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Time Delay Definitions and Characterization in the Pacific DC Intertie Wide Area Damping Controllers

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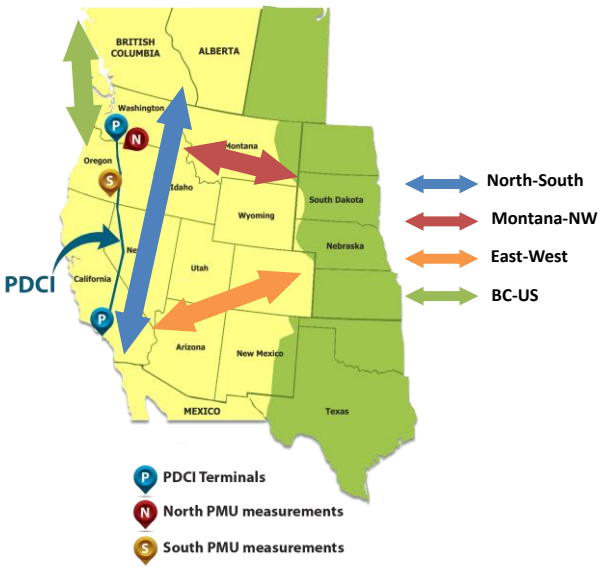
Background

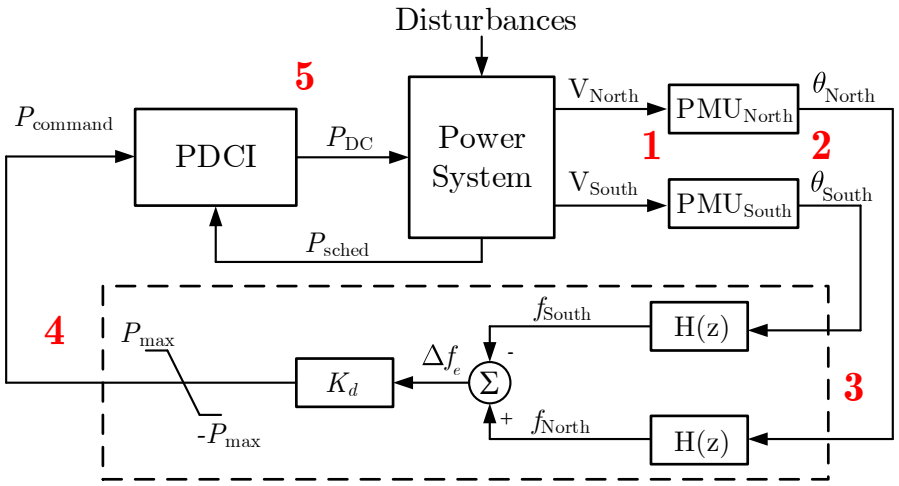
- Part of a wider project to develop a wide area damping controller in the Western Interconnection by modulating the Pacific DC Intertie

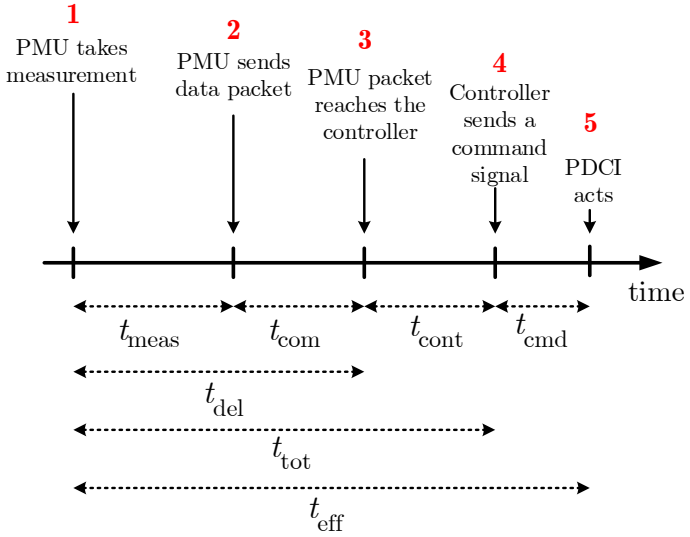


- We implemented a controller that uses PMU measurements from dispersed locations within the western interconnection
- In this paper we classified an analyzed in detail the delays in the flow of information of the controller
- We expected to find more uniformity in the delays and be defined by traditional probability functions

