SIMULATION OF GEAR WHINE SIDEBANDS IN AN AUTOMATIC TRANSMISSION INCLUDING MANUFACTURING VARIABILITY

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ABSTRACT

The current trend for planetary automatic transmissions with 8 or more forward speeds has led to new NVH error states related to gear “whine” noise, in particular the phenomenon of modulation sidebands generated by manufacturing and assembly variability.

This paper provides an overview of the causes and effects of modulation sidebands and demonstrates the application of new simulation tools to predict sideband behaviour for 8+ speed automatic transmission.

Two types of simulation methods will be presented. The first method – which can be used at an early stage of the design process - uses a simple representation of the system architecture to qualitatively identify which sidebands are expected to occur and crucially to identify which kinds of operational deflections and manufacturing tolerances are most sensitive.

The second simulation method presents the new capabilities added to an existing commercially available simulation tool to accurately predict the vibro-acoustic response of the complete transmission, providing a quantitative assessment of the sideband behaviour. This method is based in the frequency domain and can assess the effect of manufacturing and assembly tolerances on transmission gear whine noise.

Using these methods, two different planetary gear set designs are compared for noise performance. It is shown that a failure to properly account for the effects of sidebands and the influence of manufacturing variability leads to a conclusion that one design is significantly superior to the other. When the effects of sidebands and manufacturing variability are fully accounted for, it is shown that there is little difference in performance in terms of radiated noise. The paper will also present correlation of predicted results to measurements from the real transmission in both overall radiated noise and in the distribution of the sidebands.

The proper simulation of gear whine sidebands and their sensitivity to operational deflections and manufacturing variability provide a critical understanding of the mechanism that can potentially generate gear whine noise. Elimination of gear whine is important in delivering refinement for automotive sound quality. The simulation tools provide a full analysis of the NVH behaviour throughout the design process and allow potential issues with design and manufacturing to be understood and contained early in the development process.