

Discussion

Sebastiao E. M. De Oliveira (Centro de Pesquisas de Energia Electrica, CEPTEL, Rio de Janeiro, Brazil): The authors present interesting results on a practical case of the lower-frequency electromechanical mode stabilization at a pump storage plant through the use of an additional sign applied to the excitation system of one or two generator units. The detrimental effect of a high-gain automatic voltage control is also clearly illustrated in Figs. 3 and 4, while Figs. 5 and 6 show the added damping with the operation of the power-system stabilizer derived from a measure of the units accelerating power.

In Fig. 5 it is interesting to note the operation in point c (with tower outage) has more damping than in point b (with all circuits in). While the authors relate this fact to the higher damping torque provided by the PSS at the lower frequency of oscillation, we prefer to explain this fact in a different way.

As the PSS transfer function phase-lead is almost the same in all four points a to d (about 81 degrees) and from b to c and a to d the PSS gain is reduced to approximately 86 percent of the initial value, in reality the PSS effect is towards the damping reduction in the case of tower outage (for lower frequency or oscillation). Since from a to b (with all circuits in the constant α is increased by approximately 0.17 s^{-1} and with two circuits out the PSS increases α by 0.41 s^{-1} from point d to point c, in fact the lower frequency damping sensitivity to the breaking action of the Ludington Plant with two circuits out is probably much higher than with all circuits in. This results in an appreciable increase of damp-

ing, even with the referred reduction of PSS gain for lower frequencies of oscillation. For a more accurate analysis, the AVR Transfer function must be available. The comments of the authors with respect to this point would be appreciated.

I congratulate the authors for providing the very pertinent information related to the design aspects of the microprocessors based PSS.

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J. S. Czuba, L. N. Hannett and J. R. Willis: The authors appreciate Mr. De Oliveira's interest in our paper and his valuable comments.

He correctly points out that the increased damping for a tower outage condition is due to the effects of the PSS and other system components. At the reduced frequency of oscillation, the torque produced by the overall machine-AVR-PSS transfer function is more nearly in phase with the machine speed deviations as a result of PSS phase compensation. This more than offsets the reduction in PSS gain, thus giving increased damping.

The authors would also like to point out that in the Field Testing section the frequency of oscillation is approximately 0.7 hertz rather than 1.0 hertz.

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