SERVO MOTORS
Homework

A Permanent Magnet Synchronous Machine (PMSM) is performing position control under the load shown in the figure for a step reference input. An **incremental encoder** connected to the shaft of the drum is used for **position feedback**, as shown in the figure. The **flux is desired to be kept constant** during control. A **hysteresis current controller,** ($i_q^{ref} \cong i_q$) is used in the system. Under these conditions:

a) Provide a **detailed block diagram** of the unit feedback control system for this setup. Define the blocks in the diagram and specify the signals entering and exiting each block. Represent the **position controller,** $G_\theta(s)$, used for position control in the system with a **transfer function block** (include $\boldsymbol{i_d}$ **and** $\boldsymbol{i_q}$ **currents**, show the **non-simplified** block diagram).

b) Given the system parameters: Mass: M=2.4 kg, B= 0.8 N s/m , Radius: r=0.5 m, J_t = 0.2 kg m^2, B_t = 0.6 Nm s/rad, Motor inertia: J_m = 0.2 kg m^2, Motor damping: B_m = 0.2 Nm s/rad, Torque constant: $K_t = 1$ Nm/A, Back EMF constant: $K_b = 1$ V s/rad.

Design a **minimum-order position controller** that:

- Provides a **settling time,** $T_s = 4/\sigma = 8$ san
- Ensures **zero steady-state error** for a step input
  $e_{ss} = \lim_{s\to 0} s\,E(s) = \lim_{s\to 0} s\left(\theta_m^{ref}(s) - \theta_m(s)\right)$

Note: In the controller design, assume $\boldsymbol{i_d}$ **= 0**A. If the system has additional zeros and/or poles that may impair second-order behavior, place their **real parts** five times farther than the real parts of the control poles.