SVC compensation on a wide-area control in large electric power systems for mitigating small-signal instability
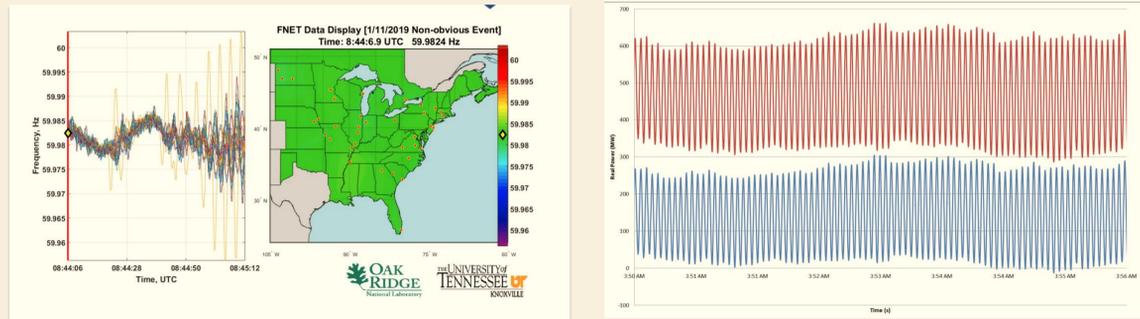
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1. Background

January 11, 2019 system wide-area impact in EI due to forced oscillation[1]
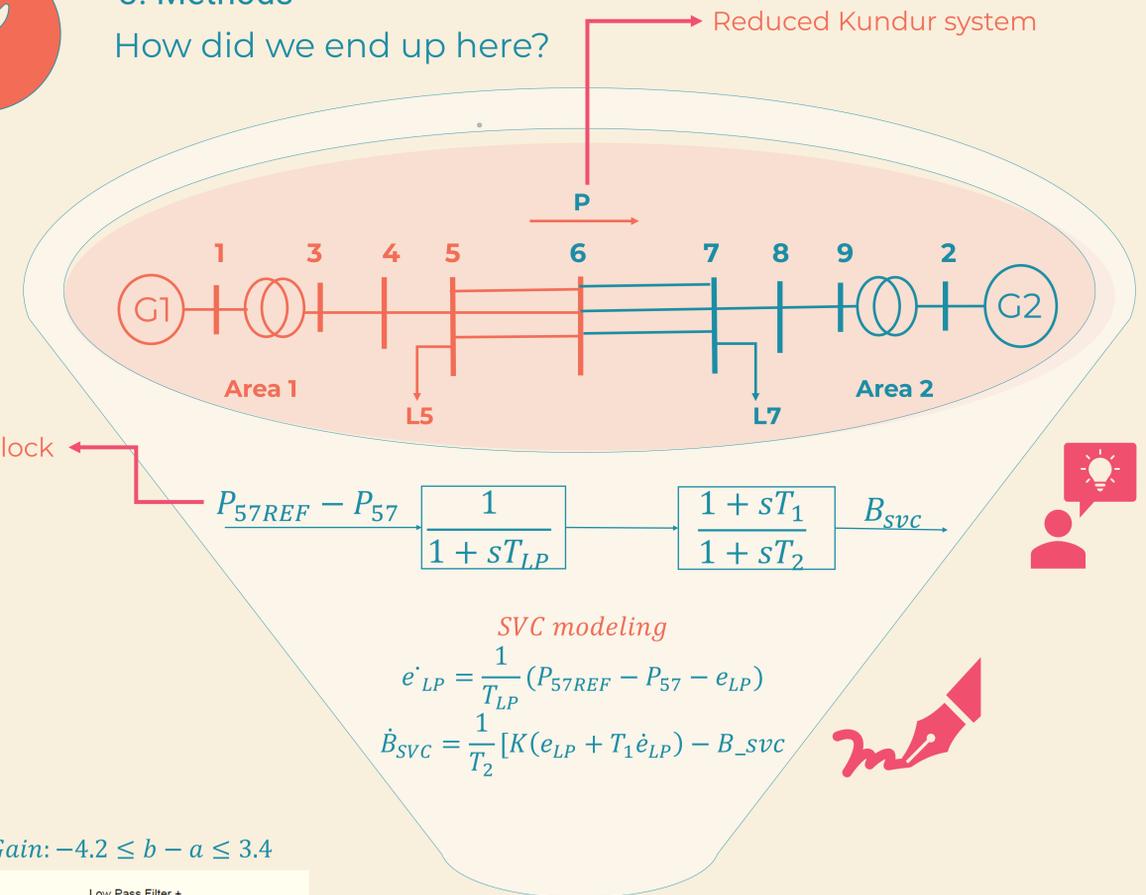
- Events might excite inter-area modes leading to potential wide-area oscillations
- Effect on power system, its component and customer
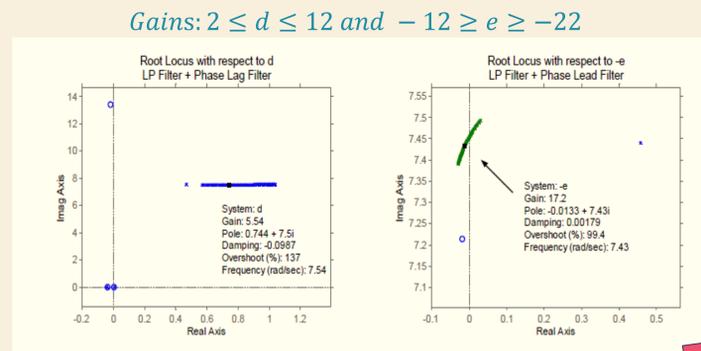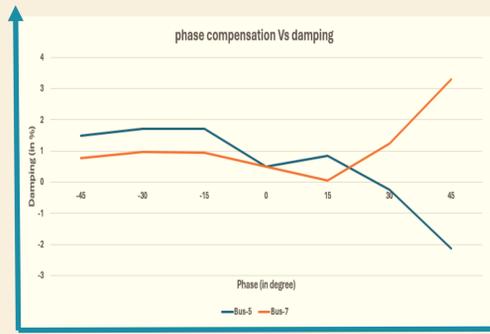- Prevention by having an inter-area mode with high damping.

