Wide Area Power System Damping Controls with Network Communication Delays

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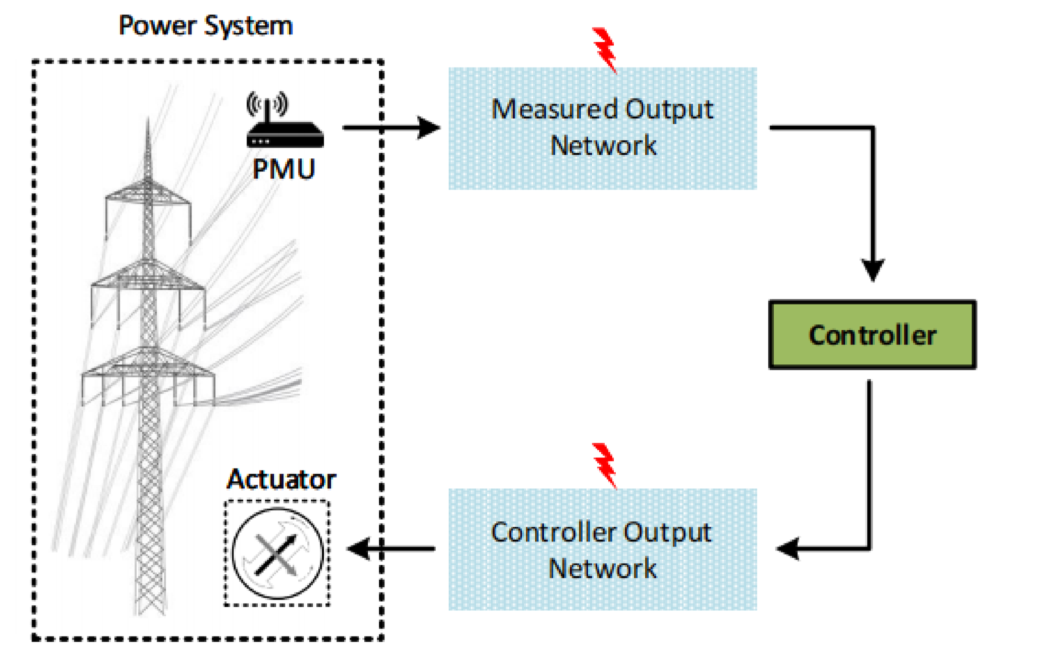
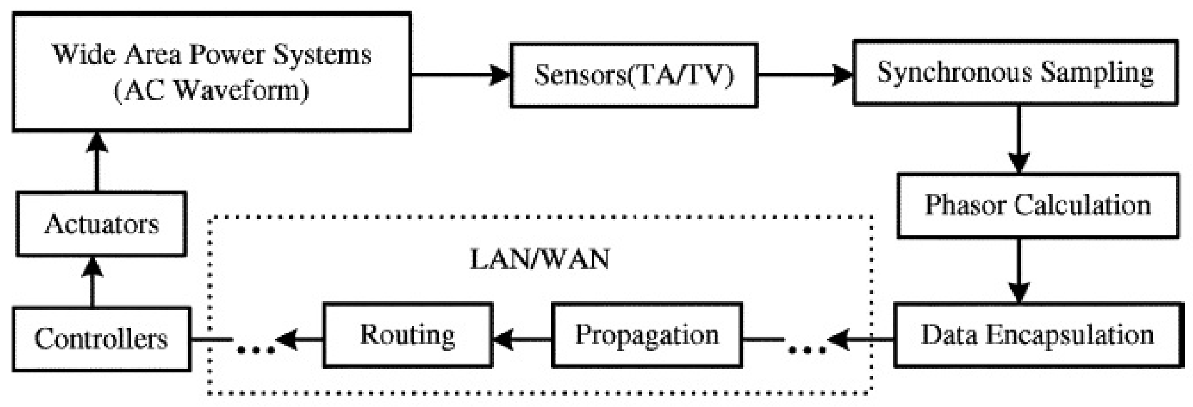
Introduction