Definition of Delays

- **Flow of information** in the controller





t_{meas} – Measurement (PMU) Delay

t_{com} – Communications Delay

t_{del} – Signal Delay

t_{cont} – Control Processing Delay

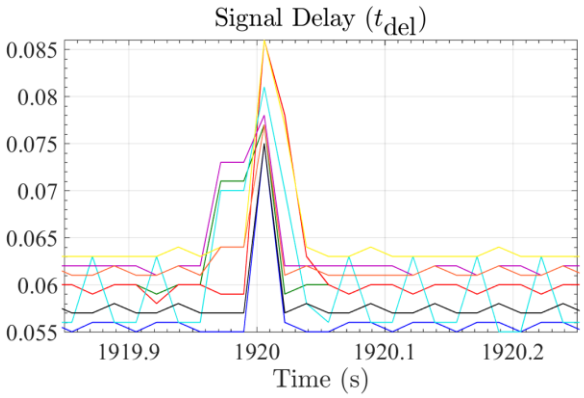
t_{tot} – Total Controller Delay

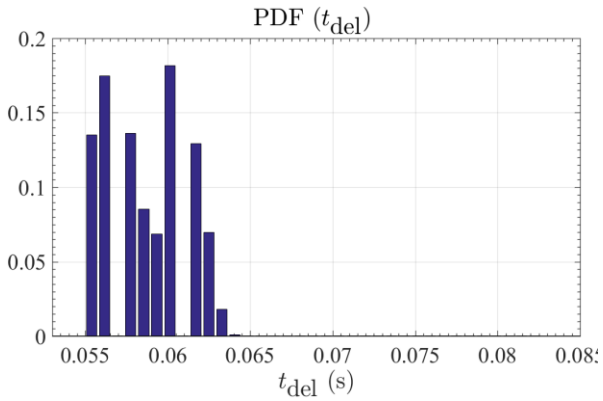
t_{cmd} – Command Delay

t_{eff} – Effective Delay

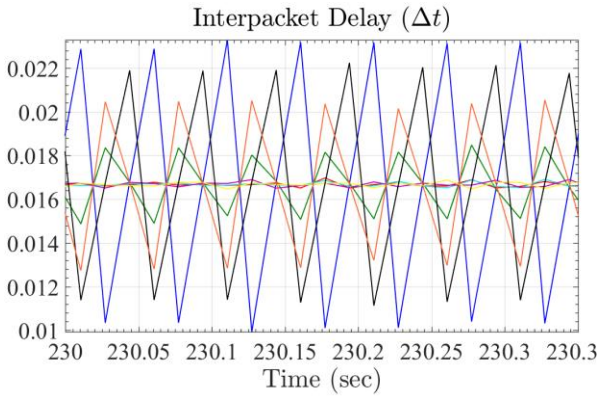
Measurement of Delays

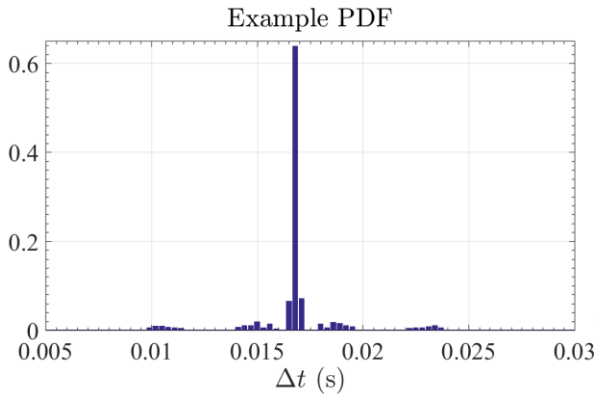
Signal Delay Average of 60ms, range [55,88] ms.





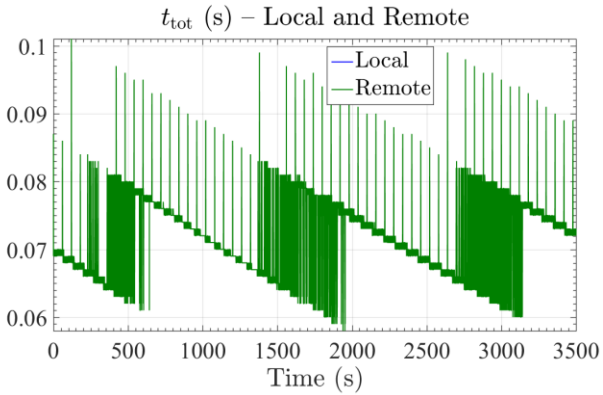
Interpacket Delay Average of 16.6ms, sometimes “oscillate”

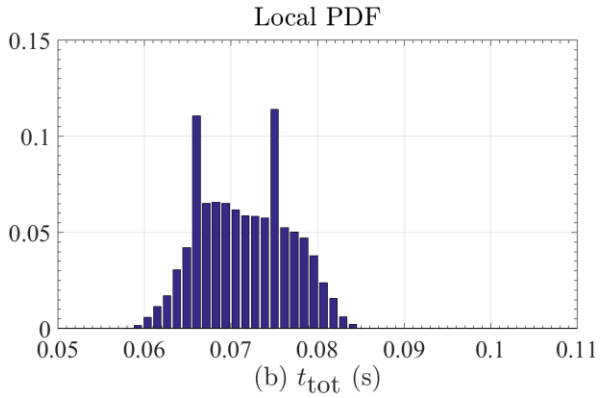




Measurements of Delays

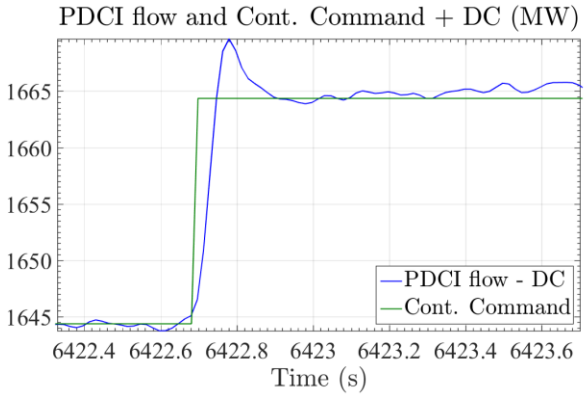
Total Delay: average of 71ms, periodicity due to drifting of clocks





Command Delay: estimated at 11ms

Effective Delay: average of 81ms and a maximum of 113ms



Conclusions

- Delays are within the expected range to be used for real time control
- A classification of delays in a Wide Area Control System (WACS) was proposed
- Delay behavior was analyzed for each stage and components of the WACS
- **Future work:** propose a detailed model of the delays (be able to replicate them)