SOME VIRTUAL INSTRUMENTS OF USE IN ANALYSIS, SYNTHESIS AND PROCESSING OF SIGNALS

EUGENIE POSDĂRĂSCU

BUCHAREST "HYPERION" UNIVERSITY ,
ELECTRONICS AND COMPUTERS FACULTY,
eugenie@pcnet.ro , eposdarascu@yahoo.com

Abstract

Modern measuring systems that use acquisitions boards are systems with informational hardware structure which presents the maximum flexibility and efficiency. The using of the virtual instruments represents a new stage in the signals measuring technique , a modern solution to replace the old hand devices or even another measuring physical instruments with software products named virtual modulus or virtual instruments (IV). These have the advantage that can assure a large flexibility and assurance for a multitude of technical applications.

This paper comes to help the electronics laboratories that are specialized on signals processing, measuring and acquisition. The utilization of the LabView programming medium based virtual instrumentation supports the synthesis and analysis problems approach of one and multi dimensional signals. The mathematical models used for these problems appeals at Fourier representation and analysis of signals. A good example is the multisensorial systems performances' evaluation using the study of proceeded signals of these. In order to be implemented the analysis procedure it was designed and presented some virtual synthesizers (virtual instruments) similar with the laboratory electronics apparatus which are able to generate these signals . On their base it followed the implementation of some software modules which are necessary to accomplish signals acquisition. A complete instrument for signals synthesis and analysis is "AnSpec.vi" virtual module.

1. INTRODUCTION

The signals theory remains one of the most interesting and attractive science of the XXI century beginning in the conditions the technical-scientific progress has a spectacular upsurge. The measuring and studying kind of signals also progressed once the appearance of the software control and digital electronics apparatus.

Now, the virtual instrumentation represents a new stage in the signals' measuring technique, a modern solution to replace the old hand devices or even other measuring physical instruments with software products that named virtual modulus or instruments. Practice, the virtual instruments represent any software and/or hardware interface added to a computer such as the user can interact with these alike the interaction with the measuring traditional apparatus. These have the advantage that can assure a large flexibility, assurance and reliability for a multitude of the technical applications of laboratory or industry. A most important application of virtual instrumentation is represented by using a computer in the signals' processing, measuring and acquisition from various sources.

The implementation of some signals analysis procedures supposes firstly to make their synthesis simulation using pre-established characteristics and so, it can validate those procedures. So, it is important to design some virtual synthesizers and analyzers of signals similar with the laboratory electronics apparatus which are able to generate these signals or to analyze their structure. For the synthesizers and analyzers accomplishment it is very important that the functions generators to perform the functions systems $\{f_n(t)\}$ with more accuracy.

2. SIGNALS SYNTHESIS

To make signals' Fourier synthesis signify to perform a wished signal x(t) starting from a orthogonal functions systems $\{f_n(t)\}$, weighted with any coefficients. The formula that reproduces the signal is given by harmonic expansion with functions systems as base. The instrument which makes this operation we will name signal synthesizer. This instrument can be made physical with hardware components or by programming using the software components as a virtual instrument. This IV has at input an orthogonal functions generator and the Fourier series' coefficients in accordance with generated functions and, also, at output the whished signal with a better approximation. The generalized Fourier series (GFS) of a signal can be the starting point for the construction of the signal synthesizer. In the fig. 1 it is presented the fundamental diagram of a signal synthesizer.

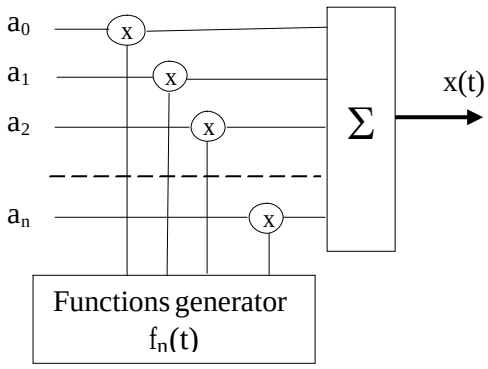

Fig. 1 Signal synthesizer – Fundamental Diagram

The processing software programs' evolution has determined that the virtual instruments' use to constitute a more practical modality for this problem's solving. With virtual instruments special created as signal synthesizers, it can accomplish both the synthesis of a captured signal window and the synthesis's simulation.

