



# E-Bike STEM Education: Lesson 4: E-Bike Controllers

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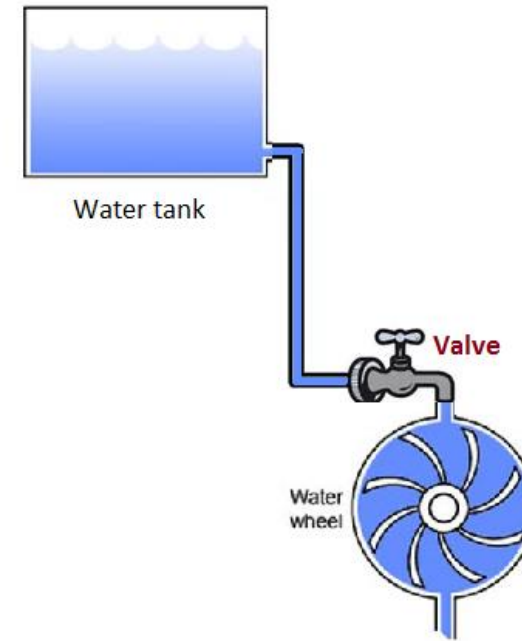
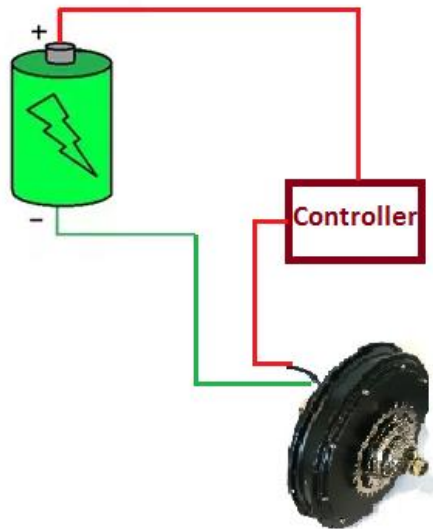
# E-Bike Controllers: What we're going to learn

- Controller purpose
- Install location and connections
- How they work
- Performance

# Controller-- like smart valve with remote control



Controller	Valve
<b>Controls motor speed and power</b>	<b>Controls water turbine speed and power</b>
<b>Limits current from battery to motor (protects both)</b>	<b>Limits water flow into turbine</b>



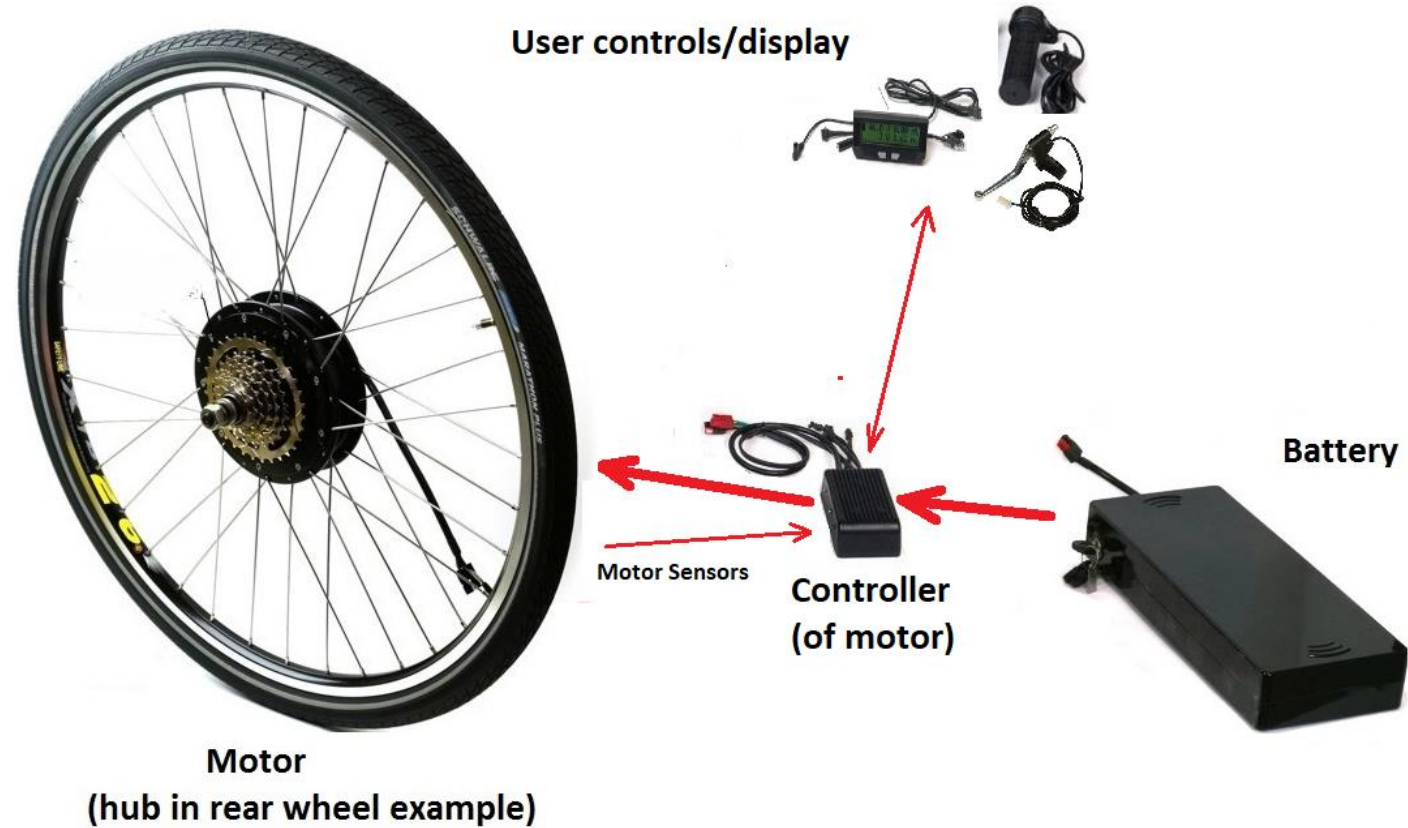
# Controller Installations

- Locations:

