Modeling engine roughness

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Clearly, sound quality evaluation has become a central focus for assuring customer satisfaction. To achieve an optimized product sound at an early stage of development, subjective evaluation methods must be combined with analysis and prediction tools to provide reliable information relevant to product quality judgments. Some years ago, a “Hearing Model” was developed explaining and describing many psychoacoustic effects, and allowing for roughness calculation in accordance with subjective listening tests. Existing roughness models work well for synthetic signals such as modulated tones or noise signals, but it is challenging to predict roughness for engine sounds because of their more complex spectral and temporal noise patterns.

Additionally, there is demand for tools to predict engine roughness inside the vehicle based only on measurements of the engine at a test bench, or even based on purely simulated data. The well-known methods of **B**inaural **T**ransfer **P**ath **A**nalysis and **S**ynthesis (BTPA/BTPS), developed and refined during the past decade, can be used successfully for predicting interior sounds based on measurements of excitation source strengths and the corresponding transfer paths to a receiver position (e.g. the driver position).

This paper will introduce an extended approach allowing the engineer to predict engine roughness based on test bench or full vehicle measurements. This approach offers new sound design possibilities by virtually changing the transfer paths. The effects of the modifications on the vehicle interior sound can be analyzed in the early design phase. Results of engine roughness prediction and subjective evaluations will be presented.

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