

Outer- vs. Inner-Rotor

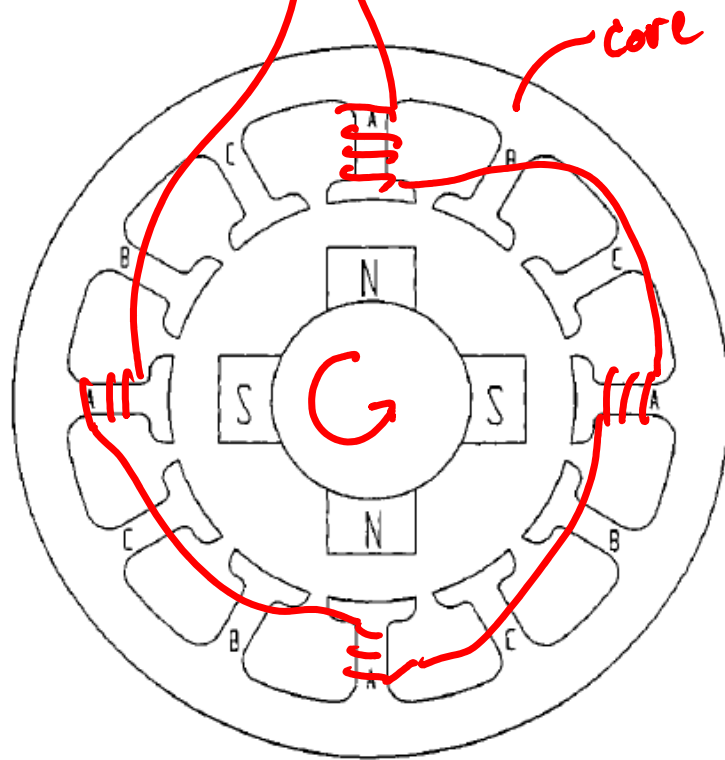


FIGURE 5.15 Multiphase inner-rotor motor.

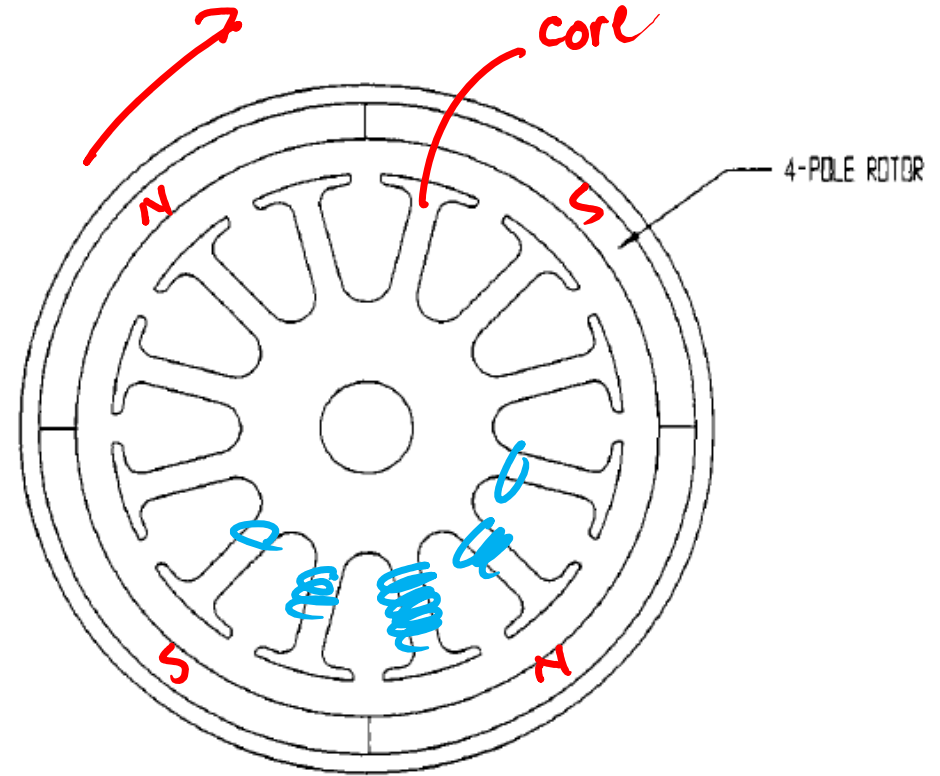
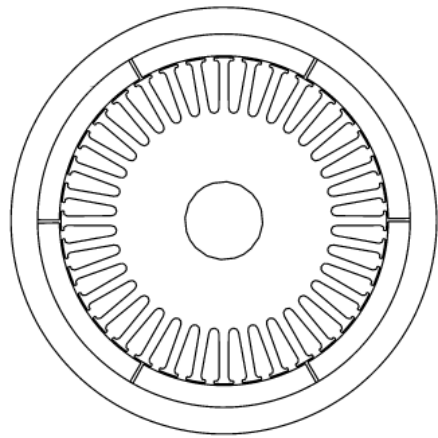