2. Main findings

SVC to work on full PSDC mode to increase the damping of inter-area mode by phase compensation and sending/receiving end of the tie-line in the power system.

Phase lead/lag vs damping plot

$Gains: 2 \leq d \leq 12 \; and \; -12 \geq e \geq -22$

Root locus for SVC @ Bus-7[2]

3. Methods

How did we end up here?

→ Reduced Kundur system

SVC controller block

$$P_{57REF} - P_{57} \boxed{\frac{1}{1 + sT_{LP}}} \boxed{\frac{1 + sT_1}{1 + sT_2}} B_{svc}$$

SVC modeling

$$\dot{e}_{LP} = \frac{1}{T_{LP}}(P_{57REF} - P_{57} - e_{LP})$$

$$\dot{B}_{SVC} = \frac{1}{T_2}[K(e_{LP} + T_1\dot{e}_{LP}) - B\_svc]$$

$Gain: -4.2 \leq b - a \leq 3.4$

Root locus for SVC @Bus-5 and Bus-7[2]

$$\mathbf{J} = \begin{bmatrix} 0 & \frac{1}{} & 0 & 0 & 0 & 0 \\ J_{21} & -\frac{K_{D1}}{2H_1} & J_{23} & 0 & 0 & a \\ 0 & 0 & 0 & \frac{1}{} & 0 & 0 \\ J_{41} & 0 & J_{43} & -\frac{K_{D2}}{2H_2} & 0 & b \\ J_{51} & 0 & J_{53} & 0 & -\frac{1}{T_{2LP}} & c \\ J_{61} & 0 & J_{63} & 0 & d & e \end{bmatrix}$$
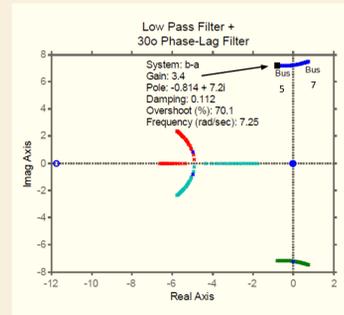
Jacobian Matrix[2]

4. Conclusion

How should we interpret this information?

- Sending side of tie-line: SVC PSDC should be phase lag compensator
- Receiving side of tie-line: SVC PSDC should be phase lead compensator[2]

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*Note: SVC : Static Var Compensator, PSDC: Power Swing Damping Control, EI : Eastern Interconnection
**This work was done by Jaime Quintero while he was student at Washington State University

References:
[1] NERC Oscillation Analysis Informational Webinar : https://www.nerc.com/comm/PC/Documents/Oscillation_Analysis_Webinar_20190913.pdf
[2] J. Quintero and V. Venkatasubramanian, "SVC compensation on a real-time wide-area control for mitigating small-signal instability in large electric power systems," 2006 International Conference on Power System Technology, Chongqing, China, 2006, pp. 1-8, doi: 10.1109/ICPST.2006.321544.