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Silviu - Marian Nastac

About New Method for Real Mechanical Systems Transmissibility Evaluation

In this paper the author present some theoretical considerations about a new method for real mechanical systems transmisibility evaluation. This method are based on the classical theory of transmisibility evaluation, that suppose the real mechanical systems composed by a lots of elements, and each element adding an additional degree of freedom to the system. The proposed method suppose two way for global transmisibility evaluation: in first case it is supposed that the inputs and the transfer functions of the system are known, and the second case when the inputs and the outputs of the system are known. The final result of this method is a global transmisibility value, that are taking into account both the input signal composition of frequencies, and the transfer characteristics of the analized system.

1. Introduction

The classical theory of mechanical vibration offer a very facilely way to compute the transmisibility. This is the most important parameter that could characterize the evolution of the mechanical system under the dynamic loads, by the point of view of the isolation and/or transmision of the excitation signal from the source, to the receiver.

Using the classical method it is possible to compute the discrete values for transmisibility, for each component of the input signal spectrum, but it is impossible to evaluating a global value for system transmisibility with considering the multiple or the random frequencies signals on input. In this case it is very difficult to compare two or more mechanical systems by the isolation capability point of view.

In the figure 1 it is presented the transmisibility diagram for a real single degree of freedom mechanical system, computed for an experimental determined value of damping ratio. In this diagram there are dignified the working significant domains, taking into account the imposed values for transmisibility, respectively for degree of isolation.

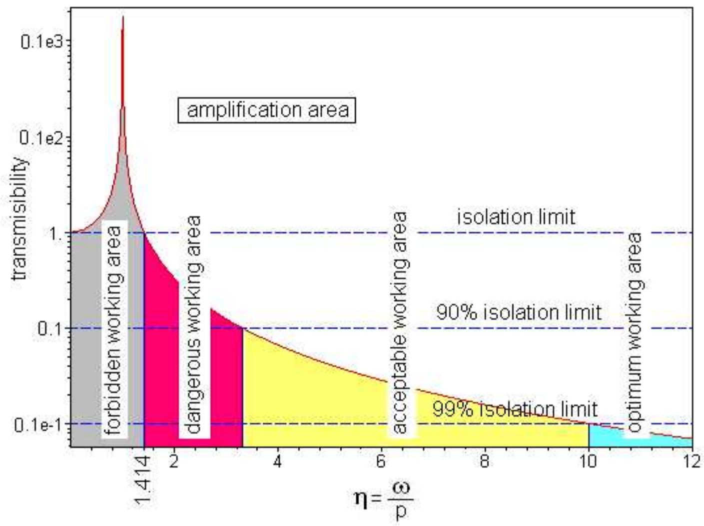

Figure 1. The transmissibility diagram

The proposed method suppose two way for global transmisibility evaluation: in first case it is supposed that the inputs and the transfer functions of the system are known, and the second case when the inputs and the outputs of the system are known. Both methods supposed that the input signals composition of frequencies are known.

The first method is applicable in the case of theoretical analysis, when it is easily to evaluate the transfer characteristic of the system. Also, this method it is applicable when the system have slightly number of components with known or easily to compute transfer functions.

The second method supposed that it i known the output of the analized system, so that this method is applicable only for the real system analysis. If the input signals spectrum it could be evaluated both for real, and for theoretical signals, the output spectrum, without known any transfer characteristics of the analized system, it is impossible to evaluate, than by experimental way.

Considering the previous suppositions, it is evident that the proposed methods offers a facile mode to evaluate the global value of transmisibility (respectively, degree of isolation) both on the case of theoretical views, and on the case of experimental tests of real mechanical systems.

The final result of this method is the global transmisibility value, that are taking into account both the input signal frequencies composition, and the transfer characteristics of the analized system - through the transfer functions or through the output signal. The most important aspect of this parameter consist that it have an unique value that characterize the working dynamic state of a mechanical system, free of complexity degree of the considered system. This unique value facilitate the comparations between two or more systems of the same working class.

2. The first method principle

The principle of the first proposed method is presented in the figure 2. As well as was described in the previous paragraph, this method supposed that the input and the system characteristics are known. In the figure, this fact was punctuated by using of question sign on the output of the system.

