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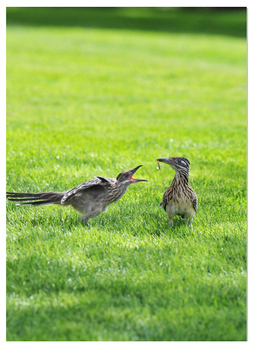
Effect of Time Delay Asymmetries in Power System Damping Control

Felipe Wilches-Bernal, Ricky Concepcion, Jason C. Neely, David A. Schoenwald, Raymond H. Byrne, Brian J. Pierre, Ryan T. Elliott



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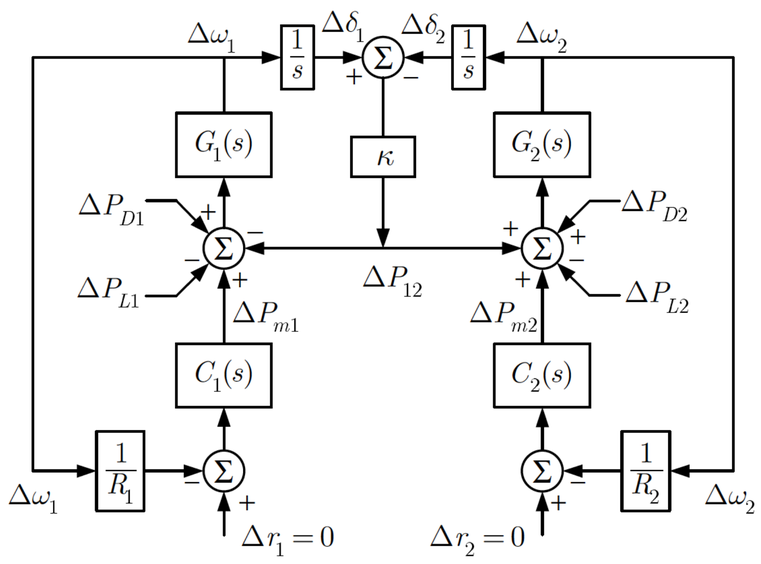
Distributed control compensation based on local and remote sensor feedback can improve small-signal stability in large distributed systems, such as electric power systems. Long distance remote measurements, however, are potentially subject to relatively long and uncertain network latencies. In this work, the issue of asymmetrical network latencies is considered for an active damping application in a two-area electric power system.

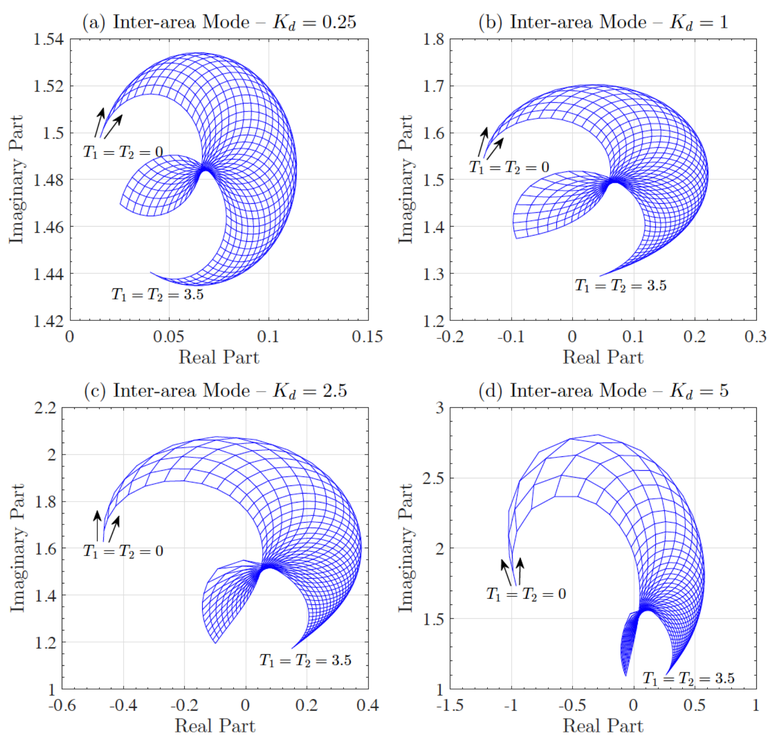


System and controller

The plant model studied is a linearized version of a two-area power system with an undamped inter-area oscillation mode at 0.24 Hz.

