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NEW POSSIBILITIES IN THE EDUCATIONAL PROCESS OF ELECTRICAL MEASUREMENTS

In the paper are presented the possibilities of preparations modern, educational tools which in the form of virtual instruments are very helpful for educational process in electrical measurements. These dynamic instruments enable to perform during the lectures demonstrations which explain better lectured theory of electrical measurements, especially when some kinds of phenomena are presented in slow down time scale. Another group of virtual instruments enable to simulate measuring sessions which are realized later in the university laboratory. The third group of virtual instruments explain the idea of remote measurements with help of modern technologies. These measurements are realized on different industrial objects. The paper presents several solutions of educational virtual instruments designed by the team of Technical University of Gdansk. They were realized using the software LabVIEW of National Instruments.

Key words: *Electrical measurements, Virtual instruments,*

1. INTRODUCTION

The dynamic development of computer technology obliges teaching staff to modify educational process. It is necessary to underline that in the last years nearly all students have access to the computers and to the Internet. For this reason, especially in countries with developed computer technology, it is possible to observe the developments of distance teaching and learning organized by various universities and organizations (IMEKO, IEE, EAEEIE in Europe, IEEE in USA, UICEE in Australia and Asia). Looking through the publication of last years connected with this problem it is possible to remark the great revolution in the educational process [1, 3, 5, 7, 8, 10, 11, 12, 13].

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Nowadays there are organized lectures through Internet which can be heard out from nearly every place. These kind of lectures form a very convenient solution for the students who have not had possibilities to take part in the real university lecture, or to those who take part in distance learning and can be consider as audiles. For eye-minded persons it is necessary to prepare lectures in printed form edited on the websites. For these lectures can be elaborated virtual instruments, which enable to perform different experiments explaining better lectured materials. There are also organized distance laboratories, which give possibilities to perform practical experiments. Of course they could not substitute real laboratory tasks, which are very necessary in engineering education but they can be treated as very good tools for preparation to practical laboratory jobs. Distance learning through the Internet assures also possibilities to contact the lecturer as well as other students and to discuss problems which were incomprehensible or were talked over students heads.

In Poland we can observed certain efforts in developing system of distance learning [2, 4, 6, 8] but we are far behind many countries in Europe. This situation must be changed and it is the high time to ameliorate our educational process and to create new educational tools. This task can not be resolved by single persons. It must be created by specialized council supported by polish government in cooperation with polish technical universities and some education center of EC.

2. FUNDAMENTAL SOLUTION

The problem of education of electrical measurements have to be resolved in consecutive steps:

- Preparation lectures materials in the form which can be used directly from the Internet browser. It would be recommended to provide them with possibility of animation different experiments clearing up various physical problems. For these reasons very helpful are virtual instruments.
- Preparation experimental tasks in laboratories in the form of virtual instruments which can be very helpful as a preparation for real laboratory tasks.
- Organized system of distance education with possibilities of conversations and consultations with teaching staff.

In the Technical University of Gdansk it possible to distinguish several teams which are interested in the development of distance learning systems and educational tools in the form of virtual instruments [2, 8, 9] The main problem in creating educational units is to choose the right software. Its main advantages have to be as follows:

- Convenient and rapid in designing new instruments,
- Interface must be intuitive in operation,
- Convenient for remote measurements and control of different objects,

- View of elaborated instruments must be nice to look at and to have great resemblance to real instruments used in the universities laboratory

3. PRACTICAL EXAMPLES

Several examples of very helpful tools which form first step in the new system of the education of electrical measurements are presented in this section.

