Petal - diy vintage bottom bracket adapted sensorless 100-250w mid-drive e-bike motor

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(almost directly) from Weds. 1/15/2020: Round two at AA a success - got the 500w motor running at low power, ~6w. Step 1 complete! Here's the plan:

- take apart existing motor, understand how it works - **DONE**
- hook up oscilloscope, understand controller better - **DONE**

- learn to 3d print (tool training 3/22) - **DONE**
- 3d print stator model for old school bottom bracket - **IN PROGRESS, v4**

- learn to lost wax/investment cast/machine/CNC to produce metal/iron stator core
- embed/attach permanent magnets to BB spindle
- wind stator

- get 48v e-bike battery, use as power supply
- cut bike frame to tabletop size
- install BB motor + controller + battery, get spinning

- test w/ cranks, *torque*

- install prototype e-motor on full bike
- test prototype

- make a few working prototypes
- hand out to others for testing/alpha

- make video documenting build process
- make promo video for web

- launch website w/ video(s)
- crowdfunding/beta

- solicit investors
- patent
- form llc/startup

- refine design
- contract manufacturer

- set up direct sale on website
- release v1

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vintage bottom bracket w/ spindle, bearings, and cups
48v battery
controller/driver
4 strong, curved magnets
jb-weld epoxy
stator iron (3d print mod, then lost-wax cast)
copper wire

SOLVED: nylon/metal washer possibly with notches for bearing cups to compress stator. or just design the stator so that it juts out enough for the bearings to compress on. need so that stator stays centered and fixed (non-rotating)

use cable guide screw hole for wires

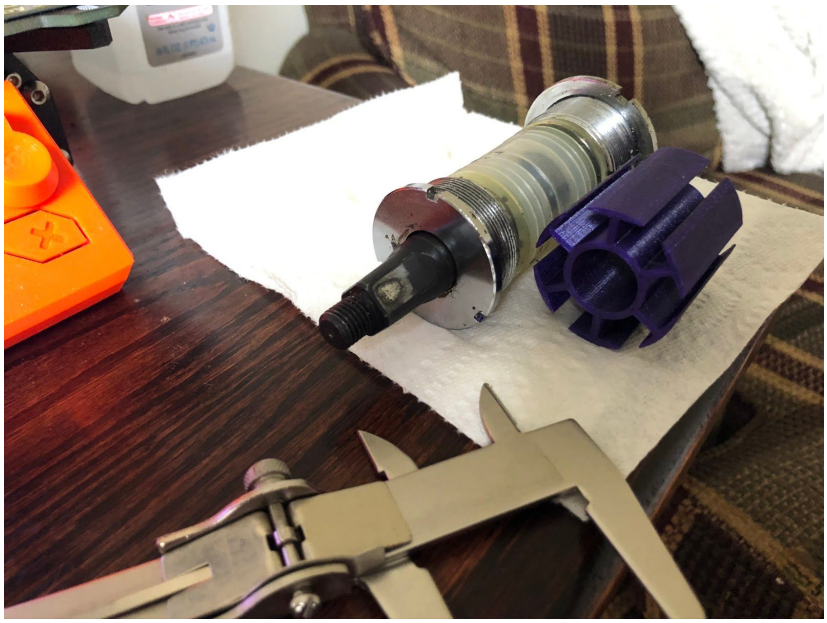
https://artisansasylum.com/

Weds. 1/22/2020: heading to AA tonight to hook up motor to scope, possibly take apart 500w motor.

Fri. 5/1/2020: 3d printed the stator, v2. This print was successful.

resources:
printer = Prusa i3 MK3S
material = prusament PLA (galaxy purple)
amount = 16.64g
cost = $.42
time = 2h12min
settings:
slicer = PrusaSlicer
layer height = .20mm quality
infill = %15
supports = none

v2 dimensions:
num_poles = 6
td = total diameter - 38mm (=(1+pr)*od)
od = center ring outer diameter - 21mm
id = center ring inner diameter - ~17mm
h = height - 43mm
pr = pole ratio - .65 => pole length ~ 6.5mm (= pr*(od/2))



Pretty damn close to the specifications for the generated object file.

