8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

UTILIZATION OF COCHLEA FUNCTION PRINCIPLE FOR DECOMPOSITION OF NON-STATIONARY SIGNALS

***Daniel Dusek[1]**

[1] Institute of Solid Mechanics, Mechatronics and Biomechanics,
Faculty of Mechanical Engineering,
Brno University of Technology, Technická 2896/2, 616 69 Brno, Czech Republic
e-mail: dusek@fme.vutbr.cz

Key Words: *Cochlea, Signal decomposition, array of resonators, basilar membrane.*

ABSTRACT

Cochlea is that part of the inner ear where acoustic signals incoming from outer air space are convert to electric signals. Pressure travelling waves in inner ear fluid space are generated by forcing of foot stapes to scala vestibuli. The travelling waves in fluid medium consequently excite also travelling waves on basilar membrane where sense organs are located. From the point of view of mechanics of hearing is very important that locations of the maxima of travelling waves on basilar membrane are frequency dependent. Low frequency tones excite basilar membrane near its apical end. With the increasing of frequency the maxima of travelling waves are moving to the basal end. This effect is caused by varying cross section and following varying longitudinal stiffness of the basilar membrane [1, 4]. The inner ear functions like a mechanical analyzer which is able to decomposes time-nonstationary signals to single frequency components in real time. This principle of inner ear function was verified by experimental measurement „in situ“ on human cadavers [1] or on physical models [6] and also by mathematical modelling [2, 3, 6].

The question can be put: Is it possible to design any device that will work similarly to human cochlea and will be able to decompose any time dependent signal to single frequency components in real time? Nowadays it is possible to use new technology MEMS for producing of this device.

First possibility of design is based on similarity to real basilar membrane in cochlea that means membrane with different properties of longwise section. Position of maximal amplitudes of vibration on this membrane will make it possible to define individual frequency components. Second possibility of design for mechanical analyzer is a field of isolated masses with springs. Different natural frequency will correspond to every mechanical system mass-spring. When the field of isolated masses is actuated, then the masses having their eigenfrequencies same like frequencies included in a forcing signal will start resonating (figure 1).

This paper will engage in handling of signals gained from mathematical model of array of resonators (figure 1).

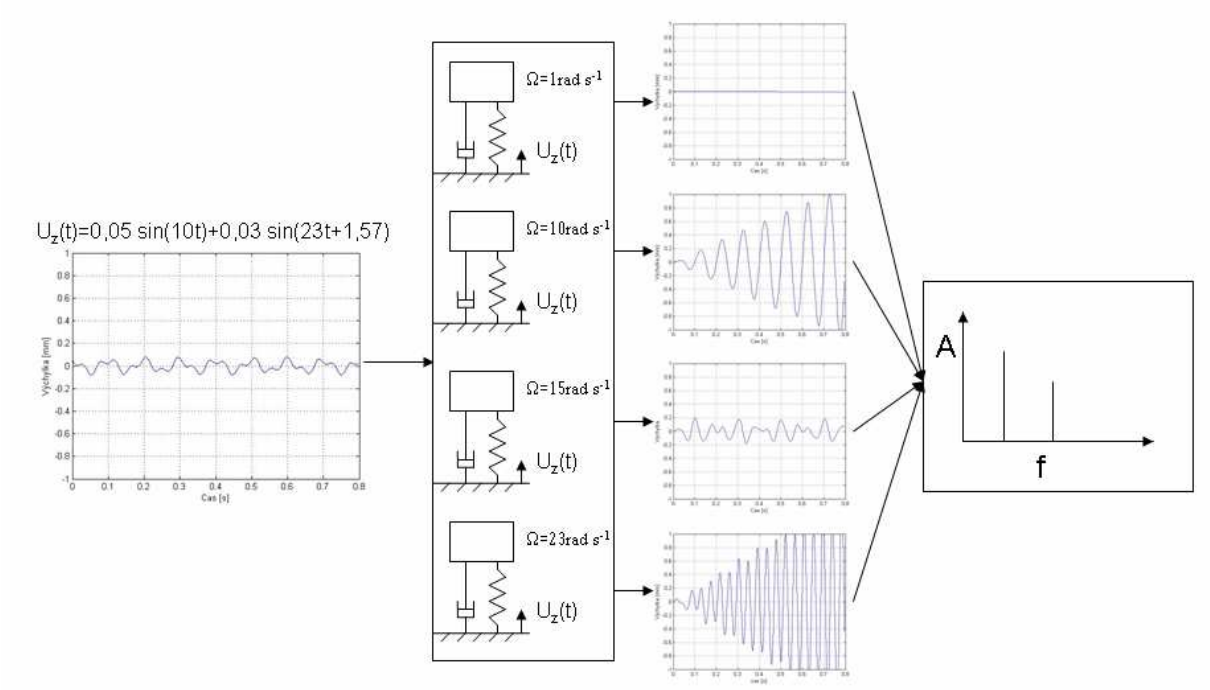

Figure 1. Diagram of signal decomposition by the model of masses and springs

ACKNOWLEDGEMENT

This paper was written with the support by the Grant Agency of AS CR - Project No.: KJB201730802.

REFERENCES

[1] G. von Békésy, “Experiments in Hearing”, McGraw-Hill, New York, 1960.

[2] K. Pellant and D. Dušek, “Modelling of Basilar Membrane Excitation”, Proceedings of the 7th International Conference on Computational Structures Technology, Lisbon, 2004.

[3] E. Givelberg and J. Bunn, “A Comprehensive Three-Dimensional Model of the Cochlea”, Elsevier Science, January 2003.

[4] L. Robles and M. A. Ruggero, “Mechanics of Mammalian Cochlea”, Physiological reviews, Vol. 81, No.3. July 2001.

[5] R.D. White and K. Grosh, “Design and characterization of a MEMS piezoresistive cochlear-like acoustic senzor”, Proceedings of International Mechanical Engineering Congress and Exposition, New Orleans, 2002.

[6] F. Chen, I. H. Cohen, T. G. Bifano, J. Castle, J. Fortin, CH. Kapusta, D. C. Mountain, A. Zosuls and A. E. Hubbard, “A hydromechanical biomimetic cochlea: Experiments and models”, J. Acoust. Soc. Am. 119, No. 1, January 2006.