Scenario: Two area, six machine system loss of generation event.

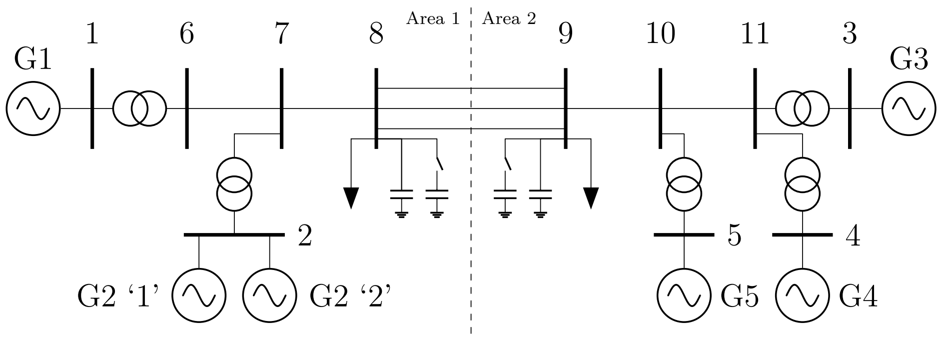


Figure 1: Six machine system.

Governed machines are: G1, G2 ‘1’, G3, G4.
Governor time constants are identical for all machines and no deadbands are used.
PI filtered AGC signals are sent every 5 seconds to G1 and G3.

At t = 2, G2 ‘2’, steps its mechanical power output P_M down by 20%.

All system settings are the same in test cases, with the exception of governor delays/filters on G3.

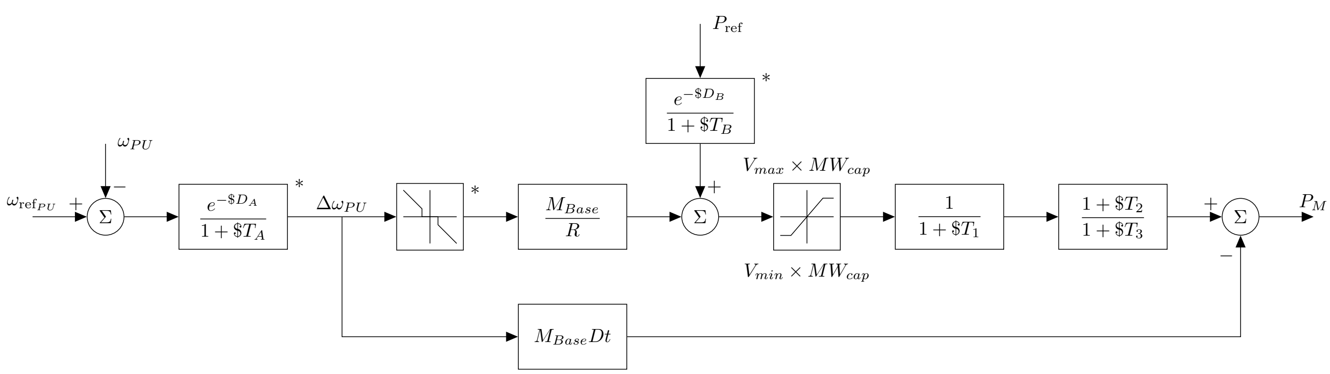
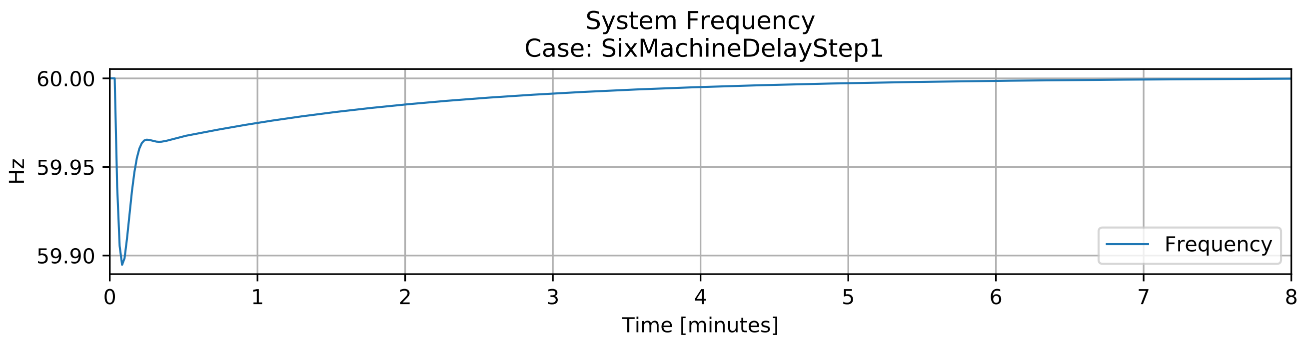