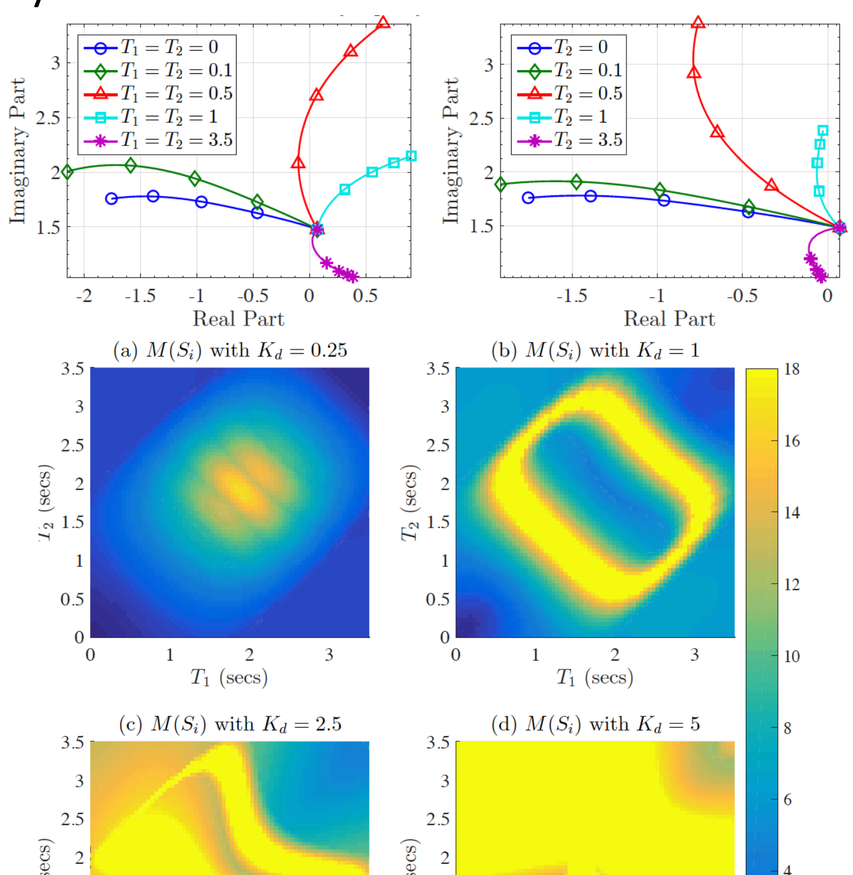
$C_i(s)$: governor
$G_i(s)$: inertia and load
κ : synchronizing torque
ΔP_{Li} : load/generation imbalance
ΔP_{Di} : high voltage DC line power injections

$$P_{D1}(t) = -K_d(f_1(t - T_1) - f_2(t - T_2))$$
$$P_{D2}(t) = -P_{D2}(t)$$



Effect on system stability

With no latencies the system is symmetric and increasing controller gain K_d stabilizes the system. For small latencies, the difference between symmetric and asymmetric delays is minimal. Stability improves with asymmetric delays as latency increases. In general, when both measurement signals experience latency, controller performance suffers. When latency increases in any signal independently, the system tends to destabilize.



Effect on disturbance rejection

The effect that load disturbances have on the plant is determined by the input sensitivity matrix, S_i. The largest peak of the maximum singular value of S_i is used as a proxy to represent disturbance rejection capability. As latencies increase jointly or independently, the system becomes more sensitive to disturbances.

Conclusions

Individual increases in either of the latencies has a lower destabilizing effect. Increases in latencies reduces system ability to reject disturbances.

Contact:
Felipe Wilches-Bernal
fwilche@sandia.gov

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