

Digital Control – EEE 8007 Tutorial Exercise

1. Simulate the following system:
$$\left. \begin{aligned} \mathbf{X}_{k+1} &= \begin{bmatrix} -1.3 & -1.6 \\ 0.6 & 0.7 \end{bmatrix} \mathbf{X}_k + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u_k \\ y_k &= [1 \quad 0] \mathbf{X}_k \end{aligned} \right\}, T_s=0.01s.$$

The input is a sine wave of amplitude 1 and frequency 10rad/s (with the same sampling time).

2. Add a process noise component and increase its variance up to the point of having the output in a +/-10% zone from its original value (approximately $q=0.01$).
3. Remove the process noise component and add a measurement noise component and increase its variance up to the point of having the output in a +/-5% zone from its original value (approximately $r=0.005$).
4. Combine all these noise signals to create a stochastic state space model.
5. Create a normal current estimator that will place the poles at -0.01 and -0.05.
6. Record the estimator gains.
7. Calculate the ITAE for a simulation time of 10s (max step size= T_s)
8. Replace the normal estimator with a KF. Set the correct values of R and Q as $R=r$ and $Q=q*\text{eye}(2)$. Record the values of the KF gain and the error covariance matrix. Calculate the ITAE for the same conditions as before.
9. Compare the results.
10. Increase the value of r 10 times and inform the KF for that change. Do you expect higher or lower KF gains? Crosscheck your answer with the results that you get from the simulation. Monitor the ITAE for both estimating schemes.
11. Reduce the value of r 10 times and inform the KF for that change. Do you expect higher or lower KF gains? Crosscheck your answer with the results that you get from the simulation. Monitor the ITAE for both estimating schemes.
12. Increase the value of q 10 times and inform the KF for that change. Do you expect higher or lower KF gains? Crosscheck your answer with the results that you get from the simulation. Monitor the ITAE for both estimating schemes.
13. Reduce the value of q 10 times and inform the KF for that change. Do you expect higher or lower KF gains? Crosscheck your answer with the results that you get from the simulation. Monitor the ITAE for both estimating schemes.
14. Repeat parts 11-14 without informing the KF, discuss the results.