Figure 1 presents the solution, which enables to examine the time response of the 2nd order transducer in the case of sinusoidal and distorted input signal. During the lectures are formulated necessary conditions, which must be fulfilled in order to obtain regular output signal e.g. the proper selection of the natural frequency of the sensor to the highest order component of the input signal. Very often students forget about this

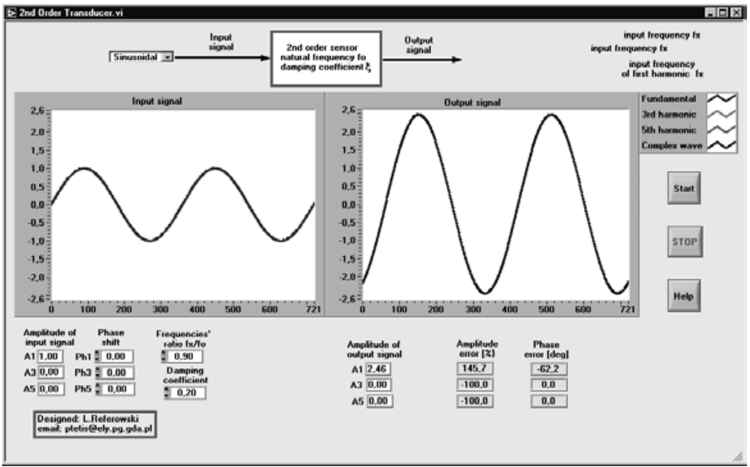

Fig. 1. Comparison time response of second order transducer in case of sinusoidal input signal, normalized frequency $f_x/f_o = 0,9$, damping coefficient $\xi = 0,2$. Amplitude error exceed value 45 %

condition and take into account the frequency of first harmonic. The misuse of such choice are presented in Figures 1 and 2. In the first case (sinusoidal input signal) for the frequency ratio $\eta = f_x/f_o = 0,9$ (f_x - frequency of measured signal, f_o - natural sensor's frequency) and damping coefficient $\xi = 0,2$ the amplitude of output signal has sinusoidal waveform and is nearly 2,5 time greater than of the input signal. For the same parameters of the sensor and in the case of distorted input signal the output signal has rather different form. It is due to the fact that the frequency ratio for third and fifth harmonics $f_3/f_o = 2,7$ and $f_5/f_o = 4,5$ is high. Therefore third and fifth harmonic are completely suppressed in the output signal which has sinusoidal waveform similar to the output signal shown in the Figure 1.

The basic informations concerning properties of the 2nd order transducer can be obtained pressing *Help* button on the front panel of described VI (Fig. 3)

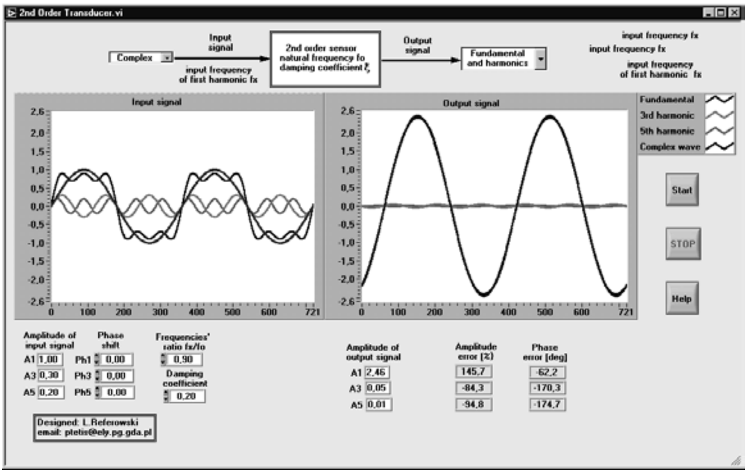

Fig. 2. Comparison time response of second order transducer in case of complex input signal, normalized frequency f_x/f_o = 0,9, damping coefficient ξ = 0,2. Amplitude error exceed value 145 %

The *Quit* button in the Help window enables to get back to the front panel.