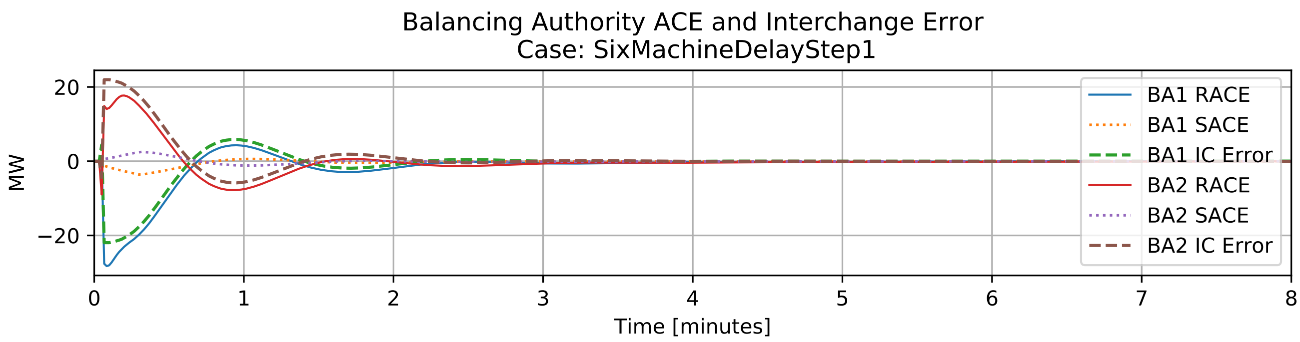
Figure 2: Governor model with optional delays and deadbands indicated by a *.

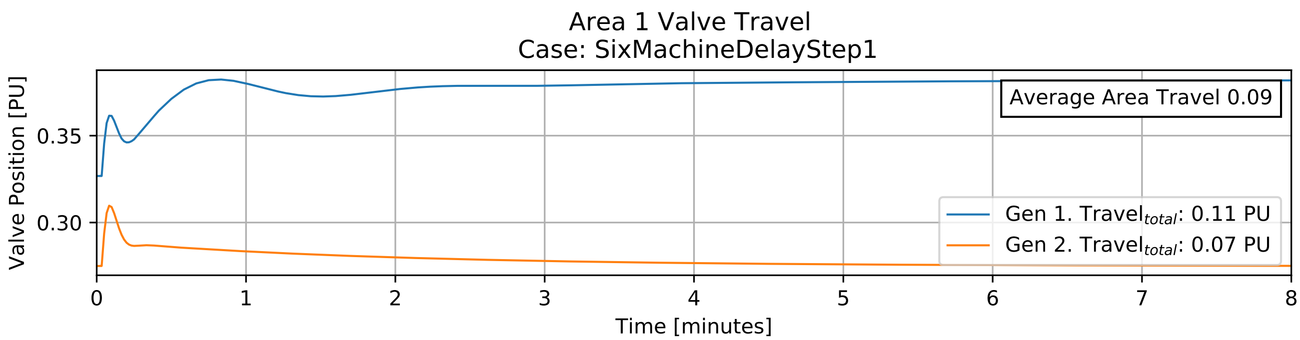
Input $\Delta\omega_{PU}$ was delayed by 40 seconds and any changes to P_{REF} were delayed by 10 seconds.
Low pass filtering of ω using a 30 second time constant was also tested.

