ECE 6414,Nonlinear and Adaptive Control Systems

Fall 2003, 3 credits Final Exam

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1. Consider the system

   $\dot{x}_1 = \sin x_2 + \sqrt{t+1}x_2$

   $\dot{x}_2 = \alpha_1(t) + x_1^{\,4}\cos x_2 + \alpha_2 u$

   Design the control law u in order to track the desired function for state x_1 given by x_{d1}. The functions $\alpha_1(t)$ and $\alpha_2(t)$ are unknown but bounded by $|\alpha_1(t)| \le 10$ and $1 \le \alpha_2(t) \le 2$. (10 points)
2. Problem 14.31
3. Problem 14.37
4. Consider the system

   $\dot{x} = f(x) + a + bu$

   The function $f(x)$ is unknown and is estimated by $\hat{f}(x)$ such that $\left|f(x) - \hat{f}(x)\right| \le F(x)$. The parameter a is unknown but is either a constant or slowly time varying. The parameter b is known. Define $\tilde{x} = x - x_d$, where subscript d indicated the desired variable, and $\tilde{a} = a - a_*$, where the subscript * indicates the actual value. Choose the sliding variable as $s = \tilde{x}$ and a candidate Lyapunov function as $v = \frac{s^2}{2} + k\frac{\tilde{a}^2}{2}$. Design an adaptive control law for the system. Show that $Lt_{t\to\infty}\tilde{x} \to 0$. (Show any extra assumptions that were needed to come to this conclusion). (10 points)