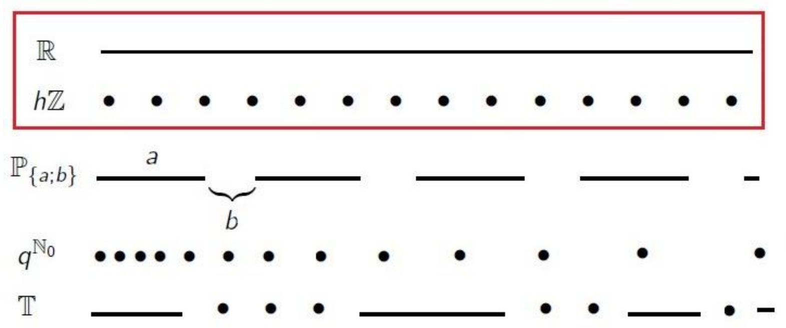
- In this poster we propose a new mathematical method to estimate the maximum allowed communication delay that does not violate the stability and performance of the power system.
- This method allows us to handle continuous and discrete dynamics as two pieces of the same framework, such that the system will switches between a continuous-time subsystem (when the communication occurs without any interruption) and a discrete-time subsystem (when the communication fails) by introducing time scales theory.



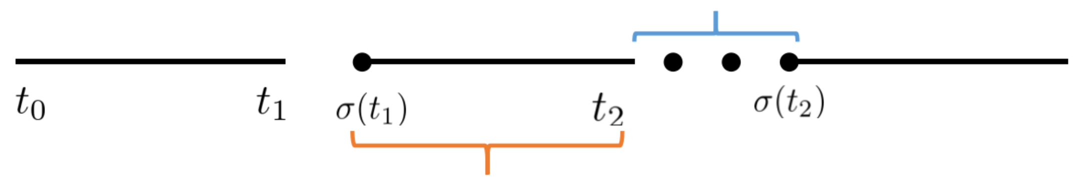


Method

