Abstract

Environmental and economical aspects make it difficult to build new power lines and to reinforce existing ones. The continued growth in demand for electric power must therefore to a great extent be met by increased loading of available lines. A consequence is that power system damping is reduced, leading to a risk of poorly damped power oscillations between the generators. This thesis proposes the use of controlled active loads to increase damping of such electro-mechanical oscillations. The focus is on structural aspects of controller interaction and of sensor and actuator placement.

On-off control based on machine frequency in a single machine infinite bus system is analysed using energy function analysis and phase plane plots. An on-off controller with estimated machine frequency as input has been implemented. At a field test it damped oscillations of a 0.9 MW hydro power generator by controlling a 20 kW load.

The linear analysis uses two power system models with three and twenty-three machines respectively. Each damper has active power as output and local bus frequency or machine frequency as input. The power system simulator EUROSTAG is used both for generation of the linearized models and for time simulations.

Measures of active power mode controllability and phase angle mode observability are obtained from the eigenvectors of the differential-algebraic models. The geographical variation in the network of these quantities is illustrated using the resemblance to bending modes of flexible mechanical structures. Eigenvalue sensitivities are used to determine suitable damper locations.

A spring-mass equivalent to an inter-area mode provides analytical expressions, that together with the concept of impedance matching explain the structural behaviour of the power systems. For large gains this is investigated using root locus plots. The effect of using two dampers is studied. For the three machine system this is done for all combinations of

the two gains in a certain range. In the twenty-three machine case one gain takes only two values as the other is varied.

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