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MODELLING AND COMPUTER SIMULATION OF INSTRUMENTS FOR CONTROL AND DIAGNOSTICS OF HYDRAULIC SYSTEMS

1. Introduction

Relations between experimentally investigated hydraulic drives, measuring instrumentation and data processing procedures can be treated as some problem of systems theory. In the structure of the system: *investigated hydraulic drive & measuring system,* these relations mainly refer to interactions in the form of exchange processes of mass, momentum, energy and information. They are expressed with formal description of connections between elements of tested hydraulic drive and instrumentation which exist in assumed system model. Structural characteristics of these connections are usually presented using block schemes, graphs or matrices for which the rules of reductions and equivalent transforms are determined. The work of a system is introduced by applying transfer functions, for instance. Differences of quality between systems of the same class (with similar properties) can be noticed in the type and kind of relations that create the structure of the system. A sort of optimization of choice the measuring system elements is possible if the measuring process is considered as a sequence of operations carried on an experimental object. External conditions, excitations and environmental interferences and simultaneously probable forms of the system damage or crash (for the benefit of diagnostics) must be known to give ability of suitable model construction. Computer simulation performed on different structure models of the same *hydraulic drive & measuring system* provide the effective solution of the optimization task.

The MathCad program and the VisSim & Analyze package have been used to simulate both the analyzed exemplary hydraulic drive system and also measuring system taken under consideration. The broad analysis of the general formulation of such a whole system optimization problem has been introduced in [1]. Here, the main goal of this paper has been limited to the presentation of the chosen models of sensors, models of DAQ devices and some DSP procedures useful for computer simulations. Particular models and some obtained results of simulations can be implemented in the domain of digital control and adapted to diagnostics specific demands.

2. Simulation of DAQ System for a Hydraulic Drive System

According to the assumption, the servo-hydraulic system shown in Fig. 1 should provide displacement - controlled type excitation of driven load in the form of harmonic oscillations. Catalogue data of the servo cylinder system involve usually dynamic characteristics like: amplitude and phase frequency response, step function response of each sub-system element, which can be applied to construction of the transfer function that corresponds to linearized model of the investigated hydraulic drive.

Next steps are: primary assumptions about quantities that should be measured and the choice of sensor types. There have been chosen four quantities: displacement, acceleration, pressure, temperature and respectively four sensor types to measure them.

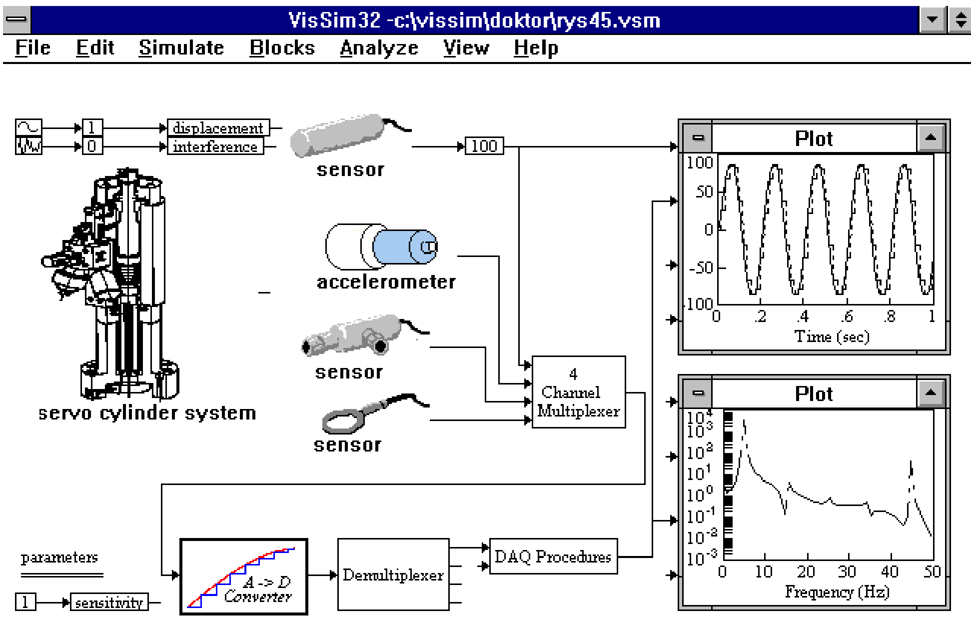

Fig. 1. Scheme of servo-hydraulic drive and DAQ system; application of VisSim package

