ENGINEERING 6951

AUTOMATIC CONTROL ENGINEERING

HOMEWORK #1

Propellers are used to dynamically position a small boat near a target. The equations governing the dynamics of the boat are:

PLANT $M\, d^2R/dt^2 + N\, dR/dt = B + D$

DRIVE $J\, dB/dt + I\, B = Z\, Q$

SENSOR $X\, dP/dt + Y\, P = R$

CONTROLLER $Q = K_P\, E + K_I \int E d\tau + K_D\, dE/dt$

ERROR $E = C - P$

where R is the actual position of the boat in meters, P is the actual position in volts, C is the command position in volts, E is position error, B is the propeller load, D is a disturbance load, Q is the control signal, K_P K_I K_D are controller gains and M N J I X Y Z are constants.

$M=2$ $N=1$ $J=1$ $I=5$ $X=0.1$ $Y=2$ $Z=2$

Determine the borderline gain and borderline period of the boat when it being controlled by a proportional controller. Determine the Ziegler Nichols gains of the boat.

Develop a simulation template to study the motion of the boat. Use this to get the Ziegler Nichols response of the boat to a step in command with height 0.5. Include 12V controller saturation. Let the time step be 0.5 seconds and duration be 4 seconds.

Develop a MATLAB m code to study the motion of the boat. Develop a SIMULINK block diagram to study the motion of the boat. Include 12V controller saturation in the code and in the block diagram.

Use the m code and the block diagram to check the borderline proportional gain and period of the boat. Use them to get the Ziegler Nichols response of the boat to a step command with height 0.5 and to a step disturbance with height 5.0.

Modify the m code and the block diagram to study the motion of the boat when controlled by an ideal relay controller with 12V saturation. Compare the amplitude of the limit cycle generated with that based on Describing Function theory. Is the system practically stable?