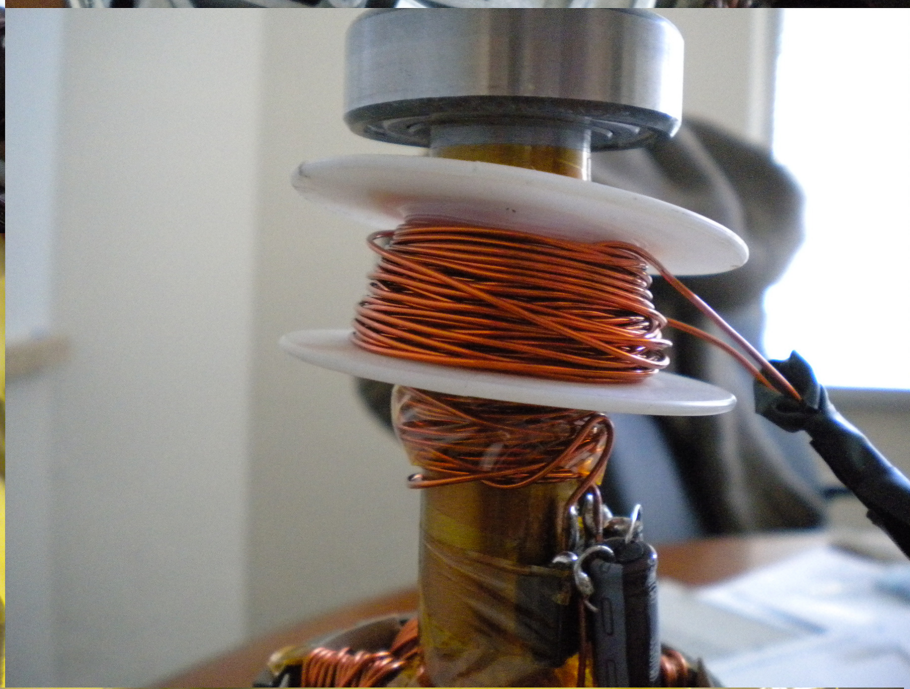

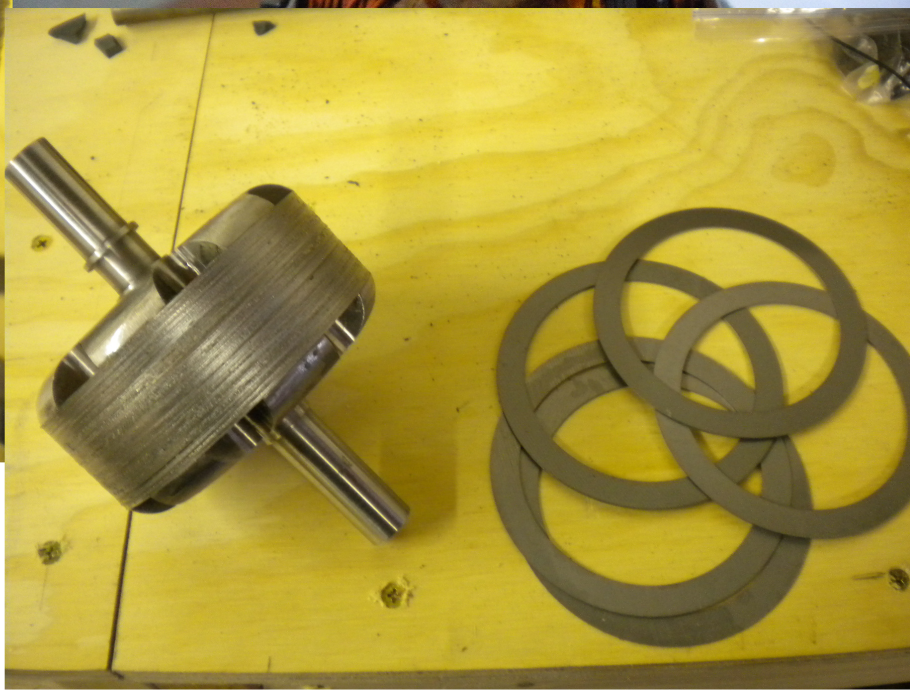

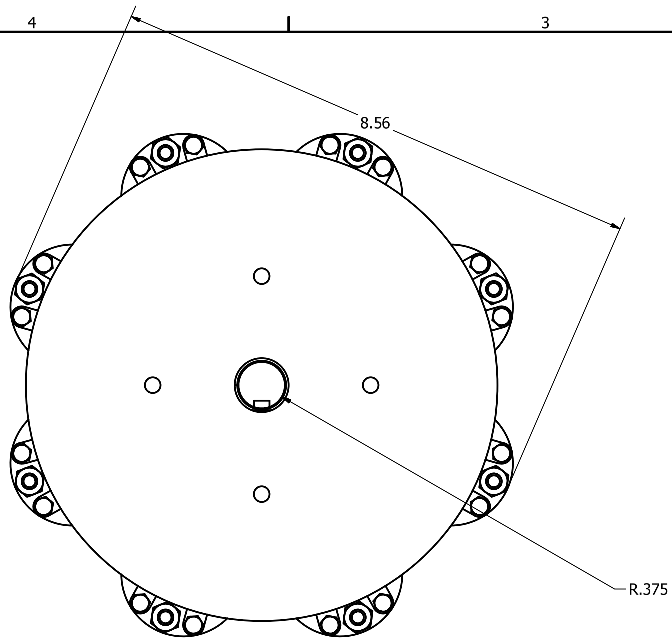

