Control Theory II — Potential Theoretical Questions for Exam II
Monday, Nov. 18th, 2002 at 6:10–7:30

1. Define system observability and state main observability theorems, (C99, p. 153, 156; Class Notes p. 10, 12).
2. State and prove Kalman canonical controllability decomposition theorem (C99, p. 158–160; Theorem 6.6), (Class Notes p. 13–17).
3. Using the Kalman canonical decomposition show that the Popov-Belevitch eigenvector controllability test implies that the controllability matrix has full rank (page 49, Zhou and Doyle 96, one-page handout distributed in class).
4. State controllability theorems for discrete time invariant linear systems (C99, p. 169–160; Class Notes, p. 19).
5. State observability theorems for discrete time invariant linear systems, (C99, p. 171; Class Notes, p. 20).
6. State and prove controllability Grammian theorem of linear time *varying* continuous systems (C99, p. 176–177; Class Notes, p. 23–24).
7. State and prove the controllability rank test for time *varying* linear systems when matrices *A(t)* and *B(t)* are *n-1* times continuously differentiable, (C99, p. 177–178; Class Notes, p. 25–27).
8. State observability theorems for time varying linear continuous systems, (C99, p. 179–180; Class Notes, p. 28).
9. State the Lyapunov controllability and observability tests for time invariant linear systems (Class Notes, p. 13–14, Lemma 3.8 from ZDG96).
10. State and prove the balanced realization Lemma 7. 3 (ZD98, p. 107–108).
11. Explain the order technique reduction based on system balancing (Class Notes, p. 6, with the error estimate given at the bottom of page 10).
12. Explain the balancing residualization order-reduction technique and indicate its main features with respect to the step (low frequency) and impulse (high frequency) system responses (Gajic and Lelic, *Automatica* paper, Section 2).
13. Present the design of full order state estimators (Class notes, p. 1–2; C99, p. 247–250).
14. Derive the separation principle for the system-observer configuration (Class notes, p. 3–4; C99, p. 253–255).
15. Present the design of reduced-order state estimator (Class notes, p. 5–7)
16. Present the pole placement technique for single-input single-output systems in phase variable canonical form (Class notes, p. 9–10).
17. Present the technique for pole placement of multivariable (multiple-input multiple-output) systems using the Sylvester (Lyapunov) equation (Class notes, p. 12; C99, p. 259).
18. Present the reduced-order observer design for multivariable systems using the Sylvestrer (Lyapunov) equation based technique (C99, p. 262; Class notes, p. 13).
19. Define Markov parameters and the Hankel matrix. Show that the Hankel matrix is equal to the product of observability and controllability matrices (Class notes, p. 14–16, C99, p. 200–202).
20. Derive difference equations for the mean and the variance for the discrete-time linear system driven by white noise. Give (not derive) the corresponding differential equations for the mean and the variance of continuous time linear systems driven by white noise (Class Notes, page OF2, and formulas (1.500), (1–510) and (1–516) of OF3–OF4).