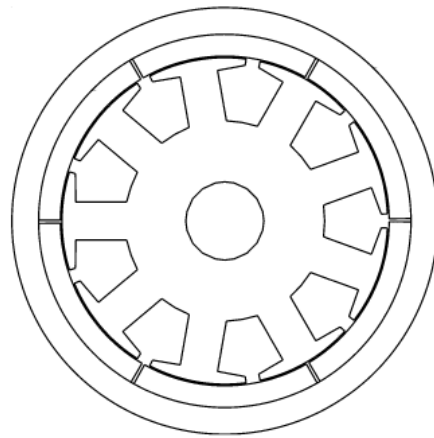
FIGURE 5.13 Multiphase outer-rotor motor.

- Traditional motors are inner-rotor
- On e-bike, need hub to remain stationary and outer wheel to spin

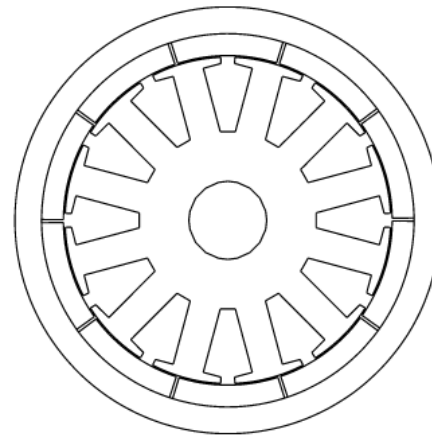
Motor Teeth/Poles Example



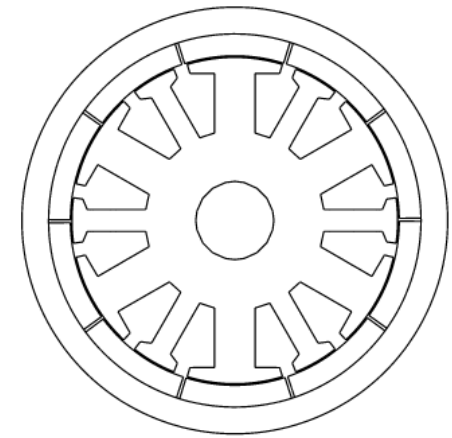
(a)
36-slot/6-pole



(b)
9-slot/6-pole



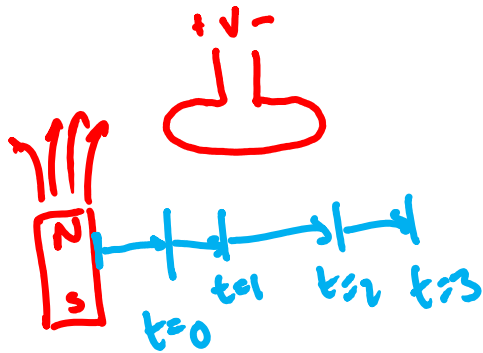
(c)
12-slot/10-pole
(all teeth wound)



