9

Advanced Topics in Modern Control

9.1 Introduction

The previous chapters saw coverage of topics ranging from classical control to modern digital control. In many modern control applications, certain other techniques are employed which are grouped here as *advanced topics*. A detailed coverage of the advanced topics – such as H_∞ *control*, *input shaping*, and *nonlinear control* – is beyond the scope of the present text. However, you can get a flavor of each topic in this chapter, and for details you are encouraged to look at the many references given at the end of the chapter.

9.2 H_∞ Robust, Optimal Control

In Chapter 6, we derived linear optimal controllers with full-state feedback that minimized a quadratic objective function, and in Chapter 7 we studied Kalman filters as optimal observers in the presence of white noise. The resulting compensator with an optimal regulator (or tracking system) and a Kalman filter was referred to as an LQG (Linear, Quadratic, Gaussian) controller. While LQG controllers exhibit good performance, their robustness to process and measurement noise can only be indirectly ensured by iterative techniques, such as loop-transfer recovery (LTR) covered in Chapter 7. The H_∞ (pronounced *H-infinity*) *optimal control* design technique, however, directly address the problem of robustness by deriving controllers which maintain system response and error signals to within prescribed tolerances, despite the presence of noise in the system. Figure 9.1 shows a plant with transfer matrix, $\mathbf{G}(s)$, input vector, $\mathbf{U}(s)$, and output vector, $\mathbf{Y}(s)$, being controlled by a feedback compensator with transfer matrix, $\mathbf{H}(s)$. The vector $\mathbf{w}(s)$ contains all inputs *external* to the closed-loop system, i.e. process and measurement noise vectors, as well as the desired output vector. The vector $\mathbf{e}(s)$ contains all the *errors* that determine the behavior of the closed-loop system, i.e. the estimation error and the tracking error vectors.

The plant's transfer matrix can be partitioned as follows:

$$\mathbf{G}(s) = \begin{bmatrix} \mathbf{G}_{11}(s) & \mathbf{G}_{12}(s) \\ \mathbf{G}_{21}(s) & \mathbf{G}_{22}(s) \end{bmatrix} \tag{9.1}$$