QuadCopter DC Motor(BLDC) + Propeller Dynamics

I decided to start on the inner loops. By this I mean the control loops for each propeller drive system. A Brushless DC Motor (BLDC) is standard for hobby-sized quadrotors, so let's assume the motor type.

I haven't sized anything yet: propellers or motors, but I can get the dynamic model figured out and put together a propeller speed control design. Ultimately we'll buy Electronic Speed Controllers (ESCs) for our Quad motors. They take PWM in and produce RPM out. All this here will be relevant when we get to that point.

DC Motor Modelling

Below I start with basic DC motor equations from just about any undergraduate dynamics textbook. I add the Bouabdallah model for the drag term, which for a simple motor would be the back-emf alone, but here I account for propeller and gearbox drag referred to the motor shaft as you can see below.

The motor-propeller speed model is non-linear. The Taylor Series expansion and evaluation about a nominal operating point is used to linearize it. As noted below, I'll need a plan for sliding these constants and the compensator over the speed range. I can worry about that later.

I'm sharing this here because I want to illustrate more steps in the derivation of the final equation than the Bouabdallah paper has space to do. When I read papers often a final equation is given after it is stated that, "the following equation has been linearized", for example. That is often a leap for me. I don't like to keep reading until I work it out for myself. Here I want to share each step.

I’ll leave this post to cover derivation of the propeller-motor equation with drive voltage as the control input.

BLDC