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Damping of system oscillatory modes by a phase compensated gas turbine governor

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ABSTRACT

The proliferation of gas turbines in power systems increases the scope for taking advantage of mechanical torque control for improved network damping. This paper describes a phase compensated governor for a gas turbine and explores its potential contributions to system damping in a multimachine context. It is shown that the inclusion of phase compensation in the governor control loop is capable of achieving dynamic stability for the system without the need of a power system stabilizer (PSS) in the generator excitation control loop and without adversely influencing terminal voltage control. In addition, it is demonstrated that a phase compensated governor (PCG) is also capable of significantly improving transient stability and by complementing the effectiveness of a conventional PSS, enables a superior overall contribution to network damping.

1. Introduction

The potential of governor control for improving the damping of network oscillatory modes has been documented in [1,2], and the benefits of utilizing the governor control in conjunction with generator exciter control have been shown. These have been explored in greater detail in [3] using a single machine infinite bas (SMIB) system. The same concept is now extended to a multi machine system in order to establish the capabilities and compatibility of enhanced governor control with other machines in the network and their control schemes.

As stated in [1,2], since the excitation and speed control loops are essentially decoupled, a controller in the governor loop can stabilize the system without having an adverse impact on voltage regulation. This has been clearly as demonstrated for steam turbines and governors in [1,4]. This paper explores in greater detail, the application of a phase compensation controller in a multi machine context. Interactions between the different machines with the phase compensated governor (PCG) and other types of prime movers are examined. The phase compensation method is applied to validate models of gas turbines, i.e., Rowen's model [5].

Dynamic performance contributions of a gas turbine PCG controller are compared and contrasted with those provided by the addition of a conventional PSS to the generator excitation control scheme for stabilizing oscillatory modes. In addition to the performance of the PCG, the overall impact of the governor control on the stability of the system is examined. Different ratios of gas turbine prime movers and conventional steam prime movers in the network are implemented to investigate the effect of increasing penetration of gas turbine technology in the power system.

2. The impact of a standard governor

Conventional governors are known to have a negative influence on system damping [6] and results in the shifting of electromechanical modes towards the unstable right half plane. The overall impact of a standard governor was previously discussed in [3], but will be repeated here for the completeness of discussion. Fig. 1 shows a simplified model of a typical power system with basic relationship between the mechanical input to the governor and the speed deviation input signal highlighted. The adverse impacts of the governor can be traced to the phase lag (usually exceeding 90°) inherent in the governor and prime mover due to their structure and the operation setting. This concept is shown graphically in Fig. 2a where, under oscillatory conditions, the mechanical power loop introduces a phase lag of more than 90°. Decomposing the vector P_m into a damping power component in phase with $\Delta\omega$ and a synchronizing power component in phase with $\Delta\delta$, it can be clearly seen that the

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