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Electric Power Steering Noise Prediction by Transfer Path Analysis

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Noise and Vibration(NV) control of automotive chassis modules is getting more significant because of recent trends toward electrification of powertrain. On the other hand, it is key issue to develop various performance with fewer physical prototype vehicles in order to save costs and time. Chassis NV performance therefore is required to be predicted and evaluated in the early stage.

This study proposes Transfer Path Analysis(TPA) for prediction of the rack assisted Electric Power Steering(EPS) noise. "Component" TPA framework allows characterizing structure-bone NV source called "blocked force", which is theoretically independent of receiver structure. For application to EPS, the gearbox is defined as active subsystem and rest of vehicle is passive one. Two connection points to subframe were considered as paths of structure borne noise into the cabin.

6-DOF blocked forces and moments of the gearbox were measured and verified on the test bench in the manner determined by ISO20270 (in situ method). Structure-borne noise level were predicted by applying blocked forces to acoustic response functions of the vehicle. The whole methodology was validated by means of comparison with acoustic response that was measured directly on the vehicle (Fig. 1).

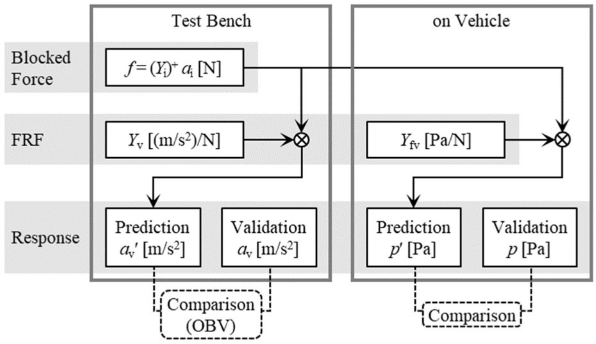

Fig. 1 The validation methodology used in the study

Fig. 2 and 3 show waterfall plots of predicted and validated acoustic response and their cross sections at specific steering velocity. Response under 500 Hz is clearly overestimated and this probably is caused by vibration transmitted from load actuators of the test bench (grey line in Fig. 3). In range of 500 to 1300 Hz a relatively good consistency was found. The mesh frequency peak of reduction gear, appearing diagonally in Fig. 2, was estimated within approximately 5 dB from directly measured level. Both under and overestimation were observed over 1300 Hz. This reason remains unclear, however contribution of other transfer paths such as steering shaft was experimentally implied in this frequency range.

In conclusion, component TPA method was successfully applied to EPS noise prediction in a particular frequency range, considering structure-borne path through carbody. For further accuracy improvements, it is necessary to enhance assumption of tranfer path and test equipment.

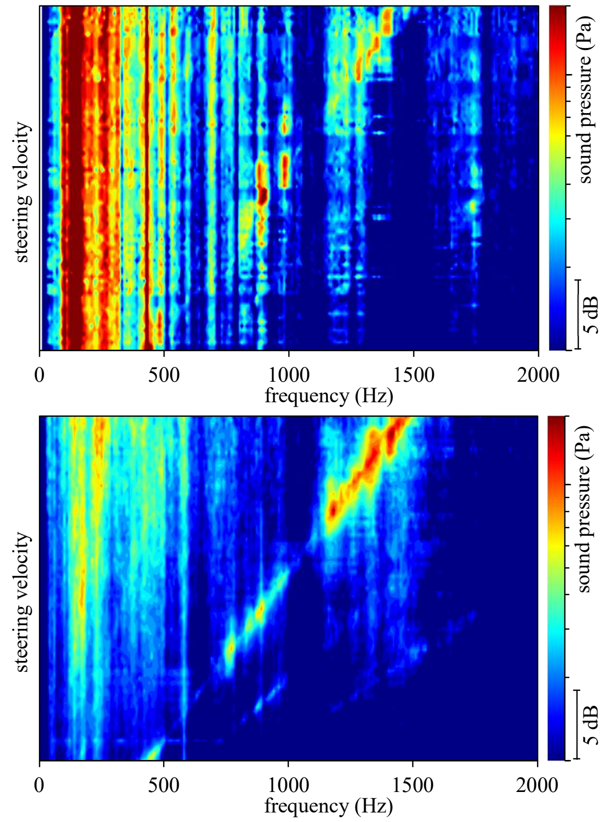

Fig. 3 Steering velocity versus frequency waterfall plots of EPS system noise level of TPA prediction(p', above) and vehicle validation(p, below)

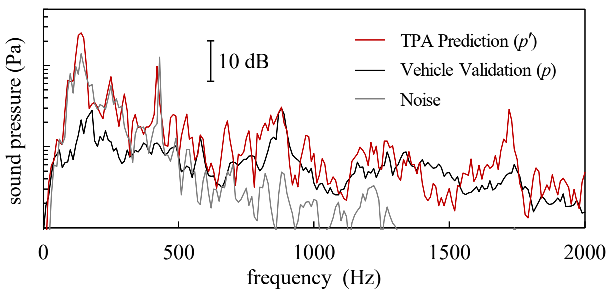

Fig. 2 Cross sections of waterfall plots of TPA prediction(red), Vehicle validation(black) at particular steering velocity and estimated noise(grey)

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