Estimating transmissibility functions in industrial vibration isolation systems by combining floor and shaker excitations

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1 Introduction

Vibration isolators are widely used in high-precision machines to reduce the transmissibility function $\mathcal{T}$, which represents the transfer from base frame vibrations to payload vibrations. Active vibration control (AVC) can be used to further improve $\mathcal{T}$. However, for industrial systems with AVC it is often difficult to show improvement of $\mathcal{T}$ via system identification, since it is hard to sufficiently excite the heavy base frame with shakers during operating conditions. In that case, floor vibrations can provide additional base frame excitations to estimate $\mathcal{T}$. This abstract presents measurement results [1] on an industrial system, see Figure 1, to show the benefit of combining both sources of excitation.

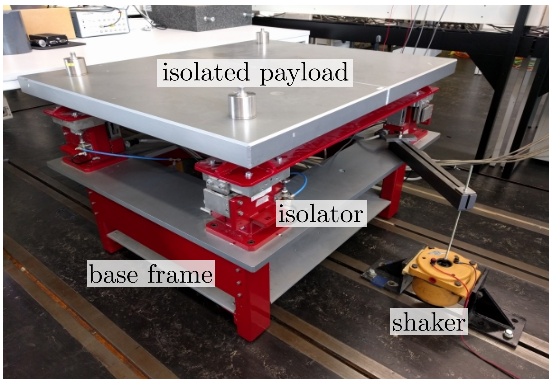

Figure 1: Industrial active vibration isolation system.

2 Approach: combined excitation

Floor vibrations generally have a random nature, while shaker excitations can be designed as either random or periodic (multi-sine) signals [2]. For the system in Figure 1, floor vibrations occur at low frequencies (< 20 Hz), while shakers are only able to provide sufficient excitation energy at high frequencies (> 10 Hz) due to mechanical limits. Therefore, combining both sources can lead to good coverage of the complete frequency range of interest, which is from 1 to 100 Hz.

3 Results

Figure 2 shows transmissibility function plots for three experiments. In experiment (A) existing floor excitations are used, but no shaker excitations. In this case, the plot shows a sudden increase of $\hat{\mathcal{T}}$ beyond 20 Hz due to insufficient floor excitation. In experiment (B) the shakers are enabled and periodic analysis is used, such that random floor excitations are considered as undesired noise. Therefore, the plot only shows $\hat{\mathcal{T}}$ from 10 to 100 Hz with high standard deviation $\hat{\sigma}(\hat{\mathcal{T}})$, i.e. uncertainty, at low frequencies because floor excitations dominate the shaker excitations. In experiment (C), both floor and shaker excitations are considered as useful random excitations, resulting in a good estimation of $\hat{\mathcal{T}}$ over the complete frequency range.

4 Conclusion

A combination of random shaker and floor excitations leads to a good estimate of $\mathcal{T}$ over the frequency range from 1–100 Hz. Future research should focus on multidimensionality aspects in the estimation of $\mathcal{T}$.

References

[1] M. Beijen, M. Heertjes, R. Voorhoeve, and T. Oomen, *Evaluating performance of multivariable vibration isolators: A frequency domain identification approach applied to an industrial AVIS.* Accepted at *the American Control Conf., 2017*, Seattle, WA, USA.

[2] R. Pintelon and J. Schoukens, *System identification, a frequency domain approach.* J.Wiley, 2012.

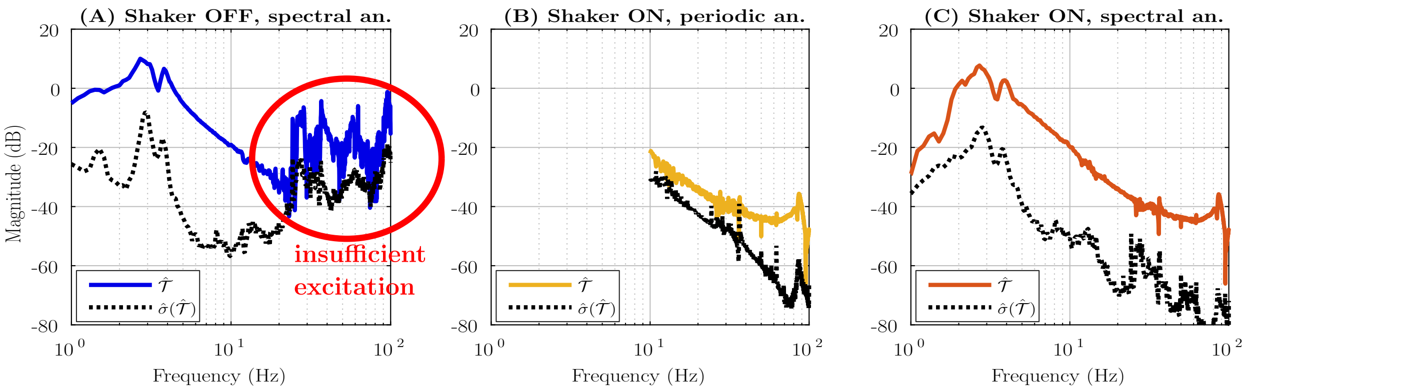

Figure 2: Bode magnitude plots showing the estimated transmissibilities $\hat{\mathcal{T}}$ and corresponding standard deviations $\hat{\sigma}(\hat{\mathcal{T}})$ using either spectral analysis or periodic analysis [2].