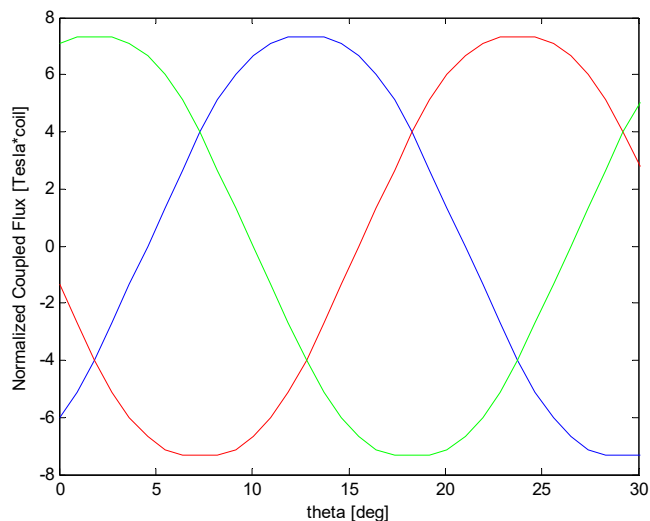
(d)
12-pole/10-pole
(alternate teeth wound)

Shaping Back-EMF

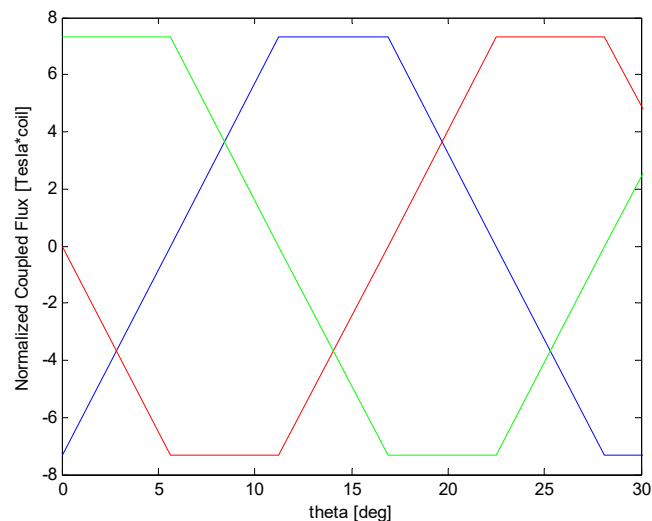
- Earlier, assumed $f(\theta_r) = \sin(\theta_r)$ resulting in sinusoidal back-EMF
- Ways to achieve:
 1. Sinusoidal distribution of windings
 - 2. Altering slot/pole/phase
- #2 is used in our motor



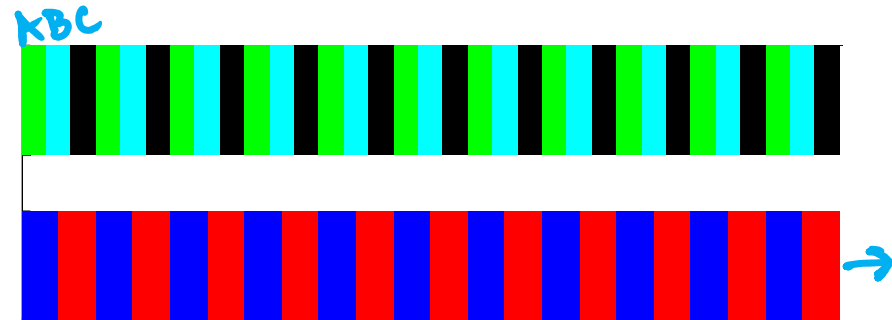
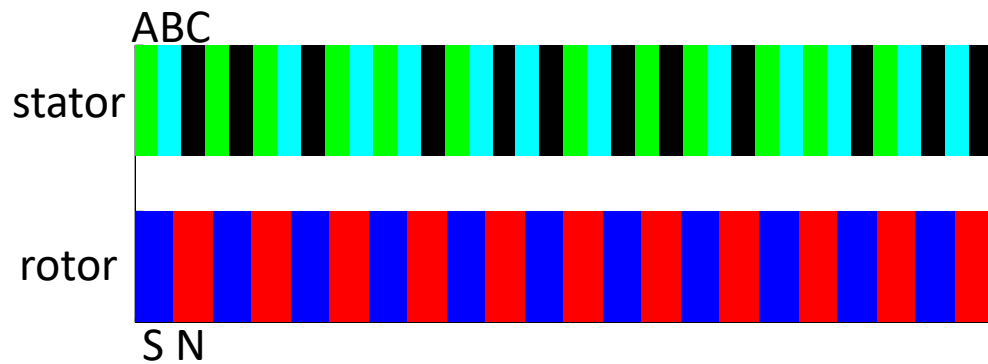
Shape of Back EMF



