Time-delay and sampled-data implementation of derivative-dependent control

Anton Selivanov[1] and **Emilia Fridman**[1]

[1]*School of Electrical Engineering, Tel Aviv University, Israel (e-mail: antonselivanov@gmail.com, emilia@eng.tau.ac.il)*

We consider an LTI system of relative degree $r \geq 2$ that can be stabilized using $r-1$ output derivatives. Since the derivatives are hard to measure directly, they are approximated using finite differences. This leads to a time-delayed feedback. We present a new method of designing and analyzing such feedback under continuous-time and sampled measurements. This method admits essentially larger time-delay/sampling period compared to the existing results and, for the first time, allows to use consecutively sampled measurements in the sampled-data case. The main idea is to present the difference between the derivative and its approximation in a convenient integral form. The kernel of this integral is hard to express explicitly but we show that it satisfies certain properties. These properties are employed to construct Lyapunov-Krasovskii terms that bound the approximation errors and lead to LMI-based stability conditions. If the derivative-dependent control exponentially stabilizes the system, then its time-delayed approximation stabilizes the system with the same decay rate if the time-delay (for continuous-time measurements) or the sampling period (for sampled measurements) are small enough.