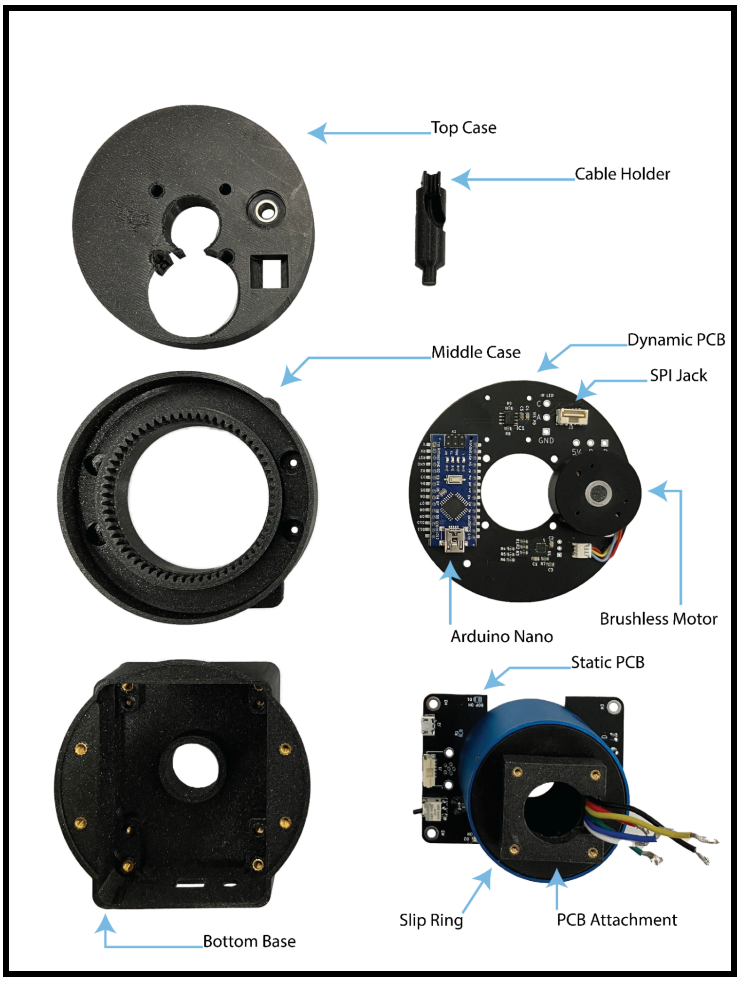
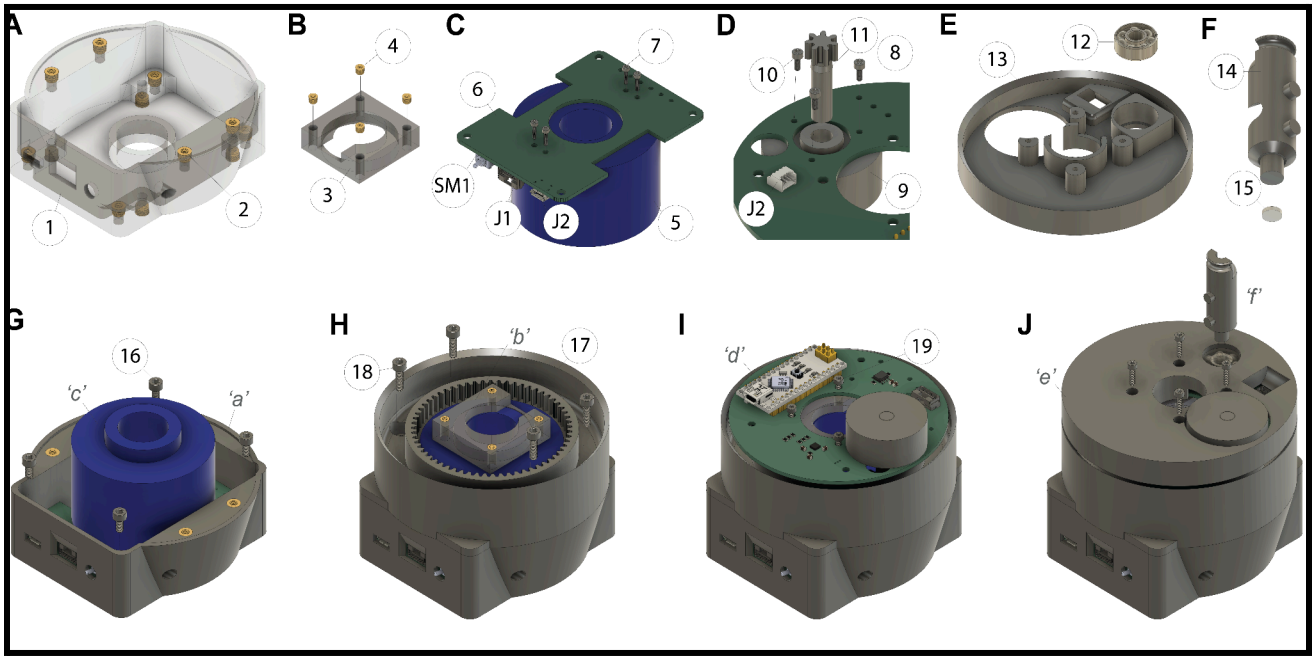
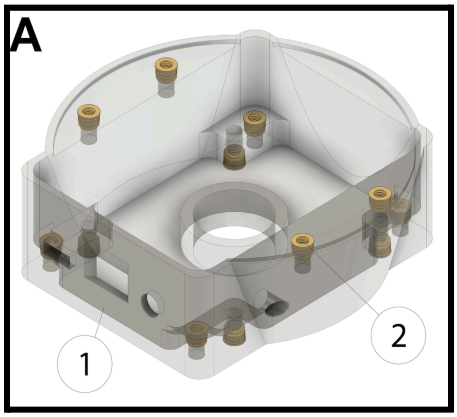
Step By Step Building Guide