- Time scales



$$\mu(t_2) = \sigma(t_2) - t_2$$



$$\tau(t_1) = t_2 - \sigma(t_1)$$

(1) Receiving perfect information and controller is evolving

$$\tau(t_i) = t_{i+1} - \sigma(t_i)$$

(2) Not receiving perfect information (delay) and controller is hold on

$$\mu(t_i) = \sigma(t_i) - t_i$$

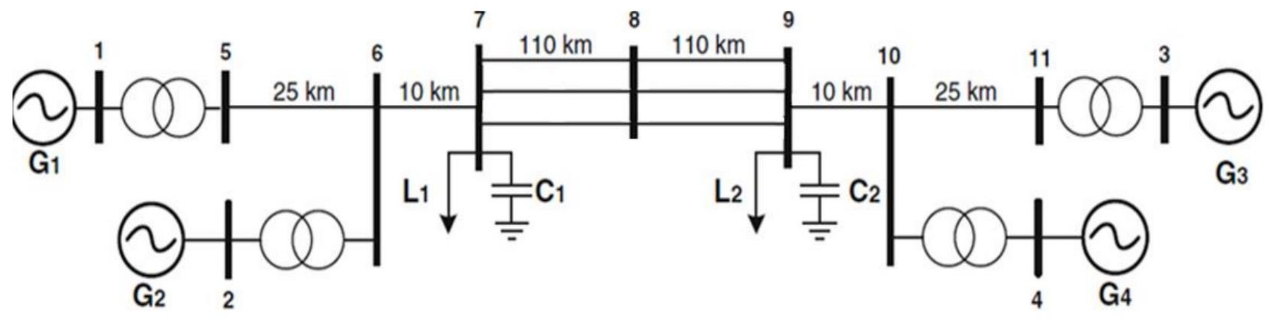
- Switched system

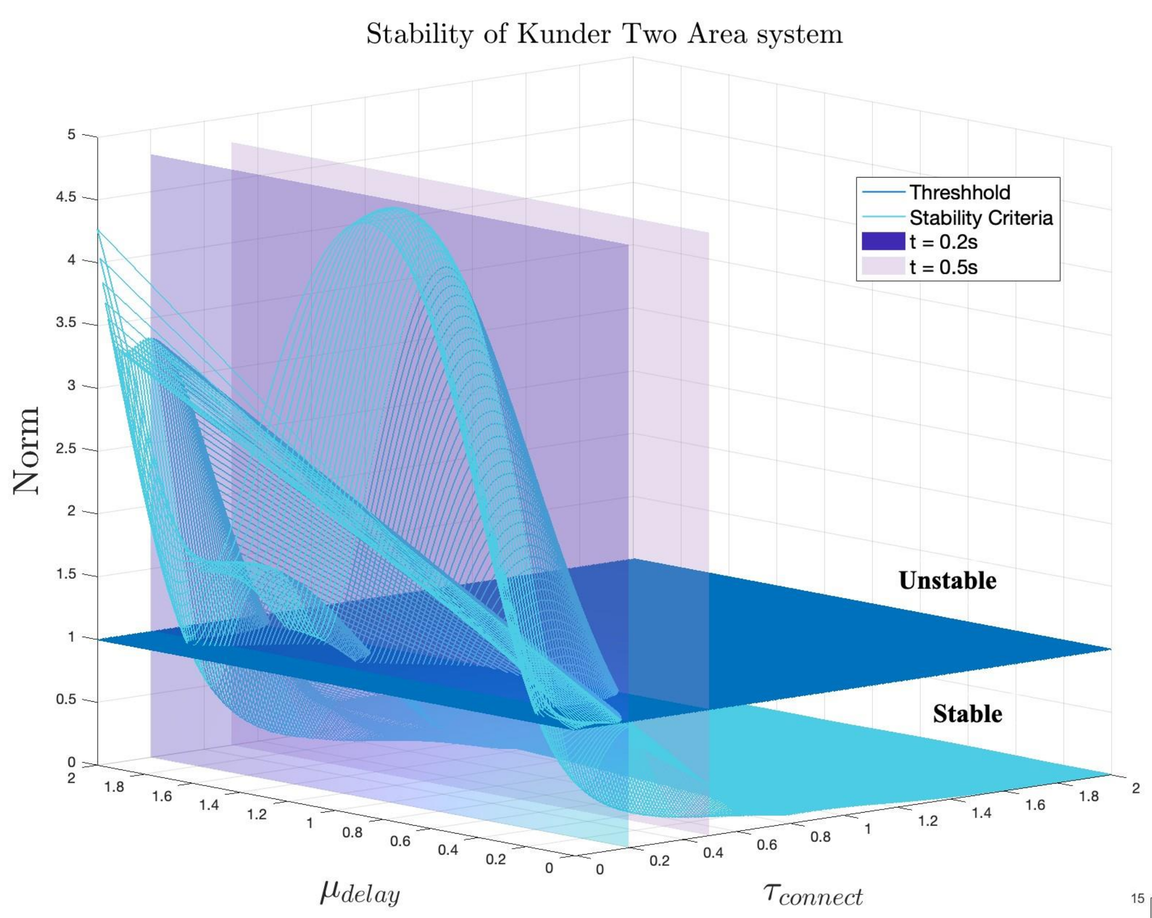
$$x^{\Delta}(t) = \begin{cases} (A+BK)x(t), & t \in \cup_{i=0}^{\infty}[\sigma(t_i), t_{i+1}) \\ \left(\frac{e^{A\mu(t)} - I}{\mu(t)}\right)(I + A^{-1}BK)\,x(t), & t \in \cup_{i=0}^{\infty}\{t_{i+1}\} \end{cases}$$

