Systematic PID Design and Practical Issues

1. Simplify the plant transfer function \( \frac{\text{Pos}(s)}{\text{Vc}(s)} \) to have dominant second order poles/zeros. Compare the DC gain with the original and discuss. Then normalize it to have the same DC gain as the original transfer function.

2. Design a P-D controller by placing the closed loop poles in the region of the s-plane that corresponds to the requirement of moving the load by 12 inches in less than 0.3 second with less than 2% overshoot and an accuracy of 2% or better. Use the transfer function from step 1 and select the controller parameters as a function of \( \omega_c \), the desired closed loop bandwidth, so that armature voltage and current are as smooth as possible. Add a torque disturbance \( T_d = 1000 \) at 2 seconds. Simulate the closed-loop system and verify the design by observing the step response.

3. In practice, a step response is not used in industry, due to the abrupt load on equipment. Instead, a standard trapezoidal profile is often used as the reference signal. The trapezoid is defined using the Simulink 1-D lookup table with the input vector as [0 1.2 3.4] and the output vector as [0 1.5 1.5 0 0]. Repeat step 1 using this profile. What changes do you see in motor voltage and current? Increase \( \omega_c \) to meet the requirements and discuss the results. What happens to the disturbance?

4. Tune a standard PID controller using Zeigler-Nichols tuning rules as in the extra credit of the previous design assignment. With the torque disturbance present, simulate the system, retune Ki and Kd for a smoother response with no overshoot, and simulate again. Discuss the differences in the responses in the transient and steady state regions.

5. Extra Credit: Design a prefilter to give you the required response without having to retune the controller. Be clear about your design method.

Report:
Write the report as a formal technical document with a title page, table of contents, sub-section titles, appendices, etc. It should include an introduction, the design process, reasoning, the simulation results, and a summary of what you have learned in this process in the conclusion. Keep it concise and to the point. The graphs should flow with the text. (Copy the graphs to MS Word). Use multiple curves on the same graph for comparison purposes.