Using software programming the signals' synthesis follows: the elaboration of signals starting from the harmonic expansion of the periodical signals, the influence's study of the harmonicas number and the study of the signals various forms (square, triangular, etc.).

To perform a virtual instrument, this must be described using a mathematical relation or expression and, then, to build the instrument with the help of the calculus structures or the graphics symbols.

3. SIGNALS ANALYSIS

Lets to considerate a determinist signal x(t) with a finite support that represents the phenomenal state at a moment t. This signal respects the measurability and finite energy conditions. Such signals are described using the harmonic expansion (GFS).

To analyze a known signal x(t) it must determinate the Fourier series' coefficients of this. The instrument that makes this operation is named signal analyzer. As well as the signals synthesizer, this can be made physical with hardware components or by programming with software components as a virtual instrument. This IV has at input the signal to be analyzed and with the help of one orthogonal functions' generator it gives at output the Fourier series coefficients in accord with generated functions. The fig. 2 presents the fundamental diagram of a signal analyzer. The terms number of Fourier series is limited both in this diagram and in the calculus regarding the signals analysis. It is wished this limiting to lead at controllable approximation errors. Using GFS, the control of root-mean square error is assured.

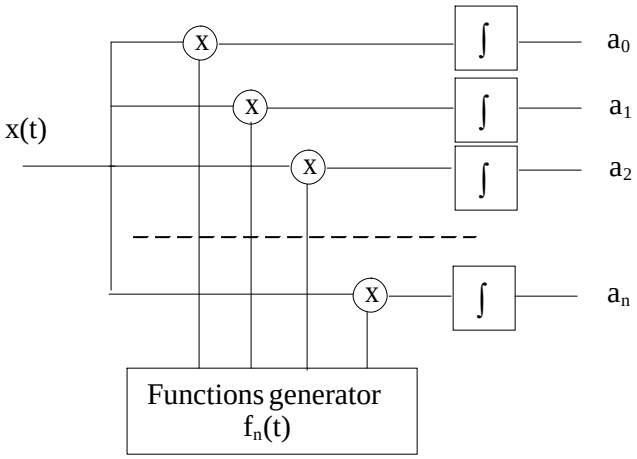

Fig.2 Signal analyzer – Fundamental Diagram

The spectral analysis of the signals has purpose to calculate the discreet Fourier transform and her use for a known signal in the influence's study of periods number and samples number and in the accuracy's evaluation at the frequency spectrum level. Because the signal's synthesis was made starting from the coefficients of the adequate Fourier series, a complete analysis will be made after these are determined from the spectral' representation of the signal and, then, they are compared with starting ones.

The analysed signals can be periodical or no periodical. For more eloquent analysis it will be studied the case some periodical signals, of period T_0, which is limited by a temporal window of duration D. The signal is sampled in N points with a sampling frequency expressed by the sampling ration $F_e = r = N/D$.

Generally they are used 5 temporal numerical windows of duration D, consist of N samples, which permit obtaining of one numerical signal y(t) (that is formed from the samples y_k) starting from the signal x(t) (that is formed from the samples x_k):

- Natural window - *P(k)*;
- Triangularly window – *Tri(k)*;
- Hanning window – *Han(k)*;
- Hamming window – *Ham(k)*;
- Blackman window – *Black(k)*.

4. THE MATEMATICAL MODEL FOR SIGNALS ANALYSIS AND SYNTHESIS

The most convenient representation used in the signals' synthesis of finite energy is represented by the generalized Fourier series (GFS) given the harmonic expansion:

$$x(t) = \sum_n a_n \cdot f_n(t), \qquad (1)$$

where $f_n(t) : \Re \to C$, $f_n(t) \in L_2$, are the orthogonal functions that belongs of one multitude M_x that forms an orthogonal and total system on an interval $\Im_t = [t_1, t_2]$.

A sampled signal x(t), with period $T_e = \frac{1}{r}$, on a duration D, will be consist of N terms, being described by:

$$x_{e,D} = \sum_{k=0}^{N-1} x_k \delta(t - kT_e) \qquad (2)$$

where $x_k = x(kT_e)$ represents the k order sampling.