The model of linear displacement sensor of LVDT type is shown in Fig. 2. The influence of sensor specific time and range of non-sensitivity on fidelity of data processing can be analyzed during simulations. The white noise generated, treated as interference, is added to harmonic signal on input of the model. Filtering features of the transducer can be noticed on the screen of Plot (a signal consumer) - the attenuation of amplitude, phase transition and smoothing of the signal. The variation of the oscillation frequency at a simulated generator enables the analysis of the application range of the modelled transducer as a sensor for dynamic measurements, taking under consideration signal processing precision.

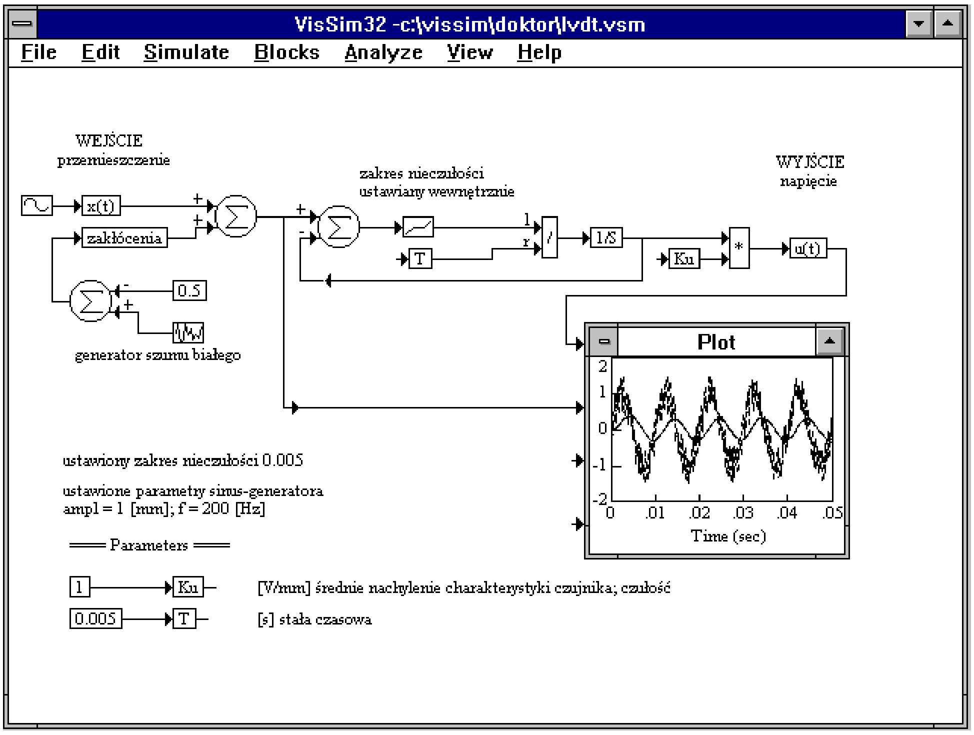

Fig. 2. Scheme of the displacement sensor model of LVDT type

Giving short comments to the next schemes one can point to the fact that in the accelerometer model, the piezoelectric properties of material has been limited only to the one material constant and the model of second degree has been adapted to the description of mass motion. The introduced model is simple but all data required for simulation: sensitivity, resonant frequency and internal damping coefficient can be determined from the standard protocol and amplitude-phase characteristic of the accelerometer. Only internal damping coefficient must be evaluated out of previously given technical data.

"Connecting" white noise signal from generator to the accelerometer model input and the Plot recorder to the output, one can obtain frequency response in form of Bode characteristics. They are presented in Fig. 3 on the right side. The upper one corresponds to an amplitude characteristics useful for comparison with a standard protocol of the real accelerometer.