For v3, I'll need to have the inner diameter wide enough to fit over the races of the spindle.

vintage bottom bracket dimensions:
center length = 43.5mm (bottom groove to bottom groove. ~45mm race to race)
spindle diameter = 16.5mm
square taper (small) = 13mm
square taper (large) = 14mm
race diameter = 21mm

standard bottom tube dimensions:
inner diameter = 34mm

v3 dimensions:
num_poles = 6
td = total diameter - 34mm
od = center ring outer diameter - 21mm
id = center ring inner diameter - ~17mm
h = height - 43mm
pr = pole ratio - .65 => pole length ~ 6.5mm (= pr*(od/2))

~5:45pm: In progress.

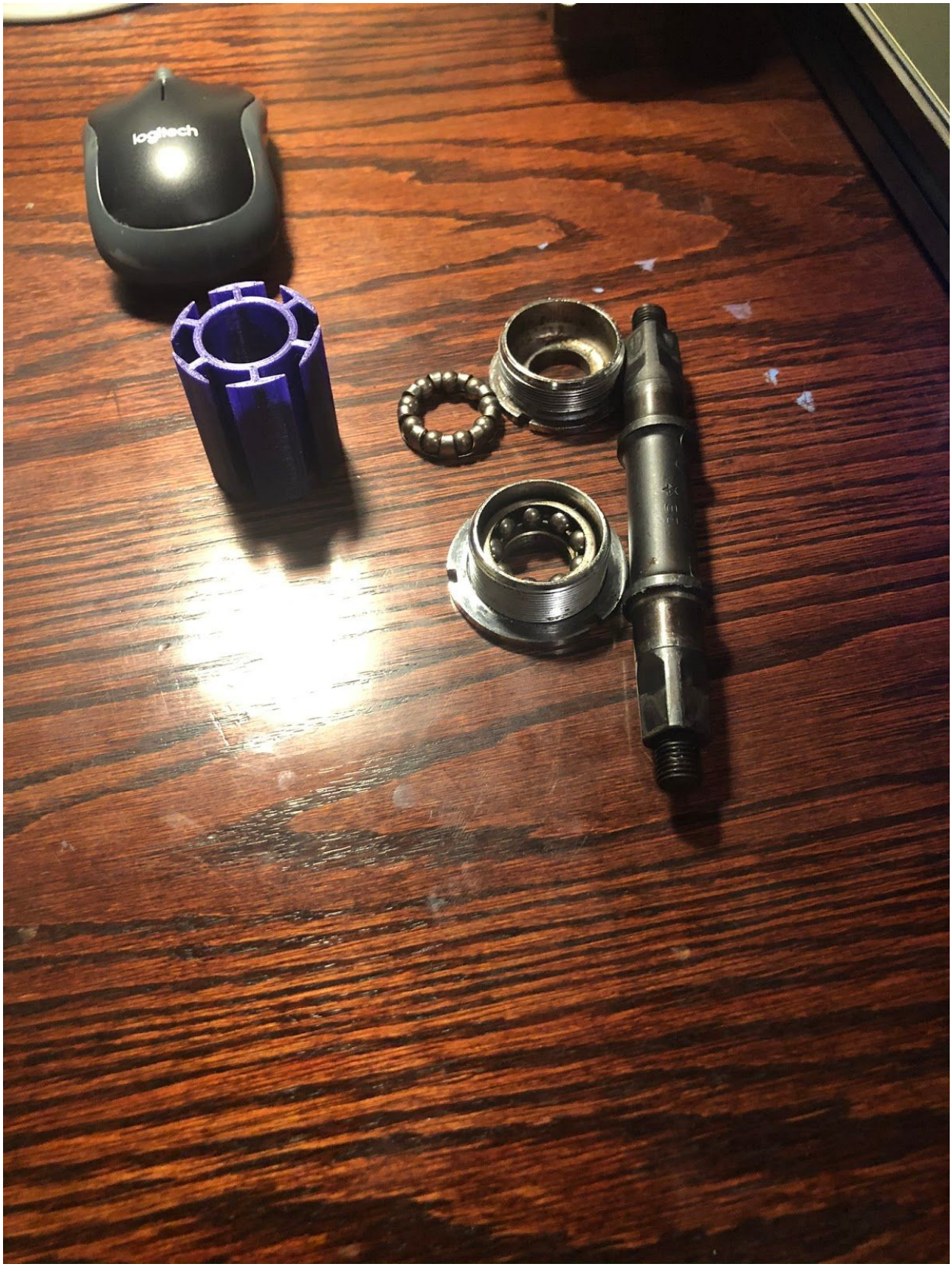
Printed successfully. With the inner diameter exactly matching the bearing race diameter, it was remarkably tight. With a lot of force and some time, I was able to get it past. It may make sense to leave it that small with a little internal sanding or something, but I'd prefer .1mm on each side and just have an inner diameter that's .2mm bigger.