Discrete Fourier transformer of a signal given of N samplings is a series of N terms described by:

$$X_{e,F} = \sum_{m=0}^{N-1} X_m \delta(f - m\frac{F_e}{N}) \qquad (3)$$

where $X_m = \sum_{k=0}^{N-1} x_k \exp(-j2\pi \frac{km}{N})$.

5. SOFTWARE IMPLEMENTATION

In order to perform the virtual devices of use in synthesis and analysis of the signal used LabView programming medium. This program is useful not only in real measurings, but also in various other projects like testings and simulations projects.

The "SFA.vi" and "GS3C.vi" virtual instruments (fig.3) are two examples of programs used for the synthesis' simulation of signal that have the purpose to generate the test signals of square, triangular and sinusoidal type. The periodical signals' synthesis is performed on duration of 2 periods, for 100 of samples/period. The Block Diagram window of the two IV uses other two subVI for the coefficients calculus and the functions generator.

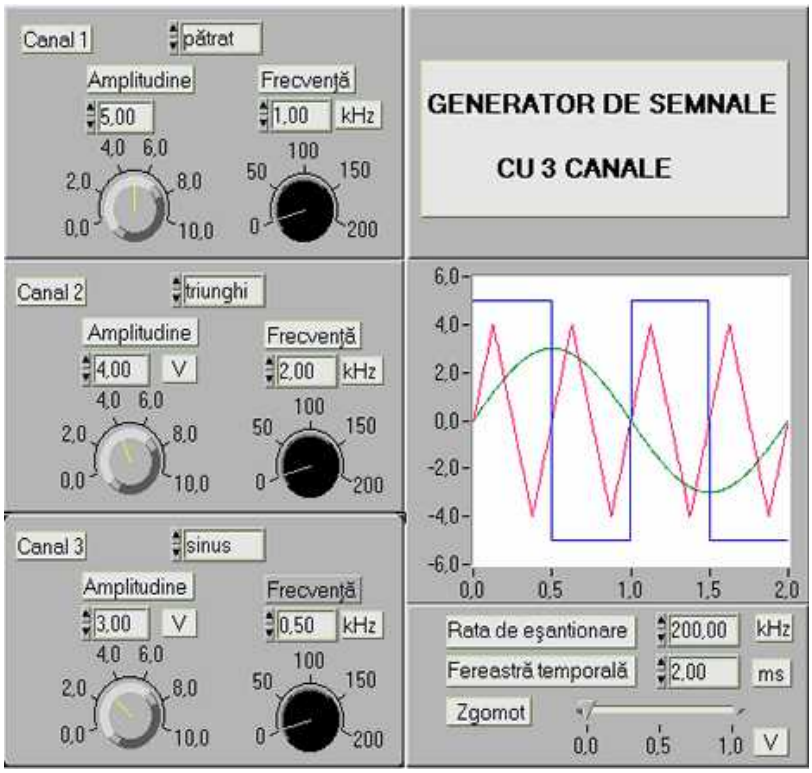

Fig.3 Signal synthesizer with 3 canals – GS3C.vi

If it wants to obtain derivate or integrated signals, then a virtual modulus "SDI.vi" can be attached to the signal synthesizers.

The spectral analysis program begins with the synthesis of a signal or more signals and it follows with the calculus of the Fourier transform for each signal, the calculus of the modulus and the assigning of the frequency spectrum that is represented with the help of one virtual oscilloscope on the front panel. Another block will recalculate the coefficients of the Fourier series of the synthesized signals.

The elaborated program (see fig. 4) in order to perform the spectral analysis of the signals that come from the multisensorial systems is based on the signal synthesizer “SFA.vi”. At its output a block “Ferestre temporale.vi” is connected. This block will modify the input signal depending on the selected temporal window. For this, the virtual instrument “Ferestre temporale.vi” 10 type windows are specified.