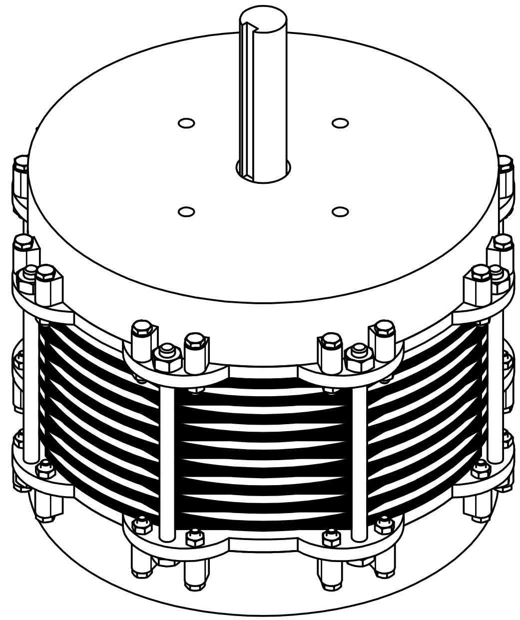

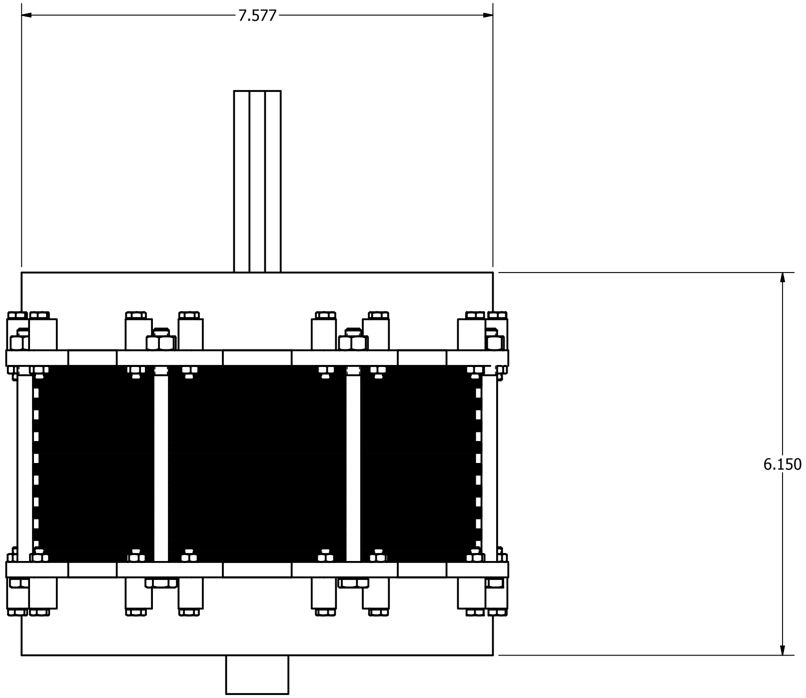

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