# COMPUTATIONAL METHOD FOR SHAPING THE VIBRO-ISOLATION PROPERTIES OF SEMI-ACTIVE AND ACTIVE SYSTEMS

I. Maciejewski[1] and T. Krzyzynski[1]

[1]*Department of Mechatronics and Applied Mechanics, Faculty of Technology and Education, Koszalin University of Technology, Sniadeckich 2, 75-453 Koszalin, Poland*

*e-mail: igor.maciejewski@tu.koszalin.pl, tomasz.krzyzynski@tu.koszalin.pl*

## 1. Introduction

Passive vibration isolators are typically constructed using the inertial and visco-elastic elements. Although the dissipation of a substantial part of the vibration energy is provided at sufficiently high frequencies, the low-frequency vibration are usually amplified due to the resonance effect [1]. As a consequence, it is difficult to achieve an effective vibration reduction in the whole frequency range by means of passive systems [2]. However, the increased vibration damping effectiveness can be obtained by applying semi-active or active systems [3]. In this paper an original methodology of shaping the vibro-isolation properties of semi-active and active systems is presented for the purpose of improving the suspension dynamics and thus effectively reduce the vibrations transmitted to the human body.

## 2. Formulation of the overall method

The block diagram of the overall method for shaping vibro-isolation properties of semi-active and active systems is presented in Fig. 1. If the vibration exposure in typical working machines is simulated by means of random input signals, then the vibro-isolation properties have to be evaluated using simulation model of the vibration reduction system. Spectral characteristics of the input vibrations are specified in such a way that the generated excitation signals are representative for different types of working machines. Output signals of the simulation model should be used for determination and evaluation of risks from exposure to whole-body vibration. The desired vibro-isolation properties of semi-active or active system can be achieved by an appropriate selection of the controller settings that are calculated with the use of multi-criteria optimisation.

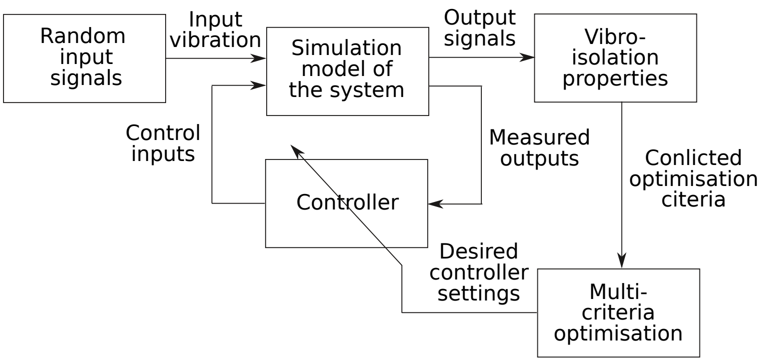


Figure 1: Block diagram of the overall method for shaping vibro-isolation properties

## 3. Simulation model of the semi-active and active systems

Simulation model of the semi-active of active vibration isolator should allow to predict the system performance under various input vibrations. If a model is a precise representation of the system dynamics then an analysis of the control strategy can be successfully conducted by using numerical simulation. The system modelling equations and control algorithm have to be combined into one model in order to simulate the closed-loop system behavior for different values of the controller settings. The block diagram representing a general simulation model of the semi-active or active vibration reduction system is presented in Fig. 2.

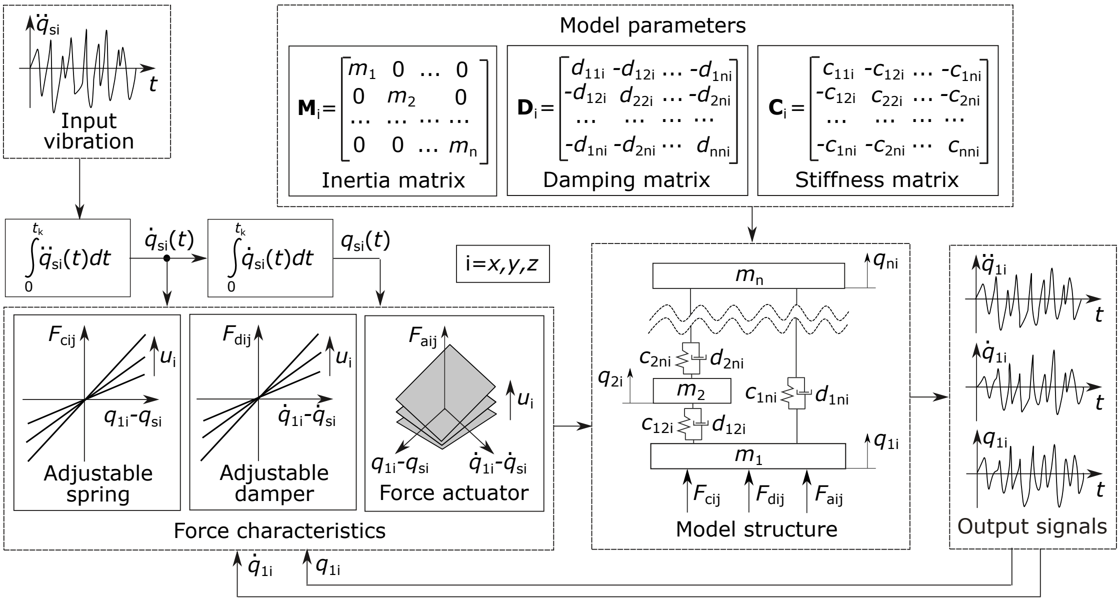


Figure 2: Block diagram for numerical simulation of the dynamic behaviour of vibration reduction systems

Since human response to vibration shall be investigated for different spectral classes of the excitation signals therefore the input vibration block (Fig. 2) is used to generate the random acceleration $\ddot{q}_{\mathrm{si}}(t)$ for different directions of the vibration exposure ($\mathrm{i} = x, y, z$). Then a double integration with respect to time $t$ is applied in order to obtain the velocity $\dot{q}_{\mathrm{si}}(t)$ and displacement $q_{\mathrm{si}}(t)$ as input signals to the model. The applied force of adjustable spring $F_{\mathrm{cij}}$, adjustable damper $F_{\mathrm{dij}}$ or force actuator $F_{\mathrm{aij}}$ is employed to compensate harmful vibrations affecting the human body. Their non-linear characteristics are described as functions of the input signal $u_{\mathrm{i}}$ and the system relative displacement $q_{1\mathrm{i}} - q_{\mathrm{si}}$ and/or relative velocity $\dot{q}_{1\mathrm{i}} - \dot{q}_{\mathrm{si}}$. The force characteristics must be evaluated for the components used in a specific type of the semi-active or active suspension system.

## 4. Conclusions

In this paper a generalised methodology of shaping the vibro-isolation properties of semi-active and active vibration reduction systems is discussed. Selecting their dynamic characteristics can be successfully employed for different excitation signals that are representative for vibrations affecting the machine operators at work. A general model of the vibration isolation system is elaborated therefore its dynamic characteristics can be selected using the multi-criteria optimisation in respect to reliable vibro-isolation criteria. Using the proposed optimisation procedure it is possible to adjust the vibro-isolation properties of semi-active and active vibration reduction systems by changing the controller settings.

**Acknowledgments** The paper is a part of the research project "Methods and procedures of selecting vibro-isolation properties of vibration reduction systems" founded by the National Science Center of Poland under the contract No. UMO-2013/11/B/ST8/03881.

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