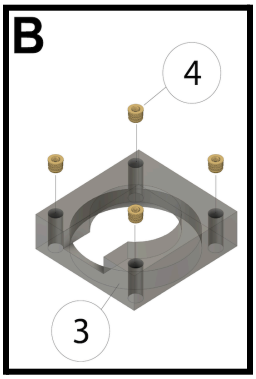
Step 1: 3D Printing

1. By using a 3D printer with a bed size greater than or equal to 250 mm x 210 mm x 220 mm (w x d x h), all needed parts can be printed together.
2. The example commutator is printed using Galaxy Black Prusament PLA. Any standard PLA should work for this device.
3. The parts are printed with the following settings
    a. 0.20mm layer height
    b. 15% infill
    c. Gyroid infill
    d. Auto Brim
    e. Auto Supports on build plate only
    f. Organic Supports
4. Prints should be oriented as follows
    a. Top case - Flat side down
    b. Middle case - Gears facing up
    c. Bottom Base - Hollow cavity facing up
    d. Cable Holder - Lying on its side
    e. Small Gear - Lying on its side
    f. PCB Attachment - Flat face down
5. Remove excess material from prints after they are finished
    a. Pay special attention to the geared pieces



Step 2: Assembling the Bottom Base (A)

1. Insert 12 threaded inserts into the 3D printed Bottom Base
    a. Use M3 x 6 brass threaded inserts
    b. Threaded inserts are smooth towards the bottom and knurled towards the top. The smooth side should go in the hole first
    c. Use a soldering iron (400F +) to heat up then push the inserts into the holes. Inserts should be pushed until their top is flush with the top of the hole
    d. Let each insert cool before moving on



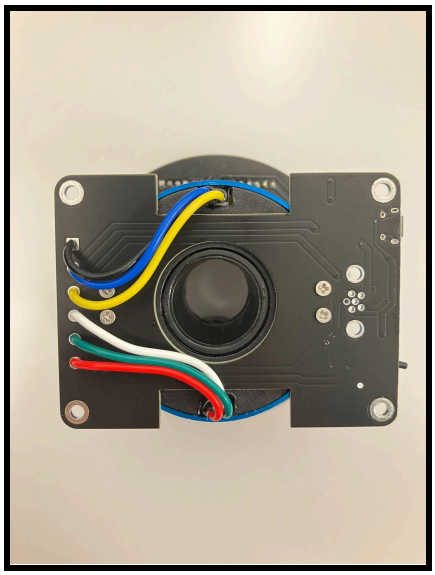
Step 3: Assembling the PCB Attachment (B)

1. Insert 4 threaded inserts into the 3D printed PCB Attachment
    a. Use M2 x 4 brass threaded inserts
    b. Follow previous tips on using threaded inserts found in **Step 2**

Step 4: Preparing Slip Ring Component

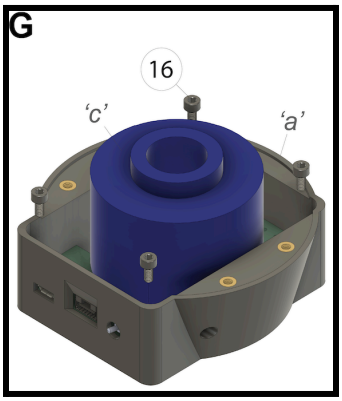
1. Remove the neck ring from the slip ring. It is not needed for this project
2. Remove the Bracket on the bottom of the slip ring. Keep the 4 screws
3. Undo the knots in the wires. Optionally these can be preliminarily cut down to 105mm so that they are easier to work with

