APPLICATION OF MATLAB FOR REAL TIME SPECTRAL ANALYSIS AND TRANSFER VISUALISATION

M. Kašpárek

Technical University Liberec
Faculty of Mechanical Engineering
Department of Applied Cybernetics
Studentská 2, 461 17 Liberec, Czech Republic
michal.kasparek@tul.cz

Abstract

On the field of undesirable noise and vibration damping new and promising technology is being analyzed. This semi-active damping technology utilizes features of piezoelectric materials and employs them to increase acoustic stiffness of thin insulation layer. The paper presents system developed in Matlab for measuring and spectral analyses of piezoelectric damping assembly. The functions and possibilities of the system are described and its usability is discussed.

1 Introduction

With growing importance of modern technology and its impact on everyday life the need for minimizing emitted noise and vibrations is rising. In order to achieve the selected goal of damping undesirable vibrations several - passive or active - approaches can be applied. However the semi-active way of sound and/or vibration damping, can hold the key for future high efficient, low space and weight demanding and adjustable sound damping, utilizing features of piezoelectric materials and employing them to increase acoustic stiffness of thin insulation layer.

The traditional active attitude of noise or vibration damping brings considerable weight addition, including microphones, active control system filtering the input and speakers or drivers creating waves of opposite phase in order to attenuate inconvenient part of sound spectrum, which can be highly undesirable. On the contrary the semi-active way of sound/vibration damping with the usage of piezoelectricity of certain materials and their behavior when wired in the negative capacitance circuit shows the potential of high efficiency damping with small space and weight demands. The principle of semi-active sound damping was described in detail in [1][2].

Presented article deals with measurement system developed in Matlab in order to test, measure and visualize properties and behavior of piezoelectric damping assembly. Its features, usability and portability is discussed in relation with current state of art of related research.

2 Measurement system description

Designed system is designated to be used with two different piezo assemblies. One of them is acoustic assembly used for research of piezoelectric actuators enhancing the acoustic stiffness of glass materials. The second assembly is used for vibration transfer research. Both of them use the same principle but the realization and related electronics are different. Therefore the adjustable parameters of output level and related are required from the system in order to maintain universal usability for both described assemblies.

Requested features at the beginning of development included universal multi-input measurement, ability of phase and amplitude spectra measurement in precisely adjustable range, transfer calculation of amplitude and related properties, high-speed measurement and number of customizable parameters.

In order to meet the entry requirements dual hybrid measuring core function was designed using MathWorks MATLAB. The core functionality is utilized in related executive script thus the control parameters are to be easily accessed and managed.

The dual core feature consists of two measuring attitudes. First method called the Sweep function uses defined frequency range and resolution for sequential single frequency measurement. If required, the measured data interpretation is being calculated on the fly.

Second part of the core utilizes fast algorithm of measurement using multifrequency signal and direct calculation of full spectrum properties at once. The excitation signal is created by filtering white noise using selected frequency range thus the resulting signal contains only frequencies from desired part of the spectrum. This function is called the Noise measurement.

The Matlab measuring program is based on Session based interface which makes it compatible with the latest versions of Matlab and also with different types of measuring devices. The huge amount of measurement parameters is adjustable, which makes the script universal for spectral analyses of any device or system. Parameters are divided into the categories of obligatory and optional.

2.1 System parameters description

The function parameters are arranged in parameter array like this:

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(s, modeM, modeA, FLow, FHigh, FRes, options)
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where first six parameters are obligatory. Last parameter options contains string of haphazard combination of optional parameters. When no optional parameters are required, then empty string can be inputted and the default values will be used.

First parameters called s contains DAQ session, created by *s=daq.createSession('ni')*. Only NI Data acquisition devices are supported at the contemporary Matlab state of art. At least four input channels and one analog output channel is required for the measurement. The initialization is also implemented in related script and can be modified according to actual needs.

Mode of the measurement is defined in the modeM parameter when either *Sweep*, *Noise* or *both* methods can be used. The Sweep method can further be adjusted in modeA parameter that influences the amplitude of generated driving signal. The amplitude can be generated in three different modes: the constant amplitude (definable by appropriate optional parameter), Linear decrease of amplitude (range is also selectable by optional parameters) and Adaptive adjustment of amplitude. This modes were created according to requests for constant energy of acoustic signal and also to diminish resonations in measured assembly. All of the presented parameters have pre-defined default values optimized for the acoustic assembly.

The frequency range of measurement is defined by numerical values in FLow and FHigh, while the FRes contains resolution of measurement which obviously applies only for discrete Sweep measurement.

2.1.1 Optional parameters

The string of optional parameters is also analyzed. Its interpretation is constructed in a way that the order of parameters is not important. All found parameters contained in the string *options* are analyzed in the order of their transcription and their values are kept during the whole measurement. The parameters not included in options string have their default values defined so the functionality of the script is not dependent on correct definition of optional parameters.

Among the optional parameters rank the set for excitation signal amplitude modification. Then the parameter determining the length of driving signal based on the minimum period count at selected frequency is present and the length of Noise measurement determined by the number of repetitions of single multifrequency noise measurement.

