Sergii Ianushkevych

Postgraduates, Department of Metrology and Life Safety

Kharkiv National Automobile and Highway University

REVIEW OF APPROACHES TO CALCULATE OUTPUT OF NONLINEAR MEASUREMENT SYSTEMS

In [1] we consider the general structure of a measuring system model, which begins with a sensitive element, which transforms one kind of energy into another Next, the preparation of an electrical signal for processing, processing directly and then visualizing the results is carried out. Such a system may exhibit nonlinear and inertial properties.

The more complete description of measuring systems is presented in [2]. The primary sensing element (the primary transducer) receives energy from the measured medium (object of measurement). In turn, the measuring medium is disturbed by the measuring instrument and the primary converter. A similar approach to the structure of measuring systems is given in [3].

Consequently, each measuring system, measuring channel or a separate sensor contains a measuring medium between the object of measurement and the primary converter and the circuit of processing and visualization of the signal. For accurate measurements with little uncertainty, it is necessary to have adequate mathematical models of the measuring system and, if possible, the most complete information about incoming random processes that are measured.

The measuring channel depending on the conditions of its operation may be:

– linear non-inertial;
– linear inertia;
– nonlinear non-inertial;
– nonlinear inertial.

This means that the mathematical models of measured channel should take into account such specifics and describe the channel with different mathematical relations. The simplest model is a linear non-inertial model. The connection between the output and the input signals in such a model is directly proportional. The most general is the nonlinear inertial model of measured channel.

Nonlinear measuring channels can be considered in pressure measurement systems [4]. The main problem of such systems is their influence on the input signal. The output signal of the system may differ significantly from the input in the form, spectrum and other parameters. In such a situation it is difficult to make the right decision about the characteristics of the input signal, especially in systems of technical diagnostics.

The simplest approach to eliminating these difficulties is to remove the conditions under which the linear measuring system becomes nonlinear. The another approach is to linearize the function of converting a measuring system to different mathematical methods, at least in the limited area of the indicated function. This allows us to use the developed and relatively simple theory of linear systems.

Specific identification methods include, first of all, block-oriented methods [5], in which the nonlinear inertial model is divided into two sequentially connected blocks. In one of the blocks a nonlinear non-inertial function of the model is modeled, and in the other one it is inertial, and the latter is linear. Depending on which block is the first, there is the Hammerstein model and the Wiener model. In the model of Hammerstein, the first link of the model is a nonlinear non-inertial, and the second is linear inertia. In the Wiener model, the order of the links is opposite.

In [6], the Hammerstein-Wiener model, which has been studied less, is considered. Three links are used in this model: two static (non-inertial) nonlinear and one linear inertial, which is between two nonlinear ones. This creates wider possibilities for the nonlinearity modeling of the measuring channel. An iterative algorithm for internal variables estimating for systems with polynomial nonlinearity proposed in [7] shows a good convergence.

Hammerstein-Wiener systems are more complex to identify than the Hammerstein and Wiener models separately, but more versatile. They, in particular, were used in the simulation of electronic power amplifiers, submarine detection systems, ionospheric dynamics [8].

References:

1. Abdu Idris Omer, Taleb M. M. Measurement systems: characteristics and models. – Europian Scientific Journal, 2014, vol. 10, №9. – pp. 248…260.

2. Ernest O. Doebelin. Measurement systems. Application and design. – McGraw-Hill Publishing Company, 1990. – 960 p.

3. John P. Bentley. Principles of Measurement Systems. – Pearson Education Limited, 2005. – 160 p.

4. Hashemian H. M. Monitoring and Measuring I&C Performance in Nuclear Power Plants. – International Society of Automation, 2014. – 362 p.

5. Heinz Unbehauen, Frank Ley. Das Ingenieurwissen Regelungs und Steuerungstechnik. – Springer Vieweg, 2014. – 123 p.

6. Jozef Vörös. An iterative method for Hammerstein – Wiener systems parameter identification. – Journal of electrical engineering, 2004, vol. 55, №11-12, pp. 328…331.

7. B Brouri, F. Giri, A. Mkhida, F. Z. Chaoui, M. L. Chhibat. Identification of Nonlinear Systems Structured by Hammerstein-Wiener Model. International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering, 2014, vol. 8, №5, pp. 738…741.

8. G. Palm. On representation and approximation of nonlinear systems, part II: Discrete time. –Biological Cybernetics, 1979, vol. 34, №1, pp. 49…52.