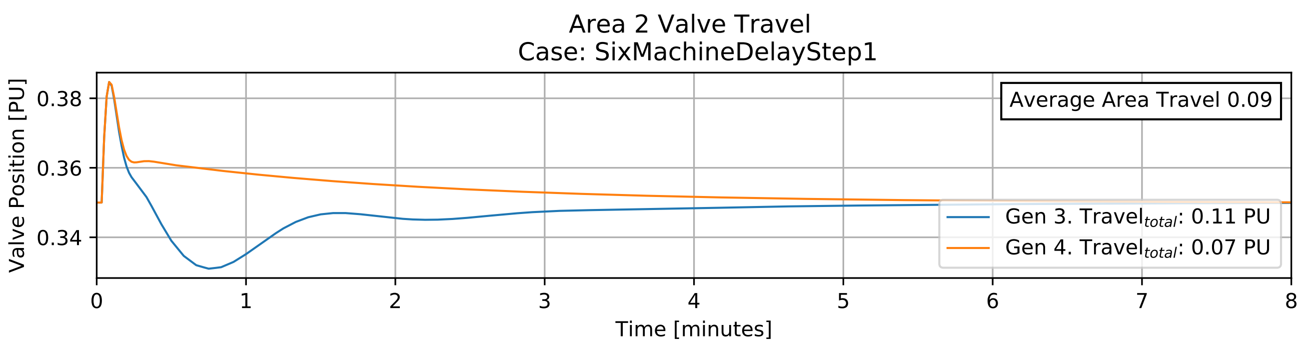
Results: The delayed governor response generates a second frequency perturbance 40 seconds after the first frequency event caused by the loss of generation. The delay also introduces minor oscillations in frequency that are eventually damped out by other governor action. Valve travel is increased by the delayed governor response. However, the use of a lowpass filter can lessen frequency effects and actually reduce valve travel.
Regardless of filtering, the delay causes a larger frequency nadir.

Base Case Results:
No Delay or filtering.