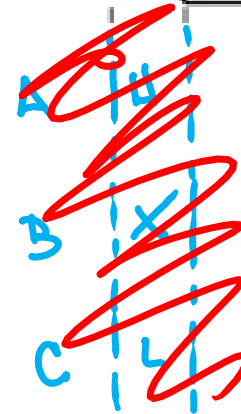
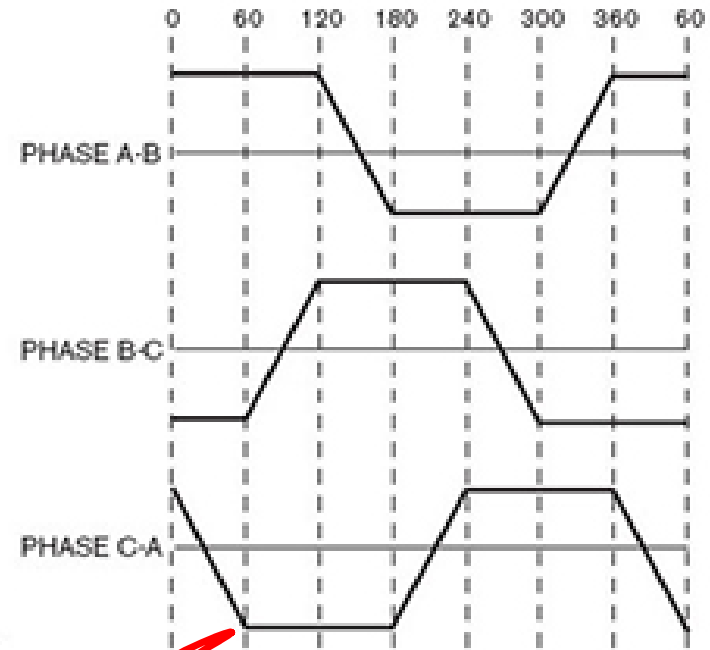
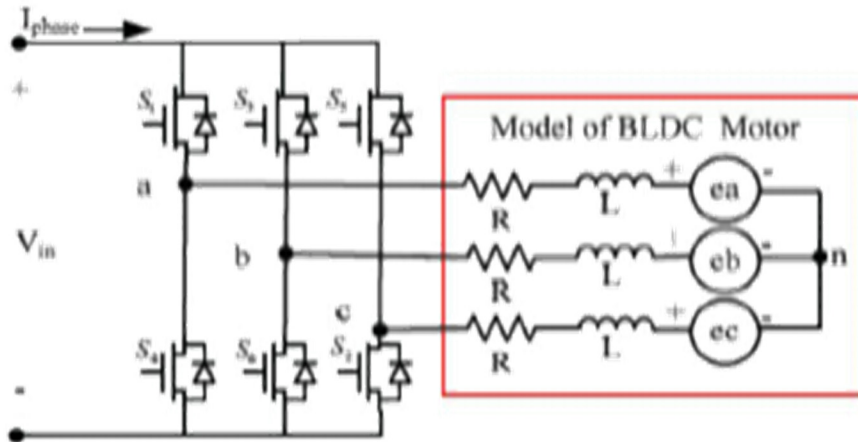
- 36 Teeth, 22 Poles
- Teeth/Pole/Phase = 0.5455