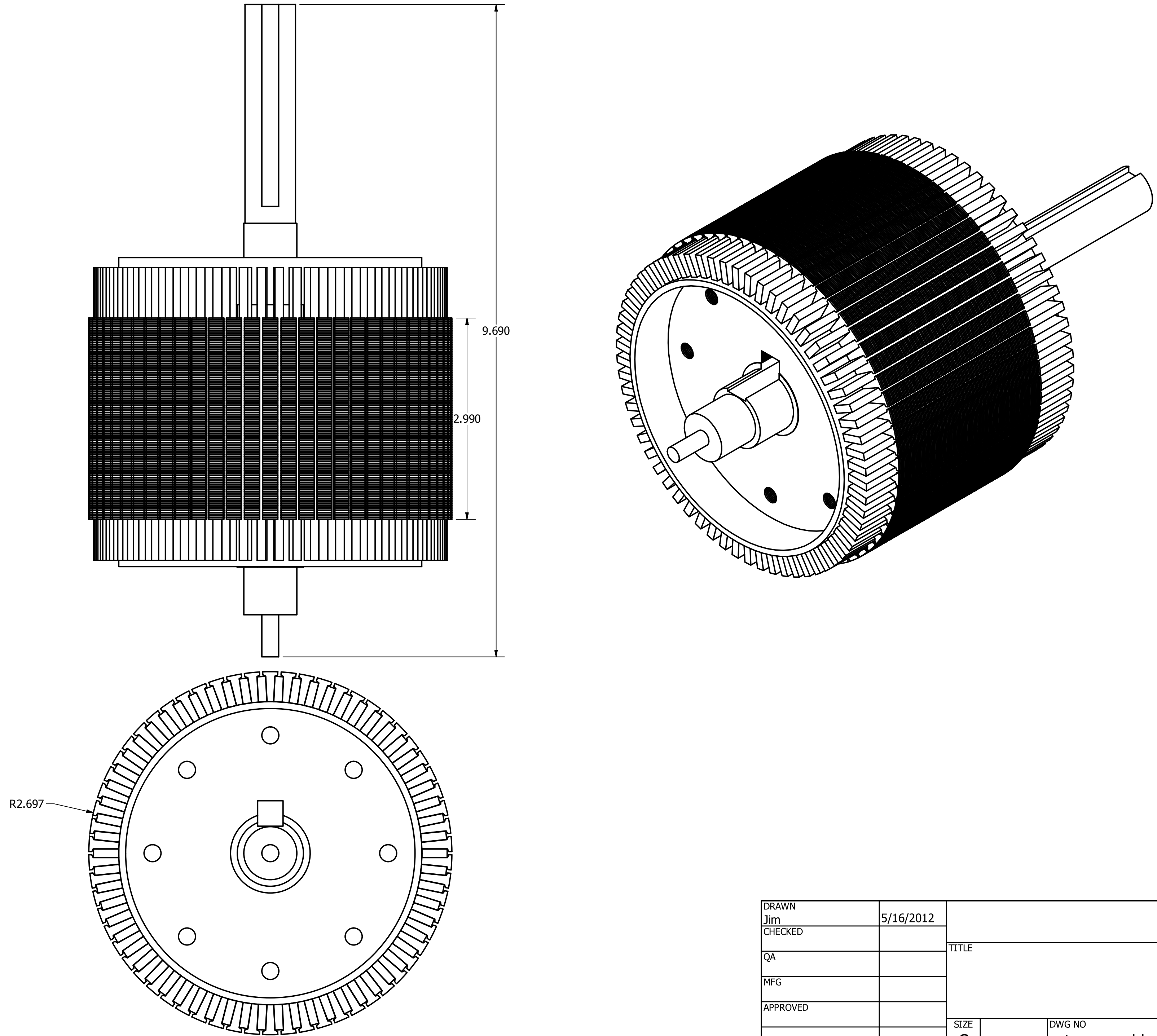

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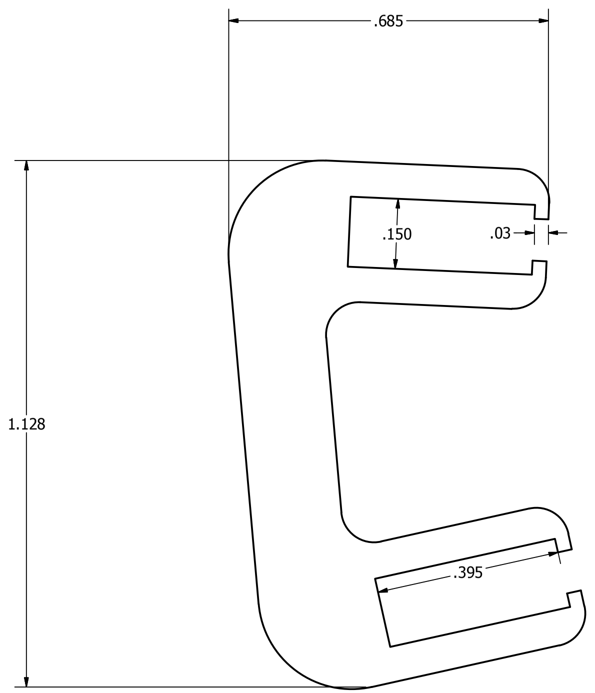

