

# Speech Quality Enhancement of In-Ear Microphone Speech

Rachel E. Bouserhal, Tiago H. Falk, Jeremie Voix

## Abstract

Communicating in noise is a difficult task for people wearing Hearing Protection Devices (HPD) in noisy industrial environments. In fact, the number one reason why workers choose not to wear HPDs in the workplace is that HPDs are a barrier to communication. This work provides a simple yet effective technique to provide workers with enhanced quality communication while maintaining appropriate hearing protection. An intra-aural HPD containing an in-ear microphone, a miniature loudspeaker, and an outer-ear microphone, with wireless radio capabilities and a link to a digital signal processor is used to achieve this task. First, using the in-ear microphone and the passive attenuation of the HPD, a speech signal is captured with a relatively good SNR, even in extremely noisy situations. The noise is further reduced using a normalized least-mean squared error adaptive filtering technique. The in-ear microphone speech quality is enhanced by extending its bandwidth through exploitation of nonlinear operators applied to the excitation signal. The technique is validated through subjective and objective measures, both showing statistically significant improvements in speech quality.