The open-loop system dynamics model for the NASA eight-axis Advanced Research Manipulator II (ARM II) electromechanical shoulder joint/link, actuated by an armature-controlled dc servomotor is shown in Figure P1.
The ARM II shoulder joint constant parameters are
K_a= 12, L=0.006 H, R= 1.4 Ω, K_b= 0.00867, n=200, K_m= 4.375, $J=J_m+ J_L /n^2$, $D=D_m+D_L /n^2$, J_L= 1, D_L= 0.5, J_m= 0.00844, and D_m= 0.00013.

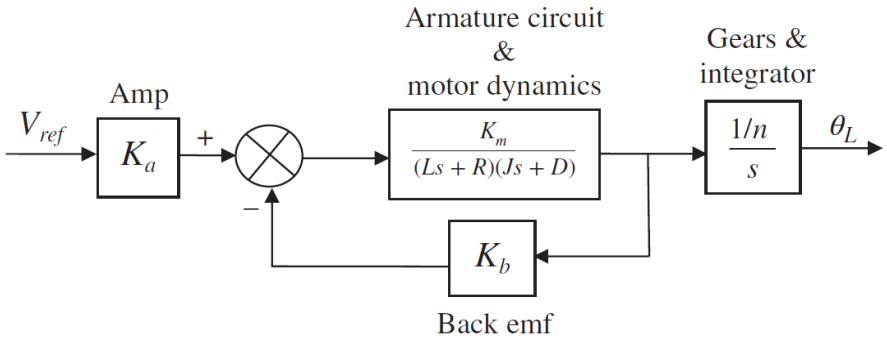

FIGURE P1 Open-loop model for ARM ll

a. Obtain the equivalent open-loop transfer function, $G(s)$ (with a unity feedback system) (**using MatLab or MatLab/Simulink**).
b. The loop is to be closed by cascading a controller, $G_{c1}(s) = K_P$, with G(s) in the forward path forming an equivalent forward-transfer function, $G_e(s) = G_{c1}(s)\,G(s)$. Parameters of $G_{c1}(s)$ will be used to design a desired transient performance. The input to the closed-loop system is a voltage, $V_I(s)$, representing the desired angular displacement of the robotic joint with a ratio of 1 volt equals 1 radian. The output of the closed-loop system is the actual angular displacement of the joint, $\theta_L(s)$. An encoder in the feedback path, K_e, converts the actual joint displacement to a voltage with a ratio of 1 radian equals 1 volt. Draw the closed loop system showing all transfer functions. (**Use Microsoft PowerPoint or Visio to draw the system**)
c. Find the closed-loop transfer function $T(s)$. (**using MatLab or MatLab/Simulink**).
d. Determine the range of K_P for which the system is stable (using root locus technique).
e. Determine the step response for four different values of K_P including stability and instability conditions (**using MatLab or MatLab/Simulink**).
f. Determine the transient parameters for a selected stable oscillatory response (rising time, settling time, overshoot (**if exists**) and compare and discuss the response (**using MatLab or MatLab/Simulink**). (choose a value for K_P)
g. What is the min. steady state error of this system?