Part III

Stabilization

The stabilization problem is one of the most important control problems. It consists of designing a controller that will guarantee that the closed-loop state equation of the considered class of systems will be piecewise regular, impulse-free and stochastically stable and has some given specifications. Most often, the desired specifications are:

- the behavior of the transient regime;
- and the behavior at the steady state;

The stability should be the first requirement since almost all the designed systems should be stable except for some special applications. For a given dynamical systems, the stability of this system is related to the values taken by the outputs that should take finite values for bounded inputs. The controllers are in general designed to make the closed-loop dynamics stable. Regarding the transient regime, in general we are interested to control the overshoot and at the same time the settling time for all the outputs. The steady state behavior traduces the desired precision we should give to the controlled outputs.

The stabilization problem has attracted a lot of researchers from the mathematical and the control communities and a lot of results have been reported in the literature either for the deterministic and the stochastic frameworks. Many approaches have been developed to stabilize dynamical systems. Among these approaches, we quote the state feedback stabilization and the output feedback stabilization techniques.

The state feedback stabilization consists of designing a controller that assumes the complete access to the state vector at each time t. This may be too restrictive in some circumstances where the technology is not available to measure some state variables or due to the shortcut in the budget. To overcome this, the output feedback control can be used. It consists to use the measurement of the outputs to control the dynamics. Notice also, that we can still use the state feedback by designing an estimator that can estimates the state vector using the measurement of the output that will replace the real state of the system. This technique is referred to as the observer-based controller.

For the deterministic singular linear systems, the stabilization problem has been tackled by many researchers and many approaches have been reported in the literature. Among these approaches we quote the ones of state feedback and output feedback.

For the state feedback stabilization of the class of linear singular system we quote the works of [52, 58, 81, 85, 87, 92, 91, 108, 127, 122, 123, 141, 142] and the references therein. In these references, assuming the complete access to the state vector of the singular systems, the design of a controller that makes the closed-loop system regular, impulse-free and stable is established and in some references an LMI approach is used for the continuous-time case. The robust state stabilization has also been tackled and sufficient conditions have been established. To the best of our knowledge, no results on the stabilization of the discrete-time cases that uses the LMI setting exists in the literature.

In some circumstances, the state feedback stabilization may not be possible due to the lack of the appropriate sensors to measure some of the state vector or sometimes due to the limitations in the budget. To overcome this, the output feedback stabilization can be used. This technique use the output measurement to design the controller. The stabilization by output measurement has attracted a lot of researchers and many results have been reported in the literature among them we quote the works of [9, 80, 75, 86, 36, 38, 82, 83, 84, 131, 110, 119, 120, 115, 113, 114, 130] and the references therein. The stabilization by output feedback has been tackled for both the continuous-time and the discrete-time singular systems. The robust stabilization using the output measurement has also been addressed. Only the design problem for the continuous-time can be stated as LMI conditions. The discrete-time case remains an open problem.

In some circumstances, the dynamical systems may have external disturbances that can not be modeled by Gaussian process to use the linear quadratic Gaussian technique to design the desired control. Under the assumption of finite energy or power of these external disturbances, the $\mathscr{H}_\infty$ stabilization has been proposed to design controller to stabilize dynamical systems. For the last two decades, this stabilization problem has been tackled by some researchers among them we quote [40, 108, 68, 134, 89, 137, 128, 48, 124, 136, 93, 46, 106, 107] and the references therein.

This part deals with the stochastic stabilization of the class of systems with random abrupt changes. Our goal is to develop LMI conditions that can help us to design a controller that guarantees that the closed-loop state equation of the class of systems under study is piecewise regular, impulse-free and stochastically stable. Few results have been reported in the literature. Among them we quote the works of [2, 21, 22, 18, 23, 20].

This part deals with the stabilization problem of the class of singular systems with abrupt changes in the dynamics. The state feedback stabilization, the output feedback stabilization and the $\mathscr{H}_\infty$ stabilization and their robustness will be covered.