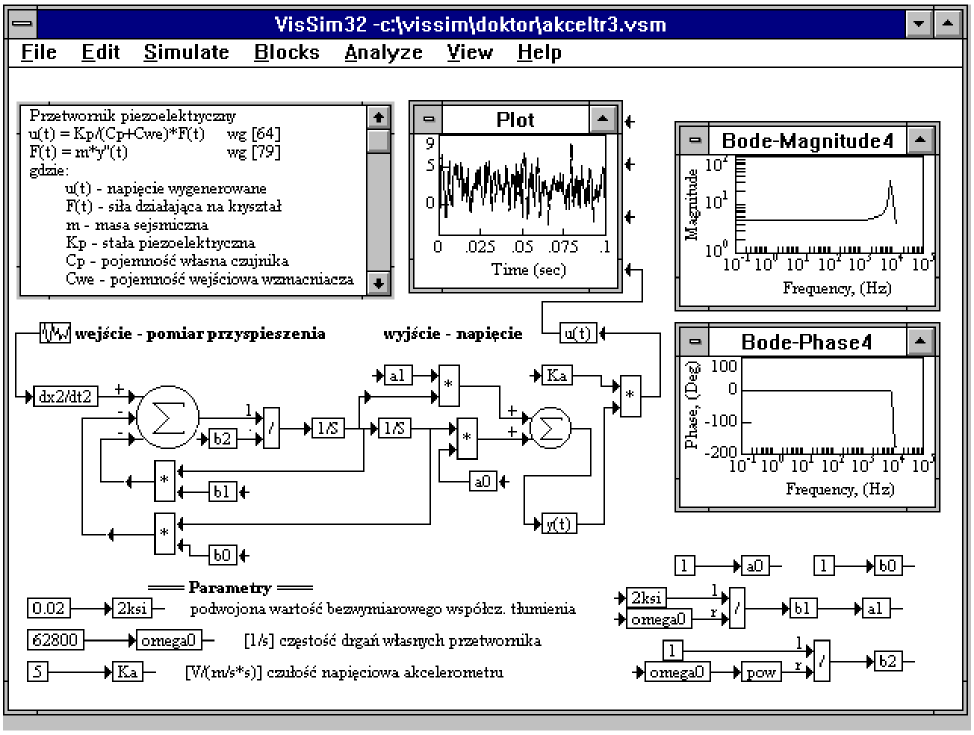

Fig. 3. Scheme of piezoelectric accelerometer simulating model

An introduced model of pressure sensor (Fig. 4) is assumed as of strain gauge pipe type and among its parameters, the data of strain gauges and features of excitation supply and demodulator are taken under considerations.