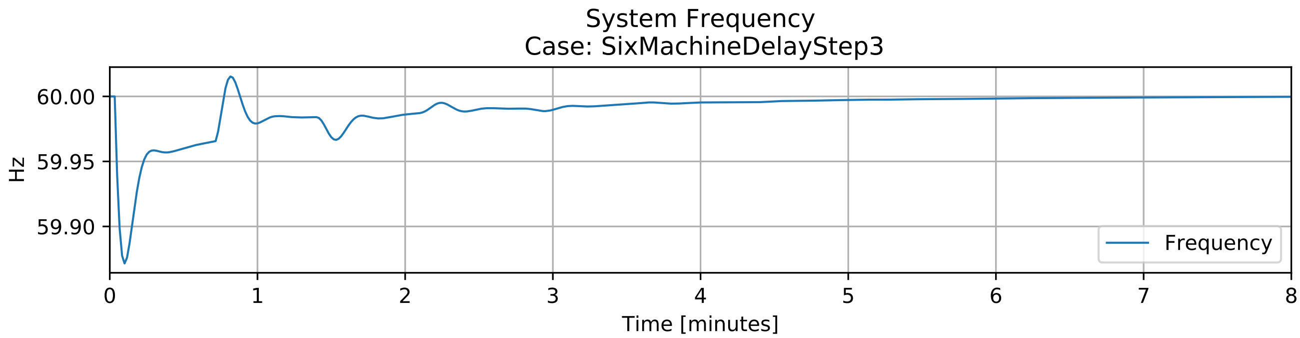


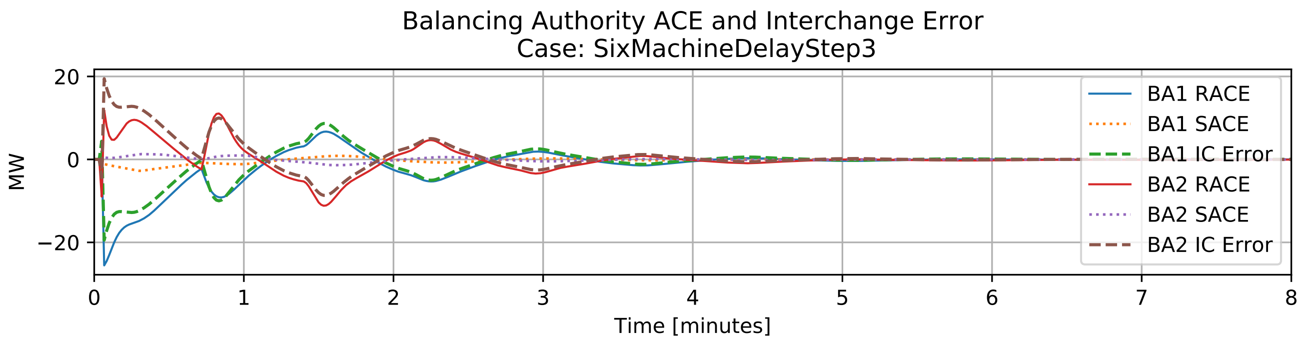


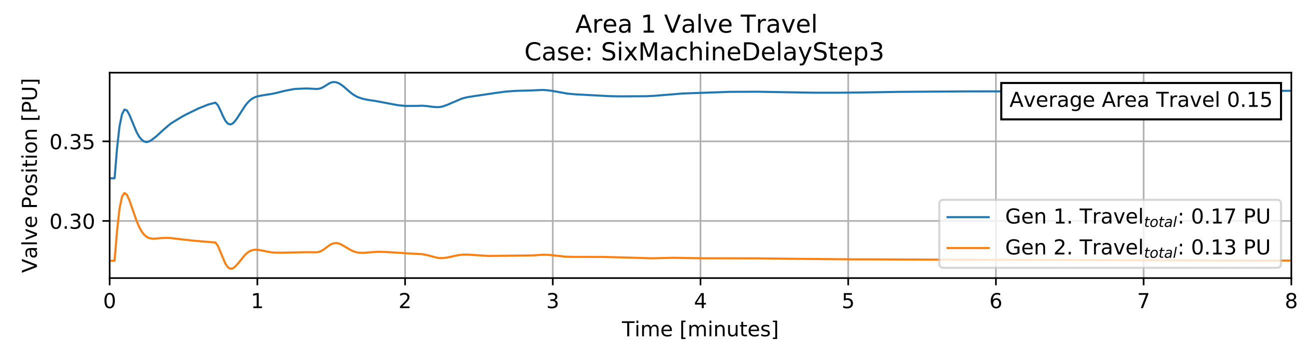


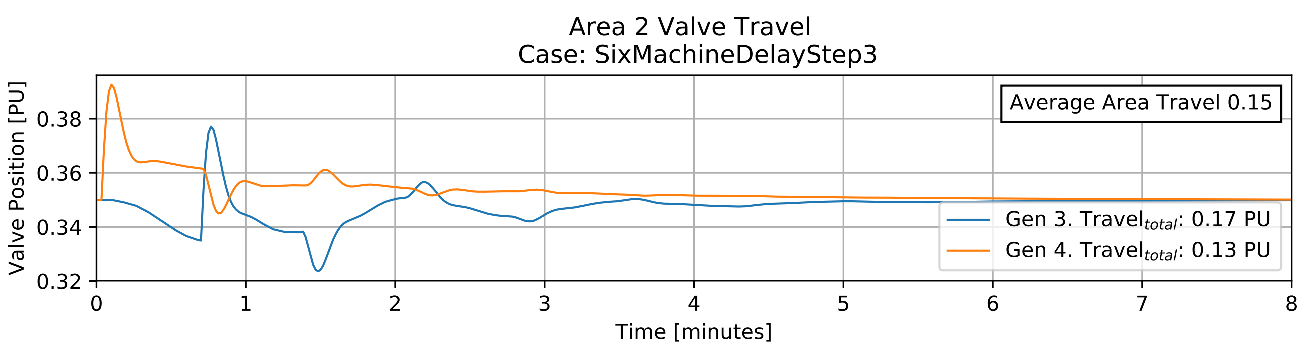


Delay Case Results:
40 sec $\Delta\omega_{PU}$ delay, 10 sec P_{ref} Delay.









Filtered Delay Case Results:
40 sec $\Delta\omega_{PU}$ delay with a 30 sec low pass filter time constant, 10 sec P_{ref} Delay.