Rated voltage	9.0V (DC)
Temperature range	-20℃~+60℃
Humidity range	0%-90%
No-load current	≦ 200 mA
No-load speed	185±10% rpm
Rated load	0.9 Kgf.cm
Rated current	≦ 550mA
Rated speed	135±10% rpm
Starting torque	4.5kgf.cm
Locked-rotor current	≥ 2.0 A
Parts List	1 x Me Encoder Motor Driver 2 x Optical Encoder Motor-25 9V/185RPM 2 x Encoder Motor Wire
Package Dimension	200 x 140 x 30mm (7.9 x 5.5 x 1.2inch)
Net Weight	222g (7.83oz)
Gross Weight	228g (8.04oz)

Figure 1: Enter Caption

I am doing the time system response to see if my model actually represents the system

here is the model

$$I_\theta \ddot{\theta} + b\dot{\theta} - \frac{hmg}{2} \sin\theta = k_{gr} k_t \Big(\frac{V - k_e \omega}{R} \Big) \tag{1}$$

$$I_\theta = \big(\frac{m}{12} (h^2 + w^2) \big) \tag{2}$$

$$I_\phi = \big(\frac{m}{12} (l^2 + w^2) \big) \tag{3}$$

$$q = \begin{pmatrix} \theta \\ \psi \end{pmatrix} \tag{4}$$

$$M = \begin{pmatrix} I & 0 \\ 0 & I \end{pmatrix} \tag{5}$$

$$B = \begin{pmatrix} b & 0 \\ 0 & b \end{pmatrix} \tag{6}$$

$$G = \begin{pmatrix} dmg\sin\theta + \frac{k_t k_{gr}}{R}\omega \\ \frac{k_t k_{gr}}{R}\omega \end{pmatrix} \tag{7}$$

$$F = \begin{pmatrix} k_{gr}\left(\frac{k_t}{R}(u_1 + u_2)\right) \\ k_{gr}\left(\frac{k_t}{R}(u_1 - u_2)\right) \end{pmatrix} \tag{8}$$

$$h = .11m \tag{9}$$

$$w = .135m \tag{10}$$

$$m = 0.725748kg \tag{11}$$

$$g = 9.81\frac{N}{s^2} \tag{12}$$

$$b = 0.0493\frac{Nm \cdot s}{rad} \tag{13}$$

$$I_\theta = \frac{m(h^2 + w^2)}{36}kg \cdot m^2 \tag{14}$$

$$I_\psi = \frac{m(w^2 + h^2)}{18}kg \cdot m^2 \tag{15}$$

$$m_w = .06m \tag{16}$$

$$r = .031m \tag{17}$$

$$R = 4.5\Omega \tag{18}$$

$$I_w = \frac{m_w r^2}{2} \tag{19}$$

motor consts now:

$$k_t = \frac{\tau_{rated}}{I_{rated}} = \frac{0.08825985Nm}{.55A} = .1604\frac{N \cdot m}{A} \tag{20}$$

$$k_e = k_t = .1604\frac{V \cdot s}{rad} \tag{21}$$

$$R = \frac{k_t(V_{rated} - k_e\omega_{rated})}{\tau_{rated}} = \frac{.1604\frac{Nm}{A}\left(9.0V - .1604\frac{V \cdot s}{rad} \cdot 14.137166924999999\frac{rad}{s}\right)}{0.08825985Nm} = 12.23519763\Omega \tag{22}$$

$$k_{gr} = 1/46 \tag{23}$$

Ok, my state variables and control inputs are

$$X = \begin{pmatrix} \theta \\ \dot{\theta} \\ \omega_1 \\ \omega_2 \end{pmatrix} \tag{24}$$

$$U = \begin{pmatrix} V_1 \\ V_2 \end{pmatrix} \tag{25}$$

so my model for pitch is

$$\dot{X} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ -\frac{hmg}{2} & -\frac{b}{I_\theta} & -\frac{k_{gr}k_t k_e}{2RI_\theta} & -\frac{k_{gr}k_t k_e}{2RI_\theta} \\ 0 & 0 & -\frac{k_{gr}k_t k_e}{2RI_\theta} & 0 \\ 0 & 0 & 0 & -\frac{k_{gr}k_t k_e}{2RI_\theta} \end{pmatrix} X + \begin{pmatrix} 0 & 0 \\ \frac{k_{gr}k_t}{2RI_\theta} & \frac{k_{gr}k_t}{2RI_\theta} \\ \frac{k_{gr}k_t}{2RI_w} & 0 \\ 0 & \frac{k_{gr}k_t}{2RI_w} U \end{pmatrix} \tag{26}$$

$$Y = \begin{pmatrix} 1 & 0 & 0 & 0 \end{pmatrix} X \tag{27}$$

so, here's my state variables for yaw, control inputs stay the same

$$X_\psi = \begin{pmatrix} \psi \\ \dot{\psi} \\ \omega_1 \\ \omega_2 \end{pmatrix} \tag{28}$$

$$\dot{X_\psi} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & -\frac{b_\psi}{I_\psi} & -\frac{k_{gr}k_t}{2RI_\theta} & \frac{k_{gr}k_t}{2RI_\theta} \\ 0 & 0 & -\frac{k_{gr}k_t}{2RI_\theta} & 0 \\ 0 & 0 & 0 & \frac{k_{gr}k_t}{2RI_\theta} \end{pmatrix} + \begin{pmatrix} 0 & 0 \\ -\frac{k_{gr}k_t}{2RI_\theta} & \frac{k_{gr}k_t}{2RI_\theta} \\ -\frac{k_{gr}k_t}{2RI_\theta} & 0 \\ 0 & \frac{k_{gr}k_t}{2RI_\theta} \end{pmatrix} U \tag{29}$$

$$Y = \begin{pmatrix} 1 & 0 & 0 & 0 \end{pmatrix} X \tag{30}$$

Where $b_\psi \approx 0$