Sun. 5/10/20, ~8:30pm:

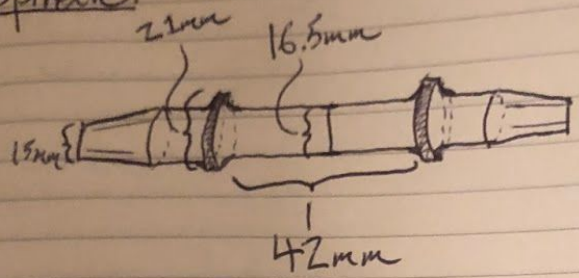
Trying v4. This time, we have:

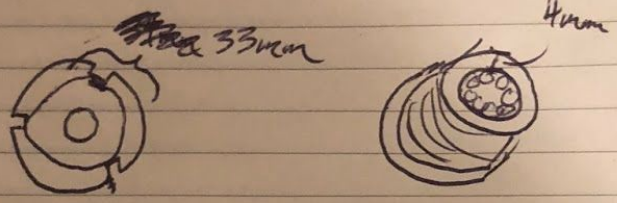
pole_num=6
id=21.2mm
od=25.2mm
height=43mm
pol_ratio=.25
cap_ratio=1.5
resolution=400

I noticed that a problem I thought I have is not a problem. When I go to wrap the copper windings, it will bulge out a little on the sides, 1-3mm. I thought I might have to shave the stator height from 43mm to 40mm to compensate. However, there is a nice 3-4mm gap on either side between the bearing cage and the end of the cup.


logitech

Spindle:



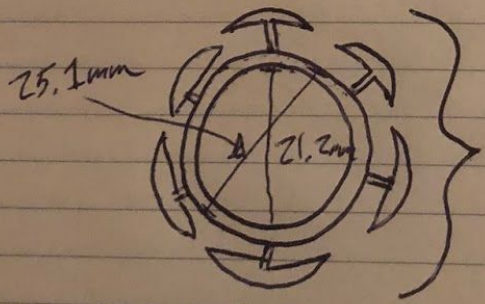


There is a 4mm gap between the cage and cap, which will be ideal to sit the winding overhang.

copper

.25

pol_pat = ~~2~~



total diam

$\Rightarrow \approx$ 34.4mm

25.1 - 21.2 = 3.9mm → 13 layers @ .3mm/layer

$10.40, 15.93g, 1h3m

Printing v4. Added a brim, turned the bed_temp up to 70c, and turned the speed down on the first few layers. Making sure to have good adhesion.