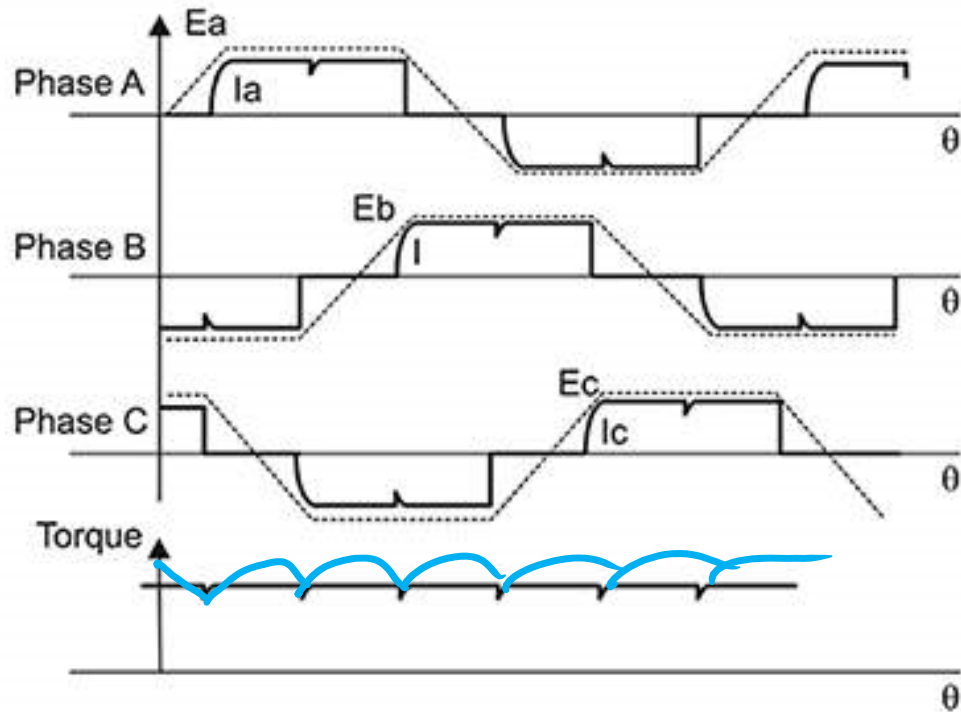
- 33 Teeth, 22 Poles
- Teeth/Pole/Phase = 0.5