Last but not the least the set of parameters was constructed in order to set and optimize the visualization capabilities of the system. While during experiment on-the-fly visualization of signals and results can be highly appropriate it can become annoying and retarding during the automated measurements and multiple repetitions. This is why during normal mode only few figures are shown containing results of the measurement. When required, additional visualization can be activated and on the contrary all visual feedback can be disabled at once selecting appropriate parameter.

Also the saving of the data is adjustable. While default set-up does not save any results on the hard drive when enabled, the measured input data can be saved in defined format. Also the transfer of amplitude and phase of the measured assembly can be calculated and by selected relevant parameter it can be saved into separate file. The transfer is calculated between inputs 1 and 2 which are meant as either microphones or accelerometers installed in the measured assembly.

3 Measurement optimization

While the functionality of Noise function as fast measurement system is highly sufficient, the single frequency sweep deals with several issues. First the length of the measurement would take too much time when sufficient length of each iteration should be constant. This means that in case of 2 second measurement length, frequency range 100 Hz - 2 kHz and frequency resolution of 1Hz the overall measurement length would be 1900*2 seconds, which is over 63 minutes and the calculation does not include any lags or delays.

From this reason the measurement length was optimized so that maximum length of one iteration is 2 seconds and it lowers with higher frequencies so that certain quantity of driving signal periods is maintained. This optimization is highly dependent on user defined parameter of desired period counts but it can lower the measurement length significantly up to 10% of initial value while the principle of single frequency sweep is preserved.

This attitude is important mainly to keep uniform conditions during the measurement, because in case of excessively long measurement the temperature changes may depreciate the measurement set because of temperature dependence of certain components characteristics.

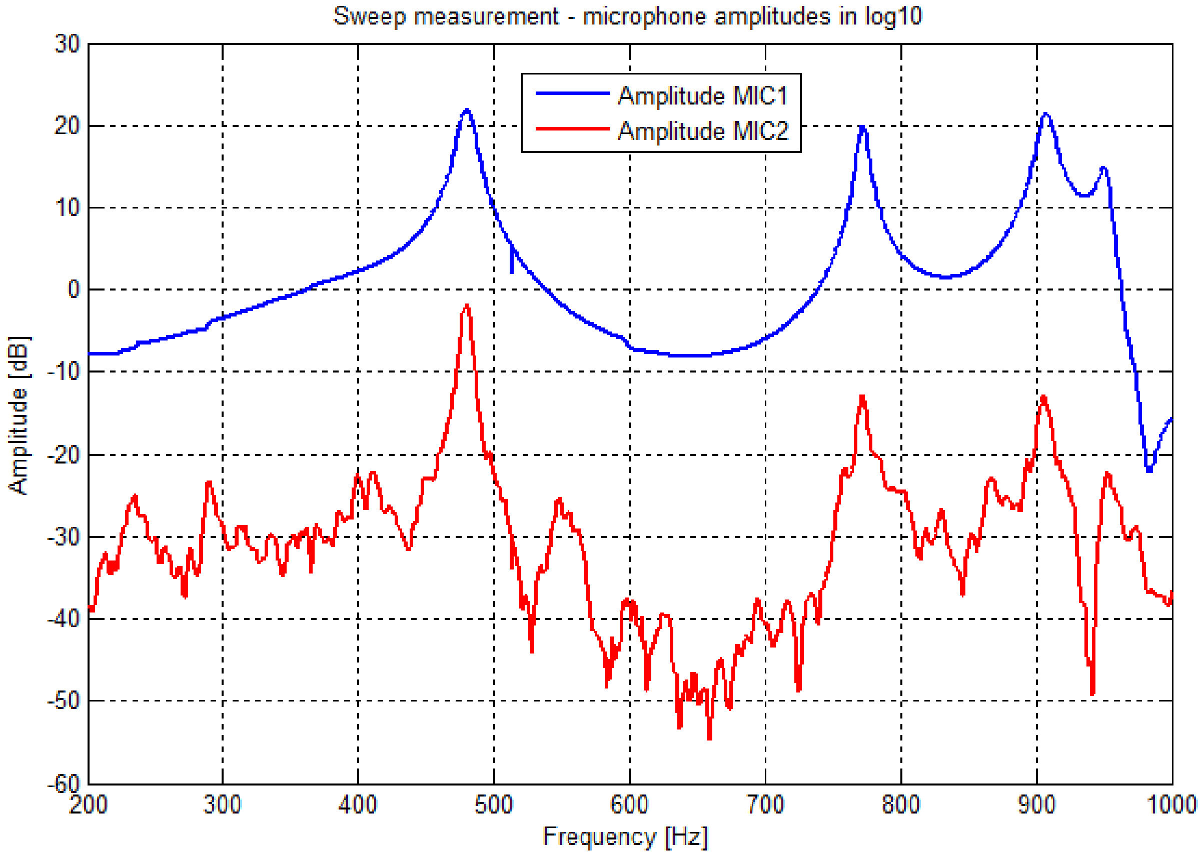

Figure 1: Measured acoustic data visualization using single frequency Sweep method