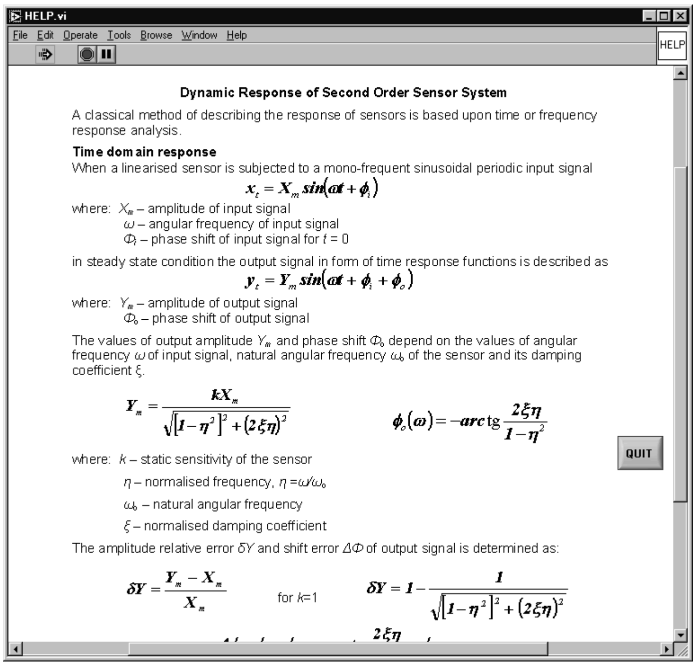

Fig. 3. Access to information files using *Help* button of 2nd Order Transducer VI

The described educational tool enables to choose optional values of sensor's damping coefficient and normalized frequency. It is also possible to remark that for previous chosen value of damping coefficient ξ = 0,2 and even small value of normalized frequency ratio η = 0,3 the output signal can be rather different from the input signal Fig. 4). This effect is due to the fact that the natural frequency of the sensor is close to the value of third frequency. Therefore there is a great influence of third harmonic in the output signal (amplitude error of the third harmonic is about 300%).

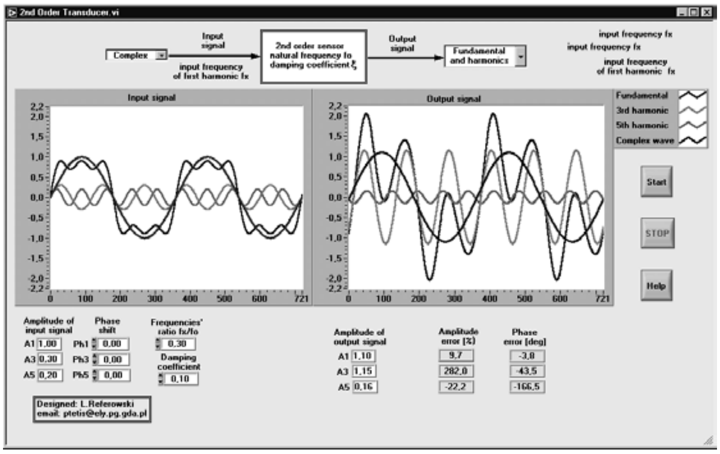

Fig. 4. Even for small value of frequency ratio η = 0,3 and damping coefficient ζ = 0,1 the output signal can be deform by harmonic which frequency is closed to natural frequency of the sensor

The Figure 5 presents a virtual instrument which is used during the lectures and as training instrument for laboratory tasks concerning dynamic signal analysis. This VI enables signal's simulation and its measurement and analysis. Input signal consists of two components. It is possible to set their amplitudes, frequencies and phase shift as well as with possibility of changing noise level. One can determines a sampling frequency and number of samples. In analysing process it is possible to choose strictly defined filter (low-pass, high-pass, band-pass, or band-elimination filter), its order and low and high cut-off frequency. On the monitor are presented filter's input and output signal versus time and frequency spectra of input and output signal. It is also possible to select Window function (Hanning or Hamming) in order to reduce the leakage in the frequency domain spectrum.

Using this VI the students have possibilities to go into the matter of:

- Aliasing effect

When the sampling frequency f_s is lower than twofold value of signal's frequency f an alias error may occur e.g. if $0{,}5f_s<f<f_s$ than the value of measured frequency will be determined as f_s-f instead of f