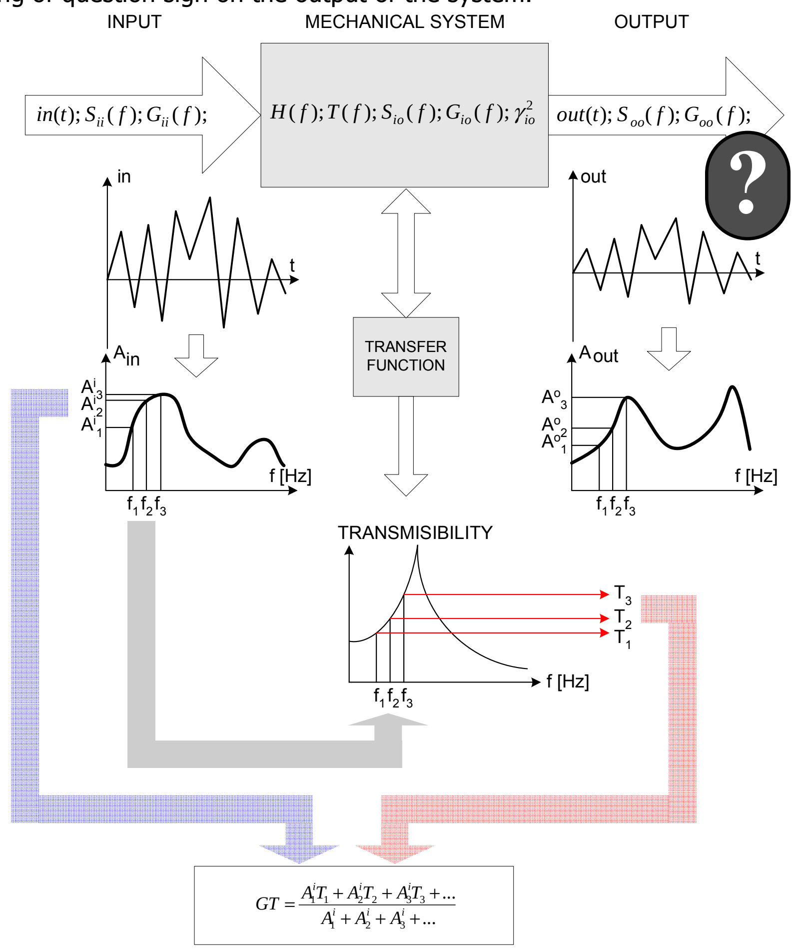

Figure 2. The first method principle of global transmissibility evaluation

The diagram shown in the figure 2 present the logical computing flow for evaluate the global value of transmissibility. Thus, it is started at the input, on which compute the signal spectrum. The next step consist by evaluate the transfer characteristic of the mechanical system - through one of the transfer function, classical transmissibility characteristic, efficacy parameter, efficiency value. At one time that the both aspects are known, it will be adopted a series of frequencies and, for each value, it will get both the suiting value of input spectrum magnitude, and the correspondent value of transmissibility. Finally, it will be used one of the expressions for global transmissibility value estimation.

3. The second method principle

The diagram of the principle of the second proposed method is presented in the figure 3. As well as was presented in the previous paragraph, in the figure is shown the logical computing flow for evaluate the global value of transmissibility, in the case of the input and the output of the system are known.

