## ENME 621 Robust and Adaptive Linear Control

Prof. M. Krstic

## FINAL EXAM: Adaptive Control December 7, 1995

Open books and notes. Total points: 25. Time 3:30–4:50.

- 1. (13 points) Problem 7.5, Parts (a) and (b), in *Ioannou & Sun*. Take all filter poles and desired closed-loop poles to be at s = -2.
- **2.** (12 points)

In the relative-degree-one minimum-phase plant

$$W_{\rm p}(s) = \frac{Z_{\rm p}(s)}{R_{\rm p}(s)}$$

the numerator  $Z_{\rm p}(s)$  is known and the reference model  $W_{\rm m}(s) = \frac{Z_{\rm m}(s)}{R_{\rm m}(s)}$  is chosen such that  $Z_{\rm m}(s) = Z_{\rm p}(s)$ . (All the above polynomials are monic.)

(a) Assume that  $R_p(s)$  is also known and show that the nonadaptive MRC problem can be solved with a controller of the form

$$u(s) = r(s) + \frac{Z_{\rm c}(s)}{R_{\rm c}(s)}y(s) \,.$$

Derive the matching conditions for the coefficients of  $Z_c$  and  $R_c$ .

(b) When a single coefficient of  $R_{\rm p}(s)$  is unknown design an adaptive (MRAC) controller with only one adjustable parameter. Give an update law and discuss stability.