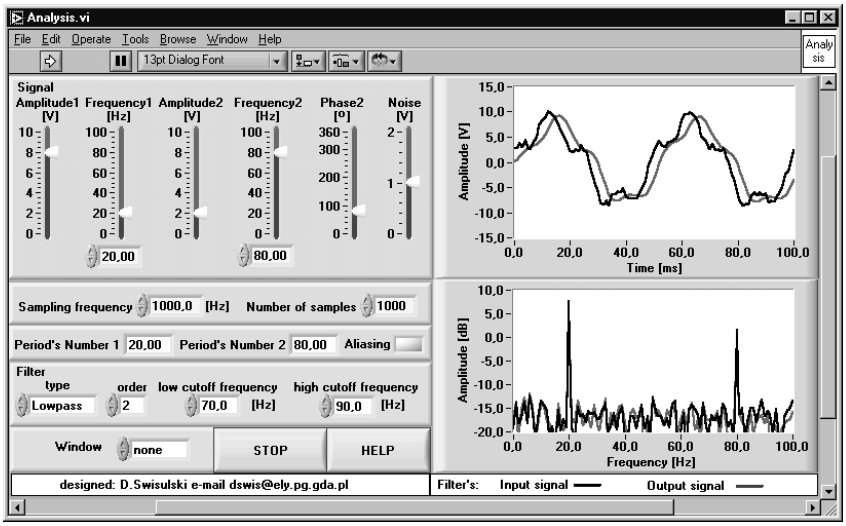

Fig. 5. Virtual instrument for studying dynamic signal analysis

- Leakage effect

A leakage error occurs when the number of periods in the sampling signal is not integer e.g. if $(N/f_s)f$ is integer, (where N is number of samples), than in the frequency characteristic will be only single spectral line with the frequency f. If this condition is not fulfilled there will be spectral line broadening as the result of leakage effect.

- Signal filtering

Changing the type of filter and its cut-off frequency for different parameters of input signal it is possible to observe this signal in the time domain and its spectrum before and after the filter, e.g. tracing filtration of unwanted component or separation of the component with useful information

- Window functions

It is possible to observe Window functions used to reduce the leakage error in the frequency domain spectrum. If in measuring signal there are two components with near-values of frequency but greatly different amplitudes than it is possible to see, in the frequency spectrum, the component with smaller amplitude only after windowing.

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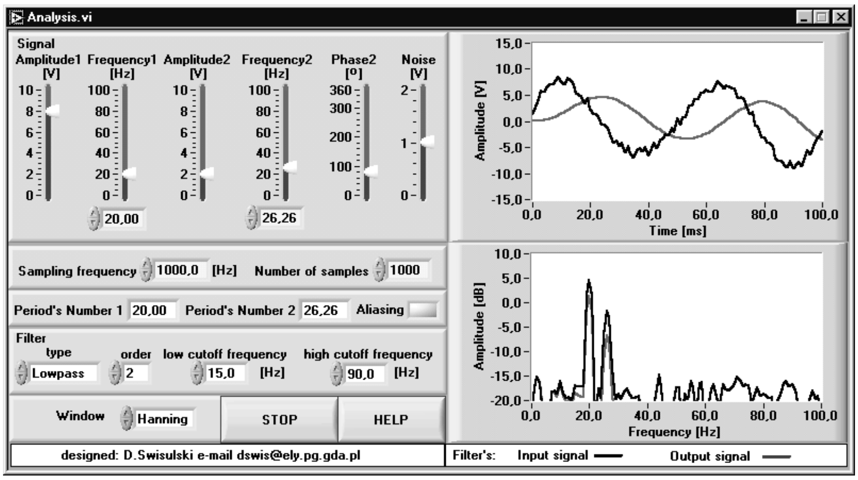

Fig. 6. Dynamic signal analysis using Hanning Window

4. CONCLUSIONS

Basing on our previous experience it is necessary to underline that created by our team teaching and learning instruments have very positive influence on educational process of electrical measurements and instrumentations.

The lectures with demonstration virtual instruments are:

- More interesting from the students' point of view,
- More approachable, as many theorem are at once accompanied by experiments which enable keep them better in mind.

Moreover:

- Possibility of using demonstration virtual instruments at home enable better understanding lectured theory and better preparations to final exams.

Laboratory virtual instruments using as training instruments or training stands offer to students:

- Possibility of good preparations to laboratory tasks realised in the university laboratories,
- Possibility of foreseen any problem which can occurs during the measuring session,
- Acquirement in manipulation with complicated instruments, it is very important advantage for the students which have first contact with measuring instruments and measuring circuits.

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