Me2400-Project-2

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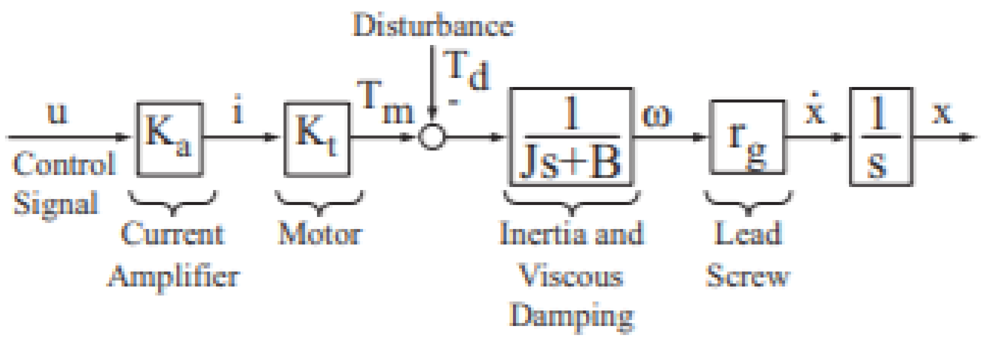
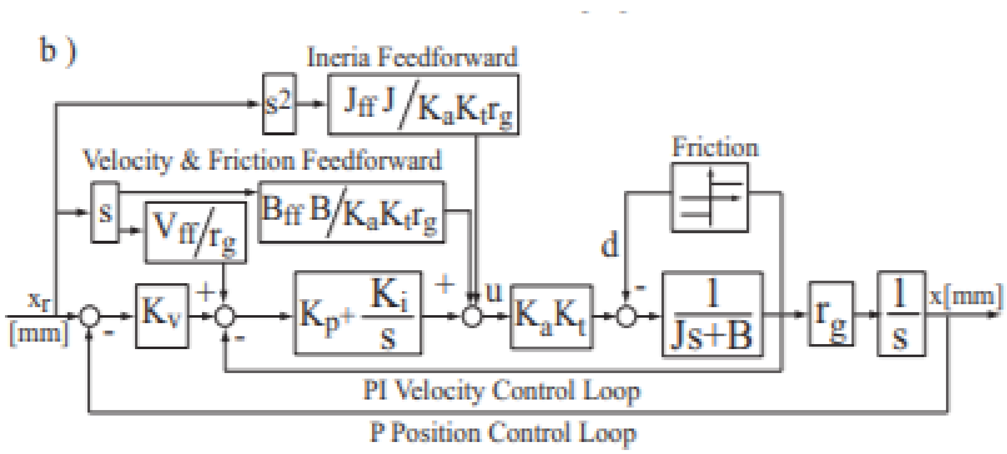
Through this project, we simulate the closed loop transfer function of 5-axis Computer Numerical Controlled (CNC) drives. Here the model considers the drive to be controlled by P-PI Cascade with feed forward dynamics and friction compensation. Study and analysis is conducted based on the paper “Identification of 5-Axis Machine Tools Feed Drive Systems for Contouring Simulation”.

The rigid body motion of a feed drive mechanism is shown in the below figure.



Here J kgm2 is the total inertia and B kgm2/s is the viscous damping of the axis. . In this model, motor and the amplifier are assumed to operate within their linear range, where u V is the control voltage command to the current amplifier modeled by a gain factor, Ka A/V, and the corresponding torque delivered to the drive is obtained by multiplying the current with the motor torque constant Kt A/V, and rg mm/rad is transmission gain of the ball-screw mechanism. torque delivered to the drive is obtained by multiplying the current with the motor torque constant Kt A/V, and rg mm/rad is transmission gain of the ball-screw mechanism

P-PI controller scheme is one of the most commonly used position control structure in commercial CNC drives. It is depicted below:-



Here, the velocity loop is closed using Proportional-Integral (PI) control by adjusting the gains Kp, Ki, and the position loop is closed by a proportional control (P) using Kv. Here the feed-forward compensation of axis dynamics is applied to increase the servo tracking bandwidth where Vf f ∈ [0,1], Bf f ∈ [0,1], Jf f ∈ [0,1] are the respective gains used to cancel the dynamics in P-PI controller.

The generalised axis model between commanded (xr mm) and actual axis position (x mm) can be written as;

$$[s^2 + a_1 s + a_2 + a_3 \tfrac{1}{s}]\, x(s) = \left[b_0 s^2 + b_1 s + b_2 + a_3 \tfrac{1}{s}\right] x_r(s) - sign(\dot{x}) d_c. \; \ldots\ldots. \; (1)$$

where dc Nm is the average Coulomb friction torque and sign() is the signum function.The model parameters can be expressed in terms of B, Ka, Kp, Kt, J, etc. These parameters are obtained using an objective function which is solved using Particle Swarm optimisation (PSO) method. Using these parameters we can simulate the axis motion by a closed loop drive system.

The true closed loop parameters for the P-PI controlled virtual drive is given in the table below;

Model Parameters	Actual value
a_1	238.4335
a_2	48421.5859
a_3	2487140.3
b_0	0
b_1	117.5424
b_2	37258.9796
d_c	2.6815

The model is simulated by substituting the value of the parameters from the table in equation (1).