Adaptive Estimation of Evoked Potentials: A Cycle-Stationary Perspective with the LMS Algorithm

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Adaptive estimation algorithms are often useful for analysis of random signals with time-varying properties since the properties of such signals can be tracked. Adaptive algorithms are commonly characterized by performance in stationary situations in terms of misadjustment and convergence time. In the analysis of evoked potentials (EP), the observed signal can, at least for subjects in "stable" conditions, be considered as composed of a repetitive, deterministic part which is corrupted by additive random noise; the noise is assumed to be stationary. Considering the periodic stimulus occurrence, the evoked responses is a cyclostationary process.

The performance of an adaptive algorithm, established under stationary conditions, is not valid for the cyclostationary case, although such an assumption is often found in the literature. In this work, we study the performance of an adaptive algorithm for cyclostationary signals and derive an optimum solution as a function of the time-average of the time-dependent autocorrelation matrix and the time-average of the time-dependent crosscorrelation vector. The optimum solution is found by minimzing the time-average of the time-varying mean square error. Estimates of convergence time and misadjustment are derived for the LMS algorithm; the results resemble those of the stationary case but with time-averaged matrices. Finally, results are presented which illustrate the performance on evoked potentials when the adaptive algorithm uses orthogonal basis functions.