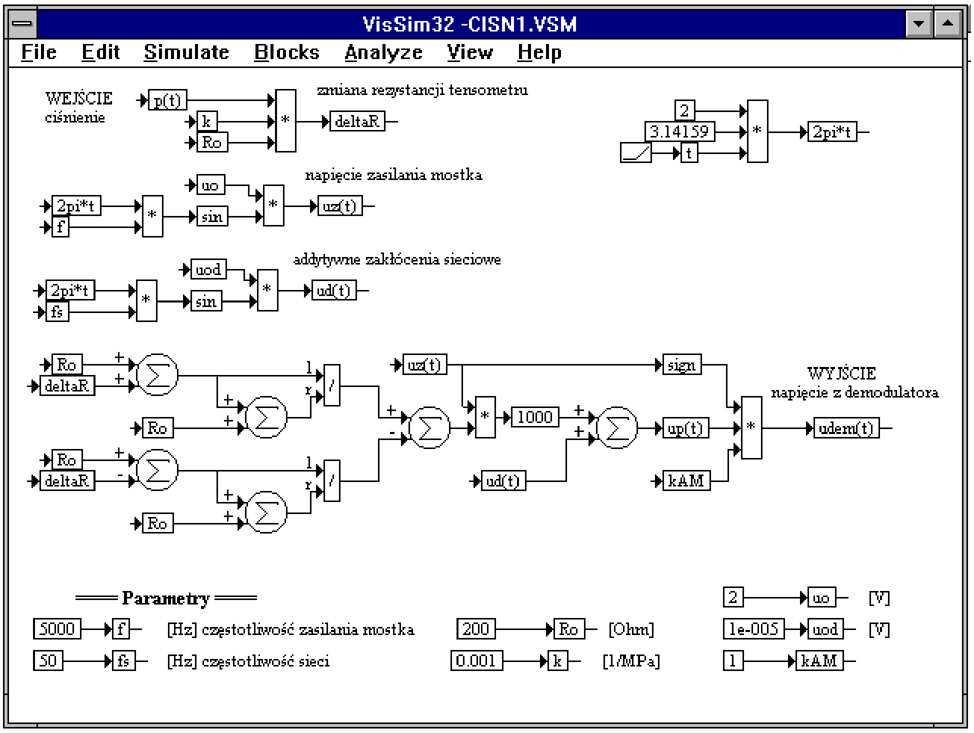

Fig. 4. Scheme of the simulating model of the strain gauge pressure transducer

The temperature sensor model is a simple one of the first range model of the thermo-electric transducer with thin connectors, without a screen and completely drawn in liquid. The model and all of parameters of the transducer (assumed as known) are introduced in Fig. 5.

Models of different types sensors must be accompanied by other models of transducers applied in classic channels of DAQ systems like A/D and D/A converters, multiplexers and triggers [1]. This way the complex simulation model of the whole measuring system can be accomplished and prepared to analyses of quality and technical effectiveness both with the model of investigated hydraulic drive system.

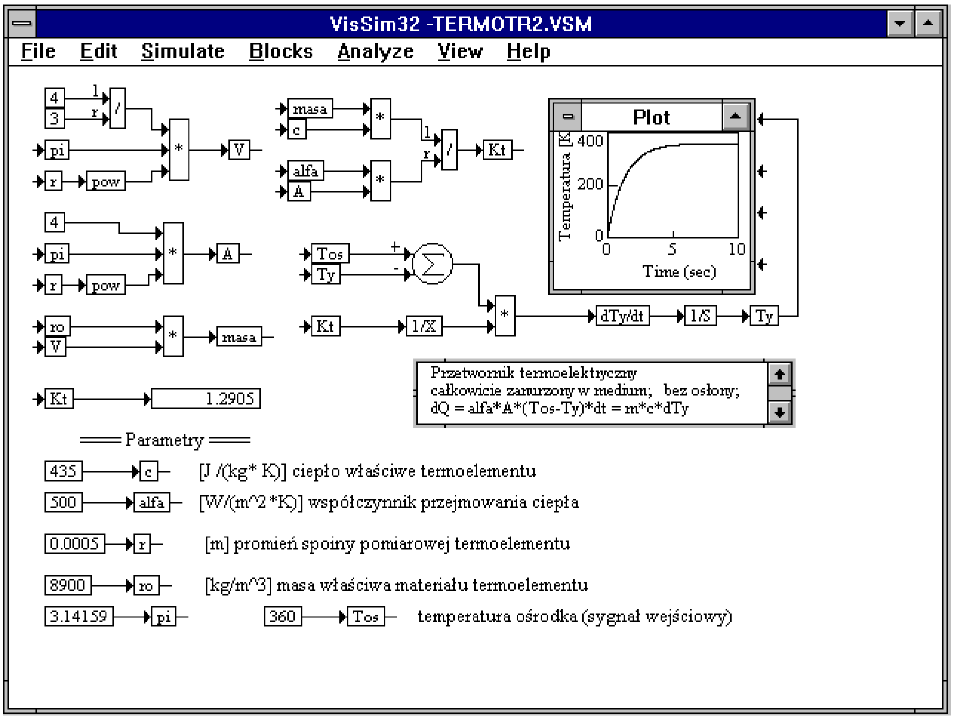

Fig. 5. Scheme of the temperature sensor simulating model

3. Conclusions

The proposed concept of computer aided choice of measurement system instruments for control and hydraulic drive diagnostics application was proved to be performable, using some simulation transducer models.

References

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