Motor Driver: Trapezoidal Control



Torque Ripple



Example Front Wheel Hub Motor

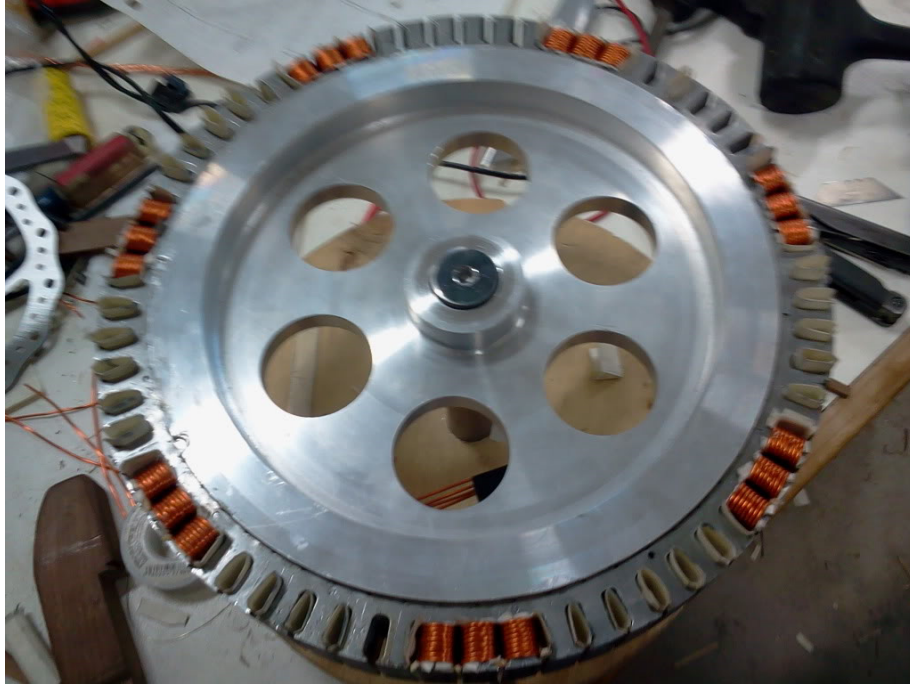


E-bike hub (stator)



Single phase wound per tooth

Stator Winding



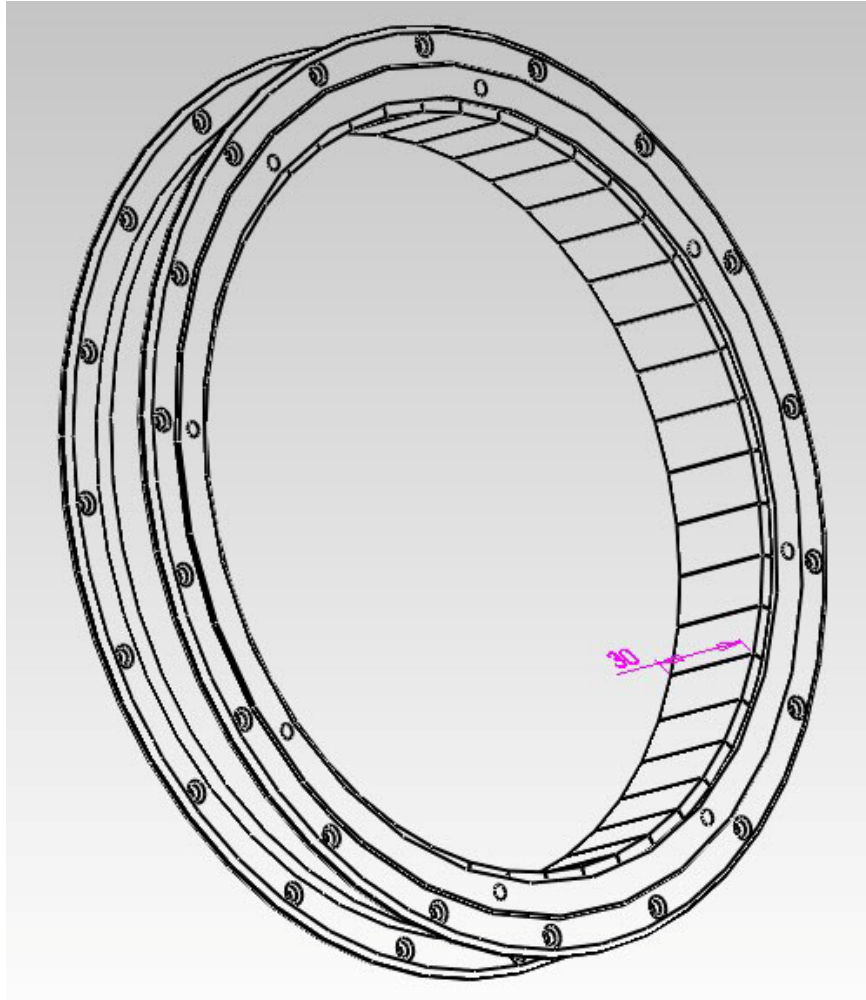
Complete winding of Phase A



Complete winding of all phases

56 pole
63 teeth

Rotor and Poles



- Outer rotor (to which spokes/wheel are attached)
- Magnets alternate N-S