

Abstract – A method of estimating a power system's electromechanical mode shape and coherence from time synchronized phasor measurements is presented. The approach uses a parametric estimate of the transfer function (TF) between signals at different buses throughout the power system. The relationship between the TF and mode shape and coherence is reviewed. A non-causal autoregressive exogenous (ARX) model is used in a least squares (LS) minimization to estimate the TF parameters and to estimate the magnitude squared coherence function. The method is applied to both a simulated system and measured data from the western North American power system and is compared to the traditional Welch periodogram averaging approach.

Index Terms – Electromechanical dynamics, coherence, mode shape, small-signal stability, synchronized phasor measurements, system identification.

1. Introduction

Knowledge of the electromechanical modal properties of a power system is of great importance for safe and reliable operation. If a mode of oscillation is allowed to become unstable, it will grow in magnitude causing a system outage such as the one observed in the Western Systems Coordinating Council (WSCC) in 1996 [1]. Accurate estimates of the electromechanical modes are therefore critical [2].

An electromechanical mode is described by the frequency and damping of the oscillation as well as the shape of the oscillation. The mode shape is the magnitude and angle of the mode relative to a reference location in the power system. It describes the relative participation of the state variables in a specific mode [3], [4].

Reliable near real-time operational knowledge of a power system's mode shape can provide critical information for power system control decisions [5]. The mode shape information can someday be used to optimize the process of generator and/or load shedding to improve the damping of a dangerously low-damped mode; i.e. only those generators and/or loads that are most actively participating in the mode would be shed.