Step 5: Combining Slip Ring And Static Pcb



1. The bottom of the slip ring that previously had the 2 brackets should be bolted to the static PCB using either the screws that came with or M2 x 6 screws
2. The slip ring wires should be positioned on either side of the PCB as shown, in coordination with the holes they will be soldered into
3. slip ring wire pinout from top to bottom:
    a. D - Black
    b. C - Blue
    c. B - Yellow
    d. A - White
    e. 5V - Green
    f. GND - Red
4. Note that the color of the wire that is associated with each pinout only matters for matching the static PCB pinout to the dynamic PCB pinout. This means if Yellow is placed in the B slot of the static PCB, Yellow should also be placed in the B slot of the dynamic PCB
5. Cut the slip ring wires to size as needed to position them inside their respective holes. There should be at least 2.5mm of wire sticking out of the hole when the wire is placed in
6. Once the correct amount of wire is cut, tin the end of the wire to make it solid. Only add enough to combine the strands, not so much that it thickens the wire.
7. Place the wire back in its respective hole and solder it to the board
8. Let the solder cool and move on to the next wire. Do this for all wires
9. Flip the combined piece over so that the commutator is on top. This entire piece will now be known as the static PCB

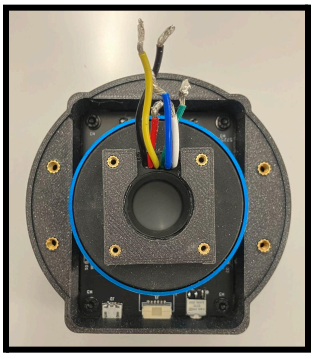
Step 6: Combine the Static PCB and Bottom Base (G)



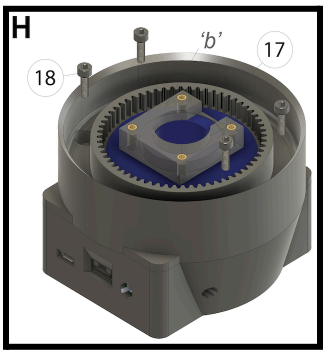
1. Use 4 screws to bolt the static PCB to the bottom base
    a. Make sure the SPI Jack is aligned with its hole
    b. Use M3 x 6 screws

Step 7: Combine PCB Attachment and Slip Ring

1. Place Super Glue around the inside edge of the PCB Attachment
2. Position the PCB Attachment so that the threaded inserts are facing up
3. The wires from the top of the slip ring should be aligned with the cutout in the PCB Attachment
4. Gently push the PCB attachment onto the slip ring where the Neck Ring previously was. This should be a snug fit aided by the Super Glue

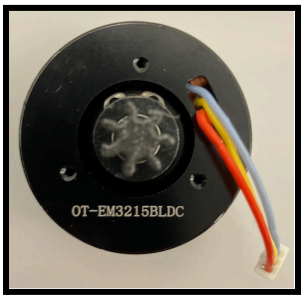


Step 8: Combine Bottom Base and Middle Case (H)



1. Make sure the Middle Case has the gears facing up
2. Align the shape of the Middle Case with the shape of the Bottom Base. One side of the Middle Case is longer and this coincides with the SPI Jack side of the Bottom Base
3. Use 4 screws to bolt the Middle case to the Bottom Base
    a. Use M3 x 8 screws

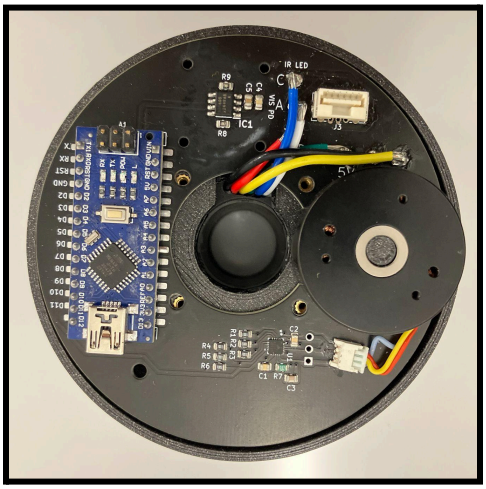
Step 9: Prepare Brushless Motor



1. Use 200-grit sandpaper to rough up the bore of the brushless motor
2. Place Super Glue around the shaft of the Small Gear
3. Place the shaft of the Small Gear into the Bore of the Motor so that the head of the Small gear is on the same side the wires come out
4. The bottom of the Small Gear Shaft should be flush with the bottom of the motor bore