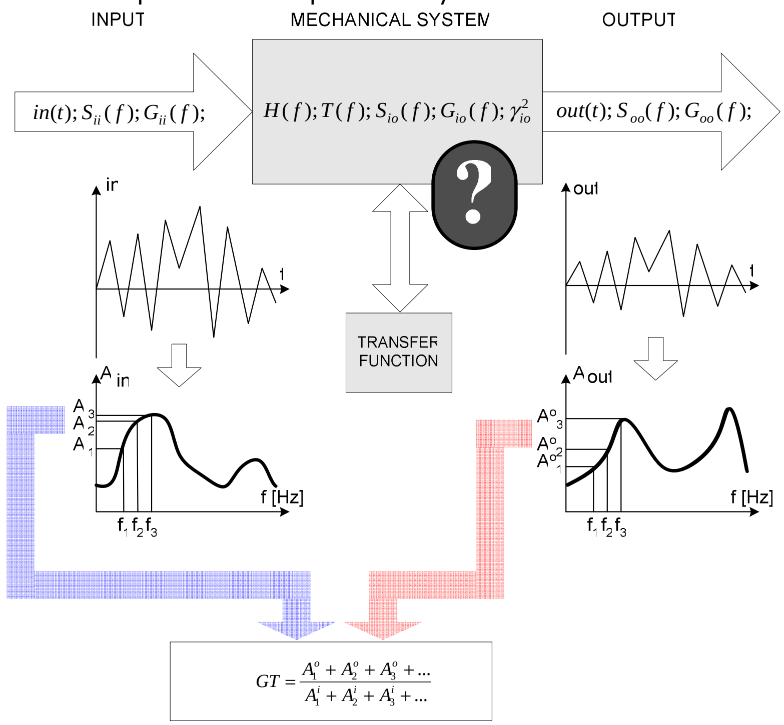

Figure 3. The second method principle of global transmissibility evaluation

As well as the first method, the unknown informations - in this case, mechanical system transfer characteristics - was punctuated by using of question sign on the output of the system.

The first step on using this method, consist by measuring of the system output when on input is injected the known signals. For each pair of in-out signals it will be evaluated the spectrum. On the next step, it will be adopted a series of frequencies and, for each value, it will get both the suiting value of input spectrum magnitude, and the correspondent value on output spectrum. Finally, it will be used one of the expressions for global transmissibility value estimation.

On the both methods, schematic presented in the figure 2, respectively, in the figure 3, it was used a generic notation of the global transitivity value, namely "GT". Depend on the effective way of the system transfer characteristic evaluation - transmissibility, transfer function, cross spectral density, cross correlation function - there is available one of the next expressions of the GT

$$GT = \frac{A_1^{in}T_1 + A_2^{in}T_2 + A_3^{in}T_3 + \dots}{A_1^{in} + A_2^{in} + A_3^{in} + \dots} = \frac{\sum A_j^{in}T_j}{\sum A_j^{in}} = \frac{\sum A_j^{out}}{\sum A_j^{in}} \tag{1}$$

where $A_j^{in}T_j = A_j^{out}$. The upper indices denote the output or the input of the system, the lower indices denote the order number of the operating frequency on the adopted series. If it is not available the transmisibility, but the transfer function, then it is necessary to evaluate the cross spectral density of the signal(s). On this case, the global transmissibility expression is

$$GT = \frac{\sum G_j^{in} H_j^2}{\sum G_j^{in}}. \tag{2}$$

If the series of frequency is very dense, then the sum become a integral, and the eqn. (2) become

$$GT = \frac{\int_0^\infty G^{in} H^2 df}{\int_0^\infty G^{in} df} = \frac{\int_0^\infty G^{out} df}{\int_0^\infty G^{in} df} \tag{3}$$

where $G^{in}H^2 = G^{out}$ and $G^{in} = G_{xx}(\omega)$, $G^{out} = G_{yy}(\omega)$ denote the power spectral density for input, respectively output of the system.

If it taking into account the expression of mean power for the input and output signals

$$P_m = \int_0^\infty G(f)df, \tag{4}$$

result that the global transmissibility is equivalent with the ratio between the mean power of the output signal, and the mean power of the input signal

$$GT = P_m^{out} / P_m^{in}. \tag{5}$$

There is observed that the transfer parameter values have the same behavior as well as the weight coefficient on the weighted mean - this fact is better illustrated in the first method; the second method frozen the transfer characteristic into the relationship between the system's input and output.

4. Concluding remarks

A valid conclusion for both methods, is alluded to the global precision of final value of transmissibility, and it is formulated hereby: the smaller frequency increment, the better final value of transmissibility. In the case of computerized procedure of *GT* evaluation, this aim is quite assured. Also, if the integral formulation is used, there is getted over this problem, because the entire domain of the signals is continuous analysed, and the global error is provided only by the numerical computing method specific error. Analysing all formulations for the *GT* evaluation, it could be declared that these methods have whole compatibility with the other known ways for evaluating the vibration degree of transmission or isolation.

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Address:

- PhD. Eng. Silviu - Marian Nastac, “Dunarea de Jos” University of Galati, Research Center for Mechanics of the Machines and Technological Equipments (MECMET), Calea Calarasilor, nr. 29, 810017, Braila, snastac@ugal.ro