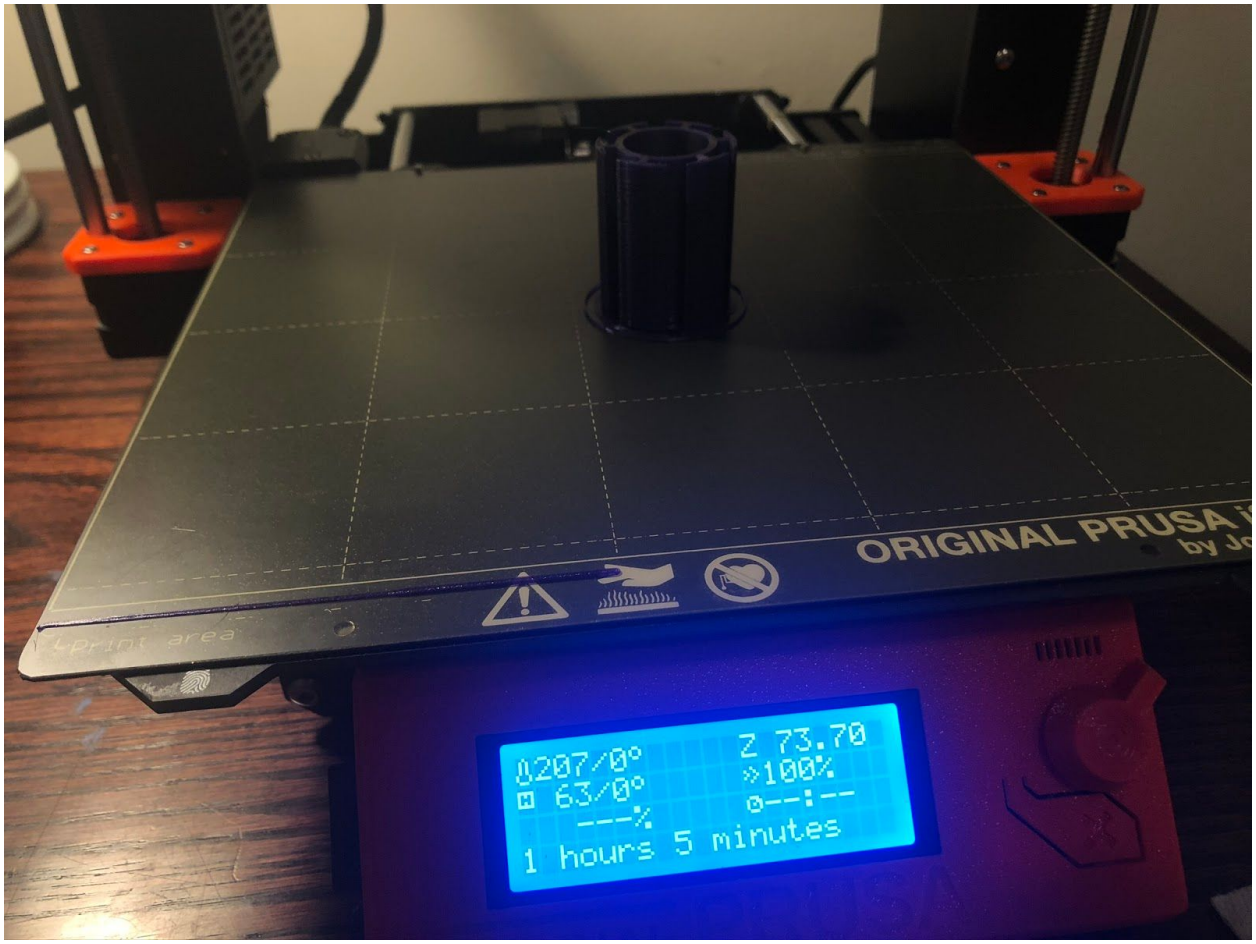
v4 printing successfully, will take 1h3m, 15.95g. PLA @ $24.99/kg = $0.40.

Mon. 5/11/20: Realized that, with the bearing cups and cages, the available length for the stator 'height' is really 42mm, not 43mm. It may be that you can compress the stator, but probably only .2mm or so, which would allow for a nice snug fit.

Ordered some neodymium arc magnets from https://www.apexmagnets.com/.

v5 has height 42.1mm.

~7pm: v5 finished printing. It's still a little too big at 42.1mm. Will try 41.1mm.



V4 is printed. It measures:

total_diam = 34.5mm
id = ~21.2mm
od = ~25.1mm
pole_length = 2.9mm

Calculations:

Would like to calculate power. Need to know:

*wire gauge
*number of windings
*current
*strength of magnets
*geometry of setup
*number of poles = 6

pole_length = 2.9mm
pole_width ~ 5mm

AWG -> diam -> num_windings:

