

## Time-Delay Systems (0510.7315)

Credits: 2.

Prerequisites: Introduction to Modern Linear Control.

1. *Models of systems with time-delay*: networked-control systems, communication network models, models of lasers, vehicular traffic flow models, models in biology.
2. *Basic theory*: solution concept and step method. Classification of systems with time-delay (retarded, neutral type systems). Existence of solutions. Linear time-invariant systems with delay: characteristic equation, solution of linear non-homogenous equations. Effects of delay on stability: frequency domain methods. Controllability, observability of linear systems.
3. *Stability and performance analysis*: time domain methods. Direct Lyapunov approach: Krasovskii and Razumikhin methods. An LMI approach to stability: delay-independent/delay-dependent conditions. Stabilization by using delays and general Lyapunov functional. Exponential bounds and  $L_2$ -gain analysis. Input-to-state stability and control under quantization.
4. *Control design*: predictor-based control, LQR problem. LMI approach to robust stabilization and  $H_\infty$  control. Systems with saturated actuators.  $H_\infty$  control.
5. *Sampled-data and networked control systems*: a time-delay approach.

### Textbook:

1. E. Fridman. *Introduction to time-delay systems: analysis and control*. Birkhauser, Systems and Control: Foundations and Applications, 2014.