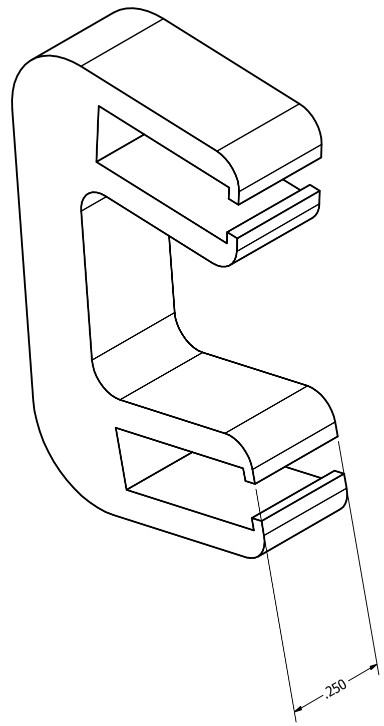

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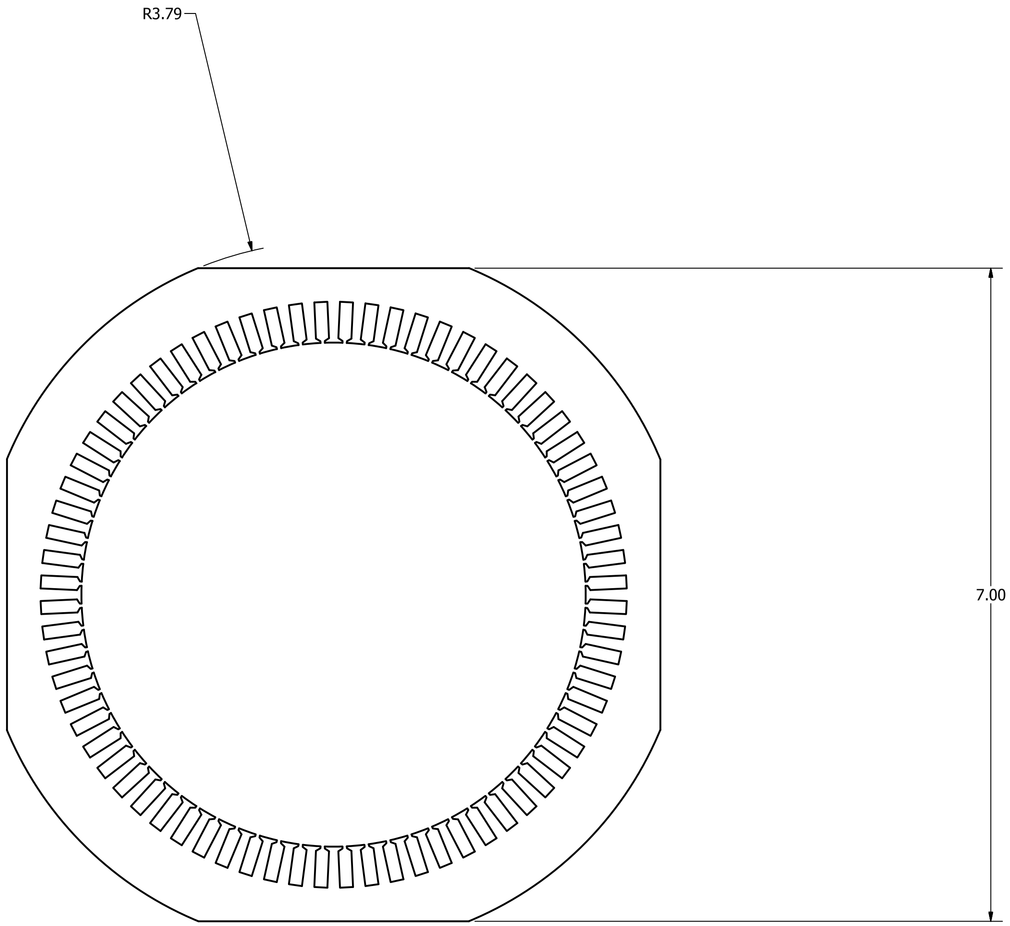

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