- Mounted inside hub motor
  - Simpler/cleaner wiring
- Separate box
  - Better heat management

- Connections:

- High current input from battery
- High current output to motor
- Hall sensor inputs from motor
- Assist level / throttle input from controls



# Remember our simple motor?

- DESIGN:

- Only one magnet, so...
  - Only one magnetic pole faces coil
- Coil only active for  $\frac{1}{2}$  of the time
  - We scraped enamel coating to make ON/OFF switch
  - The other half, it's slowing down.
- Force on coil drops fast as coil moves away from magnet

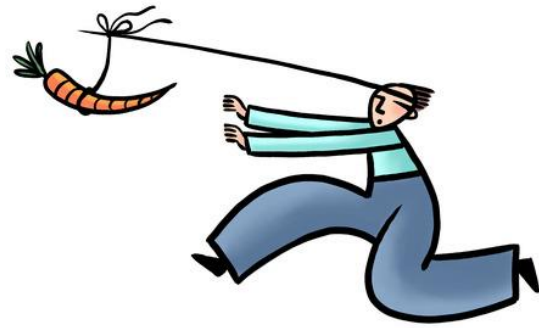
- RESULT:

- Force on coil is NOT smooth/constant
- Motor NOT efficient

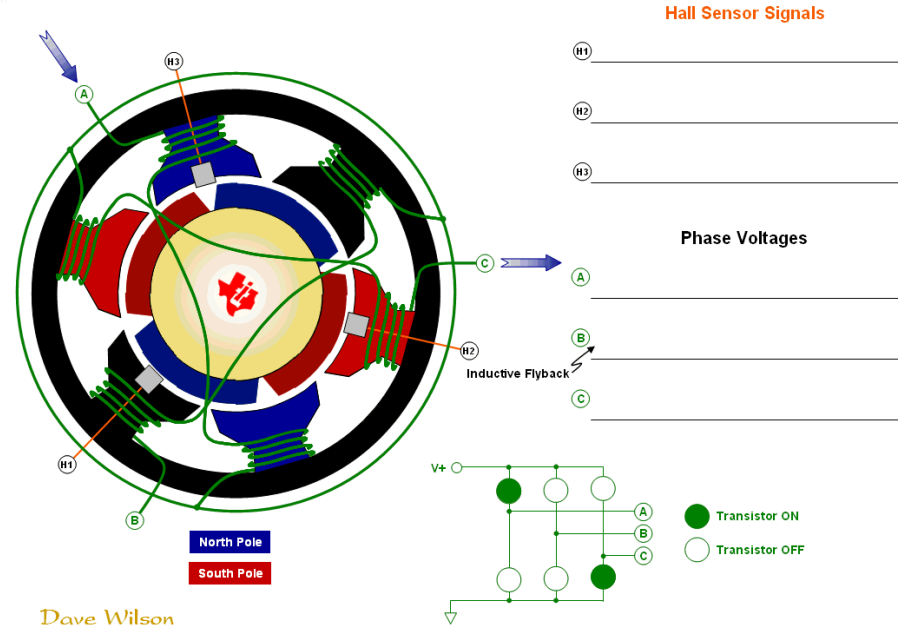
***We can improve performance by adding more coils, more magnets, and some fancy switching***



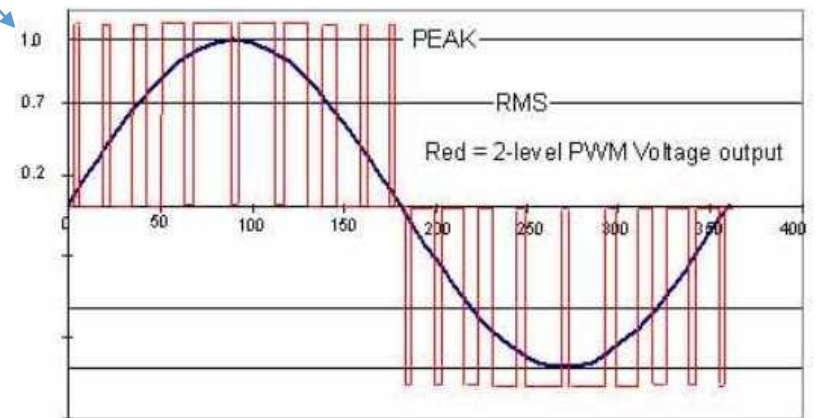
# How controllers work



- Coils switched between phases (commutation)
  - Like “Carrot on stick” motivation
    - The carrot is always moved ahead, so you keep running after it
  - Next coil’s desired **polarity** switched in as wheel rotates magnets into position
    - Controller uses magnetic Hall sensors in motor to decide
  - Throttle adjusts pulse width(s) during each phase
    - Sinewave approximation controllers are smoother/quieter
- Protection
  - Battery / motor current limit not exceeded
  - Thermal limit of motor (system dependent)



Dave Wilson



# Hands on exercise



- See inside of typical controller (MOSFETs, etc.)
- Hook controller up to tester box
- Mount controller onto donor bike