19 (1.8amp) -> .912mm -> 3
20 (1.5amp) -> .812mm -> 3

21 (1.2amp) -> .723 -> 4
22 (.92) = .644 -> 4

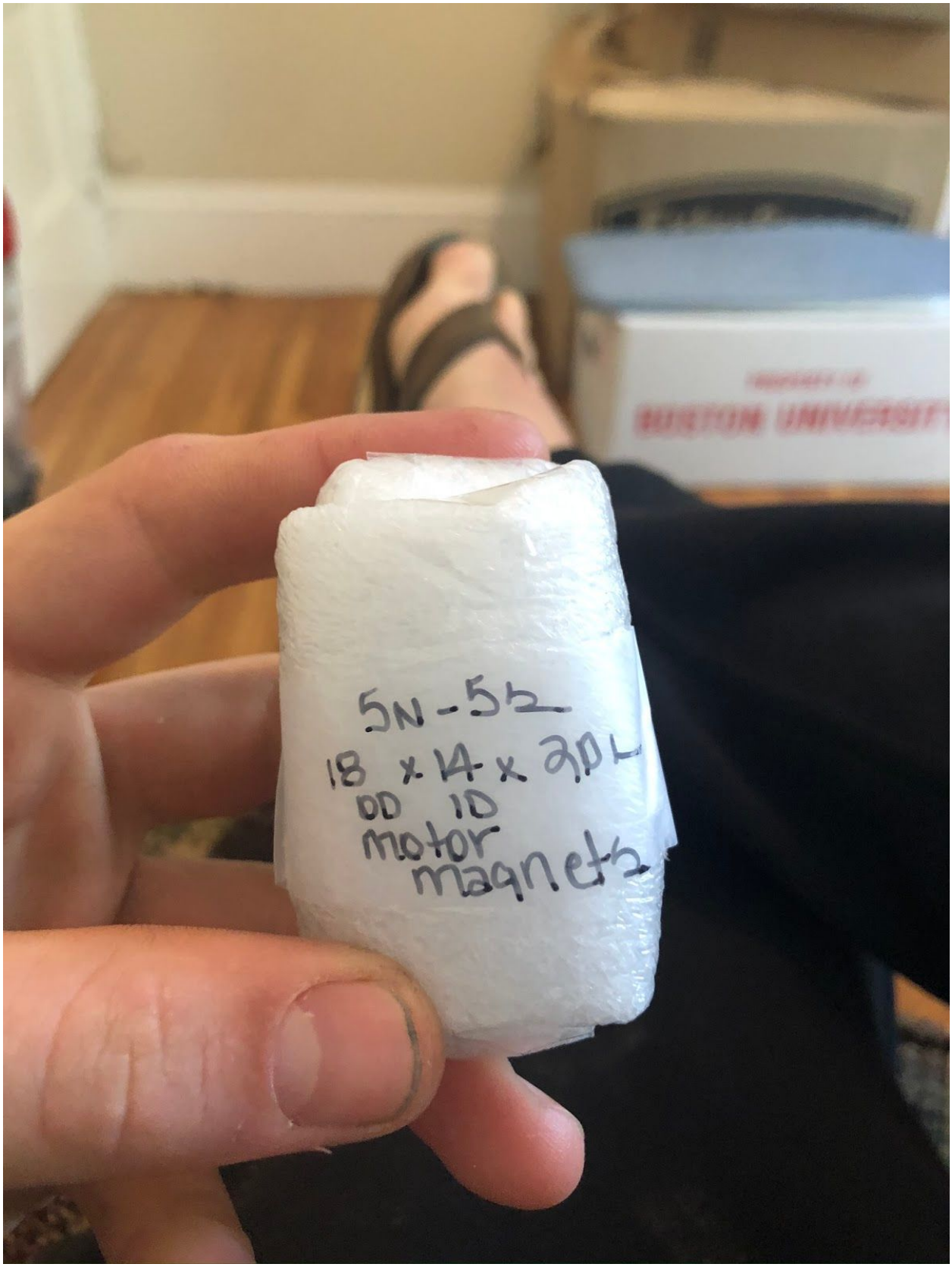
Example: AWG 21, 1.2amp max power transmission, .723mm, 4 windings around pole, 6 layers.

24 loops per pole.

Too hard - need to measure. At 48v, no more than 57watt.

Tues. 5/12/20: Printing v7, height = 41.3mm. v6 fit perfectly, but not snugly. need some compression.

Thurs. 5/14/20: Magnets arrived yesterday. At least one set fits very nicely, no need to shave down the spindle yet, and they stick right on so no immediate need for epoxy. Going to grab some copper wire, and eventually will need to find a 48v battery.


5N-52
18 x 14 x 3D L
OD ID
motor
magnets

~10pm, Thurs. 5/14/20: Found some magnet wire at “You-Do-It” Electronics Center in Needham. 22 gauge. Bought a multimeter, cutters, and wire strippers at Home Depot. Wound the stator core, and was able to generate a few mA of current by spinning the spindle.