- Stability Criteria

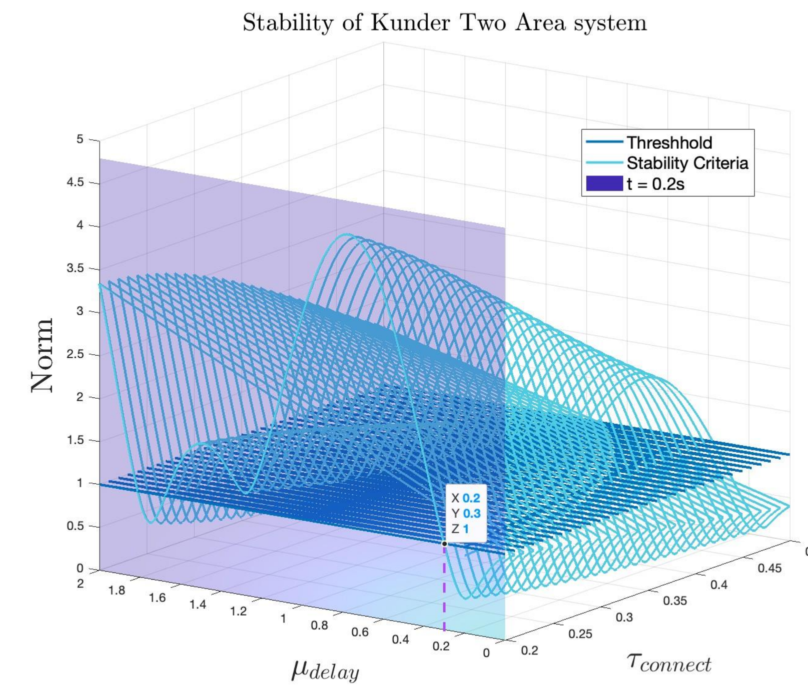
$$\left\| e^{(A+BK)\tau(t_i)} \left[I + \left(e^{A\mu(t_i)} - I \right) (I + A^{-1}BK) \right] \right\| < 1$$