Step 10: Prepare dynamic PCB and Attach Brushless Motor

1. When attaching the Arduino Nano to the dynamic PCB, ensure it is oriented such that the micro-USB port is facing away from the slip ring wire holes. This ensures that the pins of the Arduino match with the connections on the dynamic PCB
    a. The legs of the pins should be cut flush on both the top of the Arduino and the bottom of the dynamic PCB
2. When attaching the Brushless Motor port to the dynamic PCB, ensure that it is facing toward the outer edge of the dynamic PCB
3. Bolt the Motor to the dynamic PCB using 3 screws from the backside of the dynamic PCB
    a. Use M2 x 4 screws

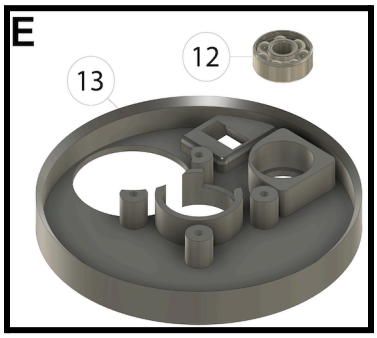


Step 11: Combine Dynamic PCB and Slip Ring Assembly

1. Place dynamic PCB on top of PCB Attachment such that the wires from the slip ring come out on the same side as the holes they will go into
2. slip ring Wire Pinout
    a. D - Black
    b. C - Blue
    c. B - Yellow
    d. A - White
    e. 5V - Green
    f. GND - Red
3. Note, this pinout should match whatever pinout was used for the static PCB
4. Cut the slip ring wires to size as needed to position them inside their respective holes. There should be at least 2.5mm of wire sticking out of the hole when the wire is placed.

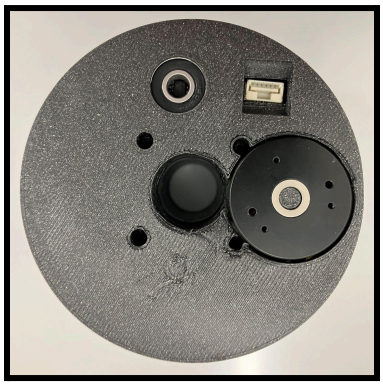
5. Once the correct amount of wire is cut, tinn the end of the wire to make it solid. Only add enough to combine the strands, not so much that it thickens the wire.
6. Place the wire back in its respective hole and solder it to the board
7. Let the solder cool and move on to the next wire. Do this for all wires
8. This is now known as the Bottom Assembly

Step 12: Prepare Top Case (E)



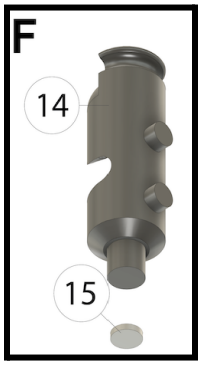
1. Place Super Glue around the inner diameter of the bearing socket on the 3D-printed piece
2. Place the bearing into the bearing socket and let it dry
    a. Pay attention to not let Super Glue touch either of the faces of the bearing as this could stop the bearing from moving

Step 13: Combine the Top Case and the Bottom Assembly



1. Align the Top Case so that the Brushless Motor fits into its cutout
2. Use 4 screws to bolt the Top Case to the Bottom Assembly
    a. Use M2 x 8 screws
    b. Note that the screws can be tricky to line up through the bolt holes in the dynamic PCB. Use a 1mm hex bolt to stick through the bolt holes of the Top Case, dynamic PCB, and PCB Attachment. This can be used as a placeholder so that the dynamic PCB does not shift as you insert the screws through the Top Case
    c. Only tighten the screws enough to hold them in place, to begin with, then once all screws are in, tighten them the rest of the way

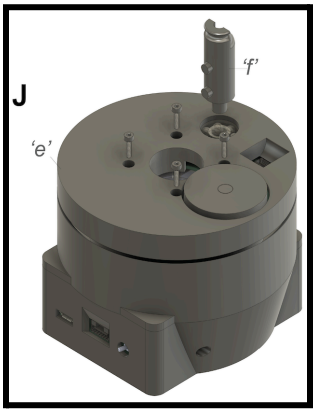
Step 14: Prepare Cable Holder (F)



1. Place Super Glue onto the bottom of the Cable Holder where the magnet will go
2. Attach the magnet to the bottom
    a. Use a 5 mm diameter magnet

Step 15: Combine Cable Holder and Commutator Body (J)

1. Place the shaft of the cable holder into the bore of the bearing
    a. This is a friction fit, do not use glue



Complete Commutator