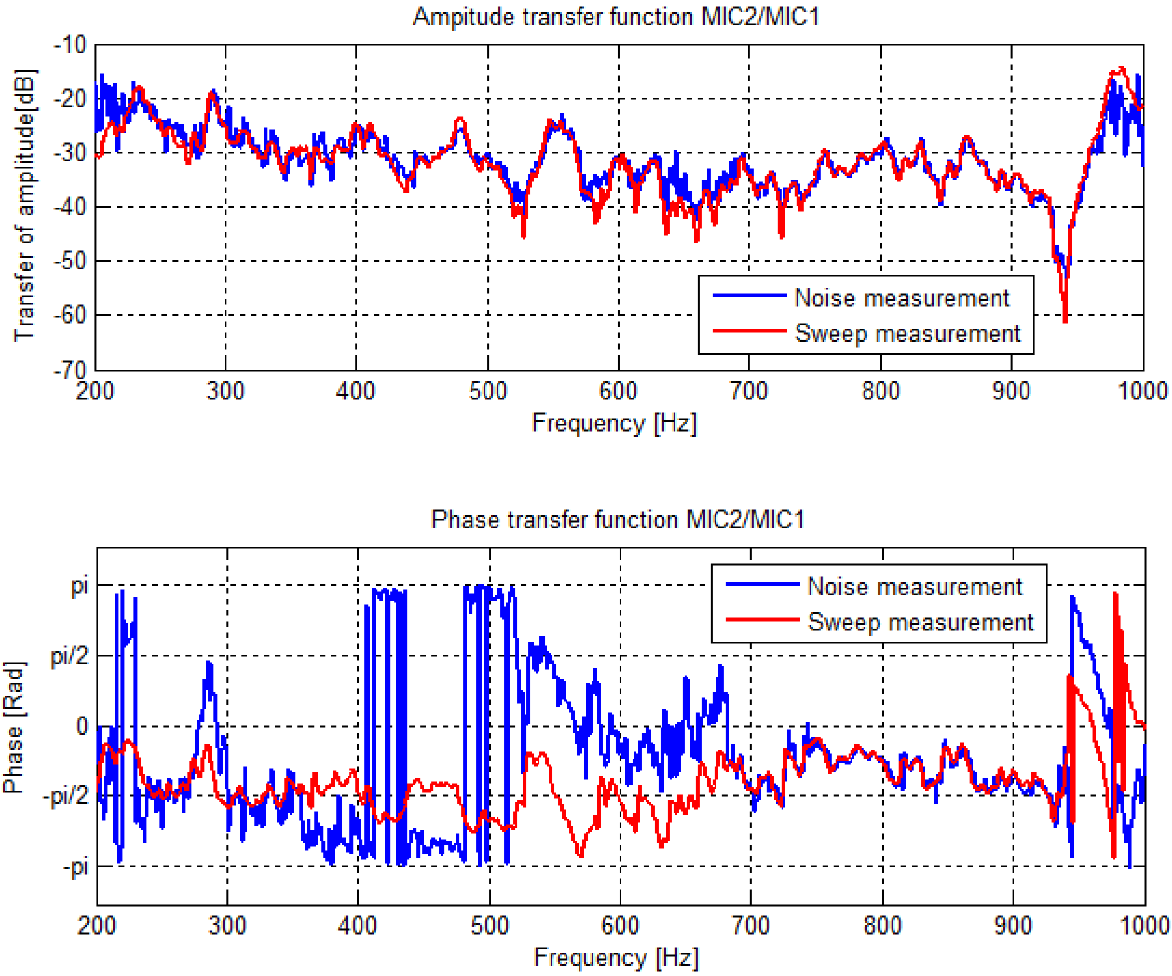

Figure 2: Single frequency Sweep and multiple frequency Sweep measurement comparison

4 Results

The paper presented the measuring system for spectral analysis of the piezoelectric damping assembly. Its core features and implemented methods were described along with possibilities of parametric setting and visualization abilities.

The comparison of both developed methods shown on Fig. 2 depicts the satisfactory correspondence of amplitude spectra measured by Sweep and Noise algorithm. The phase spectra are on the contrary very unbalanced and the results favor the sweep method as the reliable tool for detailed analyses. The single sweep measurement and its results measured by acoustic inputs are shown on Fig. 1 where the strong resonation of the assembly influences both of the microphones. The amplitude transfer and therefore also the attenuation level depicted in logarithmic scale on Fig. 2 is calculated from the data visualized on Fig. 1.

Brief results examination shows that future improvements are to be beneficial but core functionality of measurement system is satisfactory for current needs. The “noise” algorithm provides very fast and sufficiently accurate method of measuring the sound amplitude attenuation whereas the “sweep” functionality brings slow, but precise and well adjustable alternative for high-precision measurement. One of possible future expansions consists of coupling the system with 2D plane vibrometer in order to build fully automated high-precision analyses tool with vibration diffusion visualization capabilities.

References

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Ing. Michal Kašpárek, DiS
Technical University Liberec
Faculty of Mechanical Engineering
Department of Applied Cybernetics
Studentská 2, 461 17 Liberec, Czech Republic
michal.kasparek@tul.cz