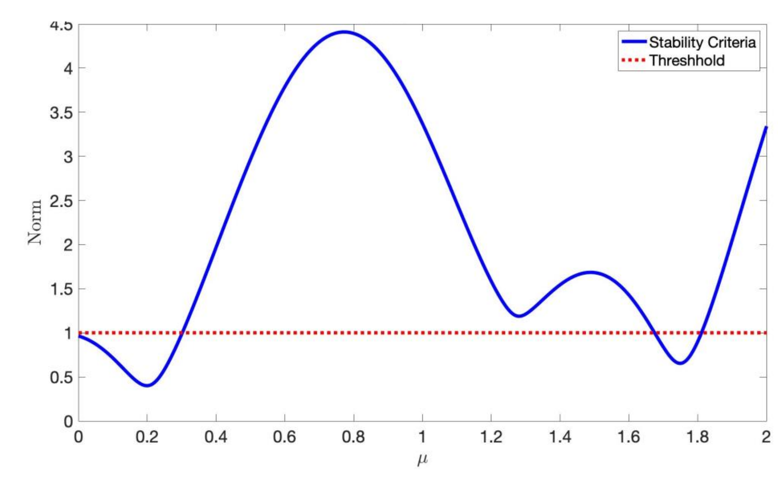
Case study



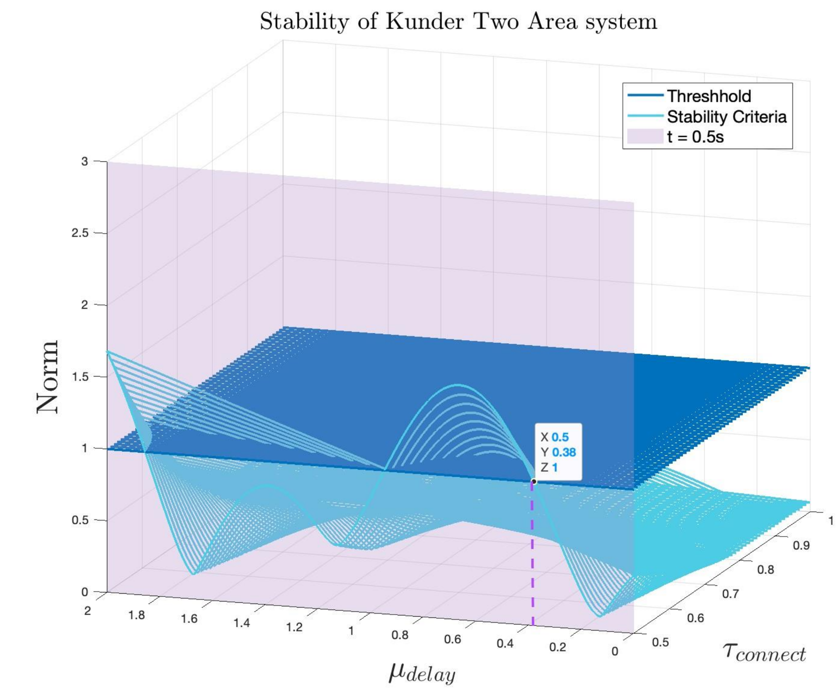


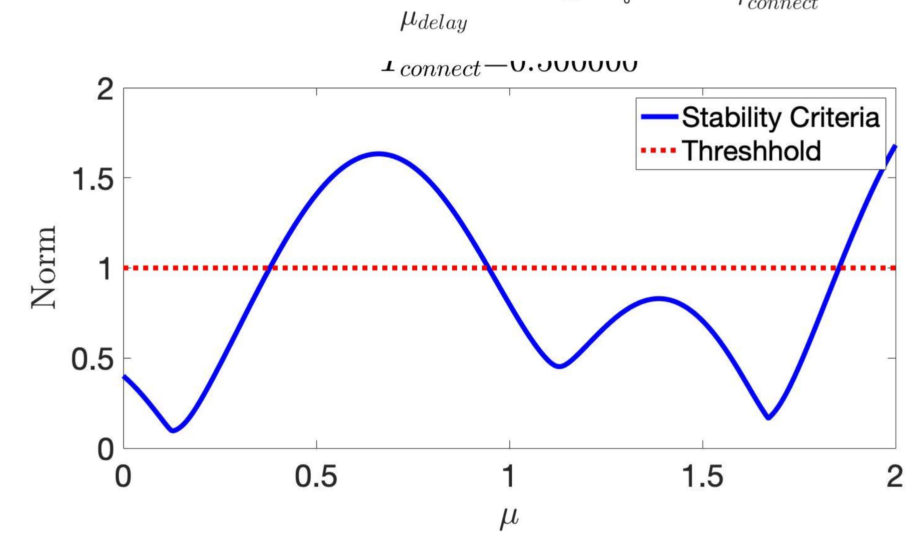
- Case 1: For $\tau = 0.2s$



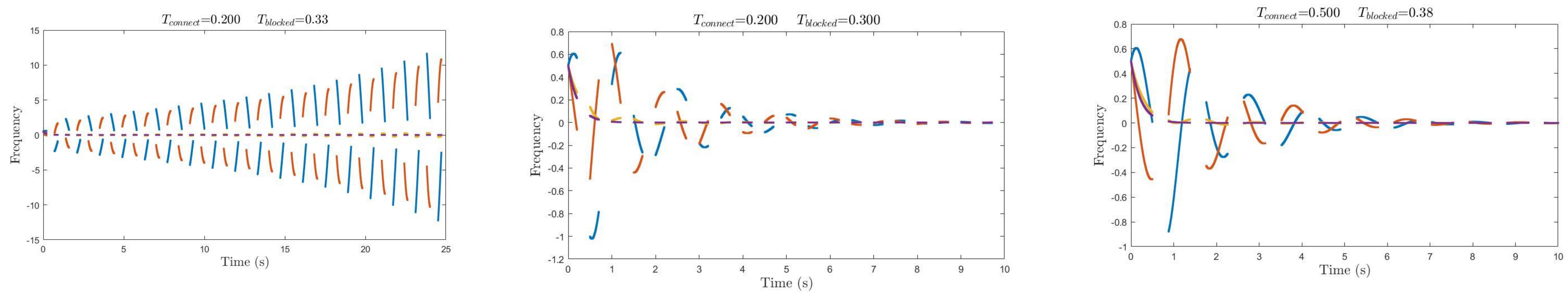


- Case 2: For $\tau = 0.5s$





- Simulink test result: when t =0.2s and t =0.5s, changing the time of the delay



Conclusion

A stability criteria has been derived to estimate bounds of the communication loss duration, which guarantees the stability of the system.

Future work

- Test stability criteria in larger system with considering communication failure.