

VIBES.technology

CASE STUDY

TUNED ABSORBER EFFICIENCY FOR ELECTRIC POWER STEERING

AT A GLANCE

CLIENT
Anonymized German automotive client

APPLICATION
Rigidly mounted Electric Power Steering (EPS), cabin tone at 640 Hz

PRODUCTS USED
DIRAC, SOURCE, COUPLE

KEY RESULT
About 4 dB lower cabin SPL at the EPS tone with a 0.1 kg tuned absorber, found virtually without hardware changes

CASE STUDY

TUNED ABSORBER EFFICIENCY FOR ELECTRIC POWER STEERING

This case study, carried out by a client with support from VIBES.technology, shows how a set of tuned absorbers can be applied virtually to find out how well they work on a rigidly connected Electric Power Steering (EPS) unit.

EPS units in electric vehicles must meet cost targets as well as the noise, vibration, and harshness (NVH) targets set by OEMs. Test campaigns that repeat parameter variations on hardware are being replaced by hybrid modeling, which lets engineers modify parts of the assembly virtually.

For assemblies with rubber bushings, an efficient countermeasure against structure-borne noise is to change the bushing stiffnesses virtually with VIBES' Stiffness Injection method. This EPS had no rubber bushings: it is integrated into the vehicle as a stressed member. A different late-stage countermeasure was therefore investigated: tuned absorbers at the connection points.

The project goal was to remove an annoying tone around 640 Hz in the cabin, caused by the EPS, with tuned absorbers at the interface.

PROCEDURE

The in-situ blocked forces at the two connection points were estimated in SOURCE using the Virtual Point Transformation (VPT). Here, blocked forces are the vibration forces a source would generate if its connection points (i.e. its interfaces) were held perfectly rigid so that no movement could occur. By determining the blocked forces, we gain a set of source descriptors that are not contaminated by structural feedback from the receiver (either the bench or vehicle). As such, they can be used for accurate transfer path analysis, simulation, and predictive modeling of different source-receiver combinations without the need to retest the source in each case.

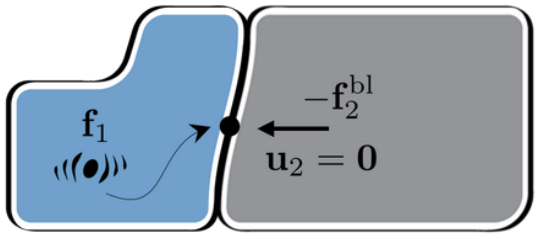


Figure 1: Application of blocked forces to component interface showing cancellation of receiver response.

The two main connections were each modeled in DIRAC as a full Virtual Point (VP) with six degrees of freedom (DoF), three translational and three rotational (see Figure 2).

For the tie rod end, a simpler 3-DoF VP model was sufficient.

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The Virtual Point served as a common interface node between the test bench measurements and the vehicle simulation. Dynamic substructuring, transfer path analysis, and the tuned absorber study could therefore all use one collocated interface definition.

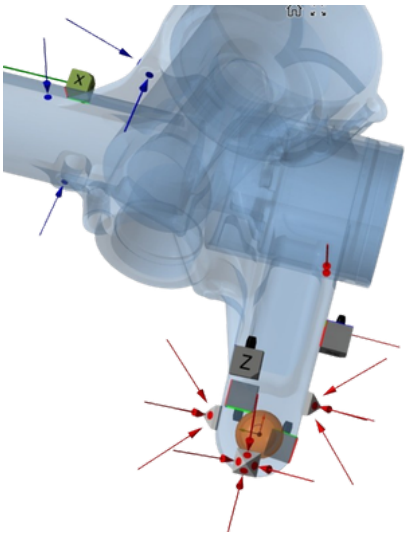


Figure 2: 6-DoF Virtual Point (orange sphere) in an example steering gear interface

In **COUPLE**, the absorbers were attached to the two 6-DoF VPs only (see Figure 3). Their stiffness k was tuned to the tone's peak frequency of 643 Hz from the absorber mass m with the formula:

$$k = m(2\pi f_n)^2$$

For damping, typical datasheet values for hard-rubber and plastic tuned absorbers were used. The parameters were then varied to find a set that reduces the 640 Hz tone in the cabin with as little added mass as possible.

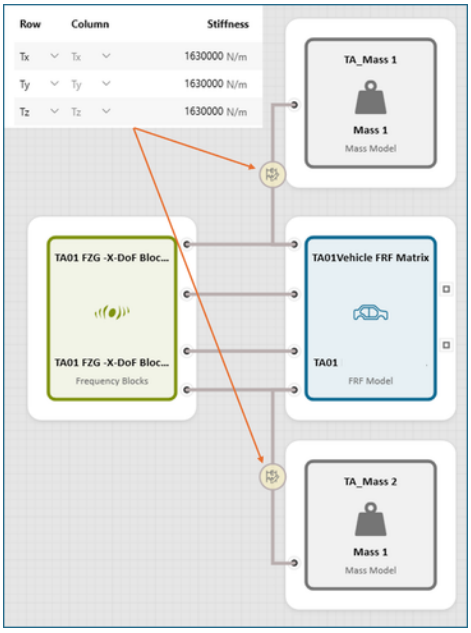


Figure 3: Tuned absorber (0.1 kg) mounted on the two 6-DoF VPs, shown in COUPLE.

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RESULTS AND DISCUSSION

A well-designed set of tuned absorbers clearly reduces the critical tone in the cabin (Figure 4).

The absorber mass was varied from 50 g to 250 g in steps of 50 g. An absorber of 0.1 kg with a stiffness of 1.63 MN/m already reduced the cabin sound pressure level (SPL) at the tone by about 4 dB. Because other sources in the cabin mask the remaining order-dominated tonal noise, this reduction was judged sufficient.

This shows that a late-stage countermeasure is enough to suppress the relevant noise component in the cabin.



Figure 4: Narrow band comparison of cabin SPL (co-driver microphone), with and without tuned absorbers. The arrow marks the 10 dB grid spacing.

CONCLUSIONS

This study addressed the challenge of optimizing a rigidly connected EPS with tuned absorbers at the interface, with respect to the noise received at the occupants' ears. The method combines in-situ blocked forces with Virtual Point technology for accurate source characterization, and uses VIBES' Hybrid Modular Engineering approach for virtual optimization. Design concepts can be checked against full-vehicle NVH behavior without modifying the vehicle hardware, which reduces test cost and the risk of a late redesign.