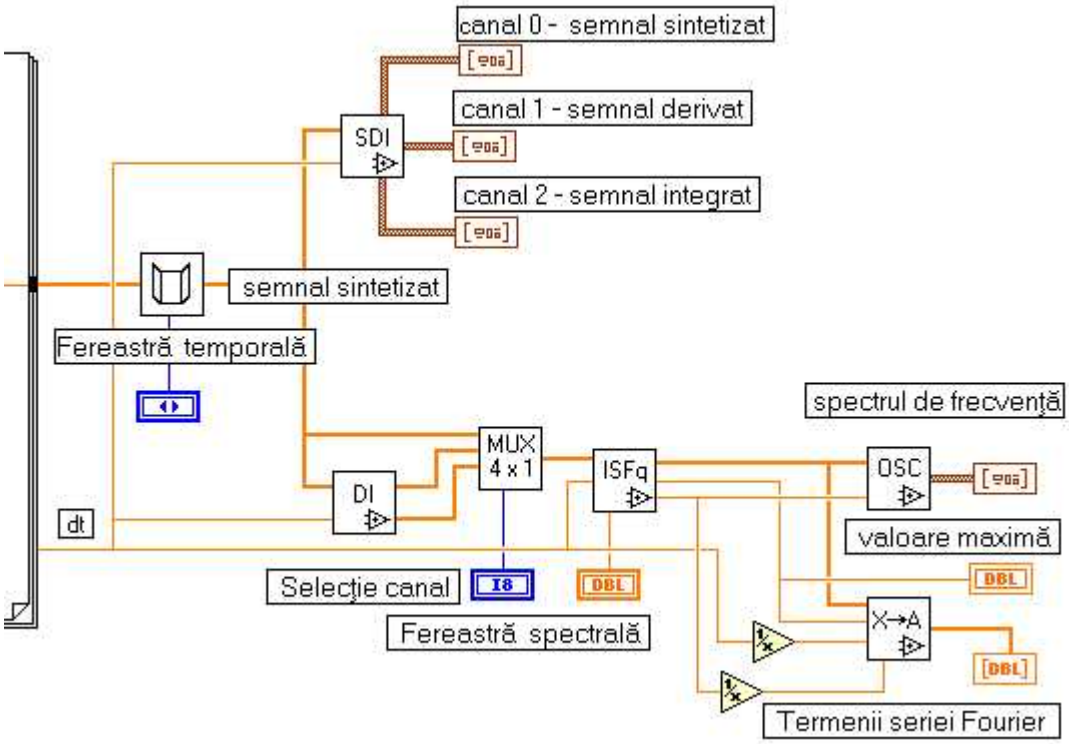

Fig. 4 The software structure of the instrument “AnSpec.vi” useful in signal’s synthesis and analysis

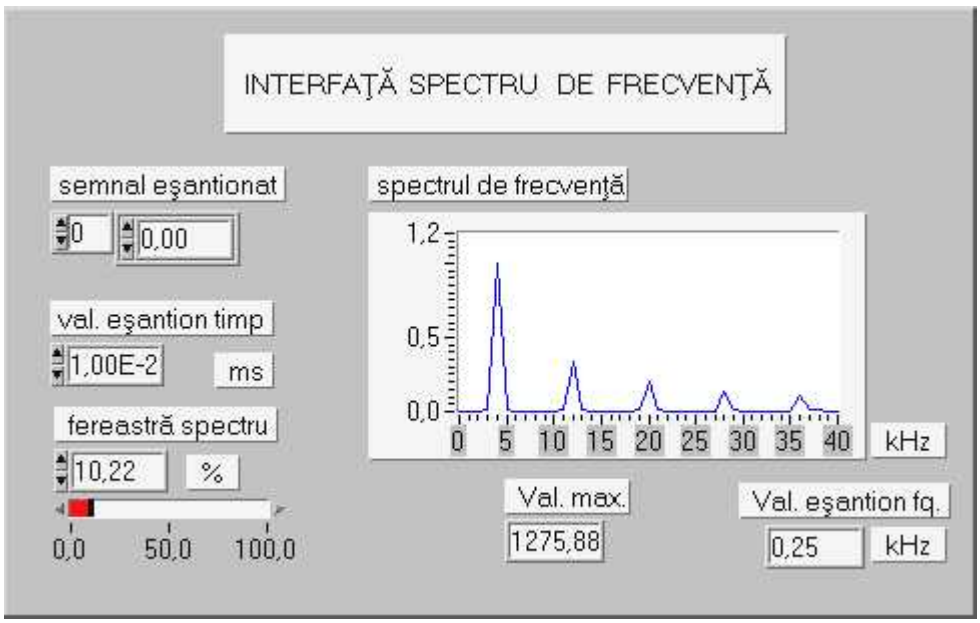

Fig. 5 The front panel for the frequency spectrum interface given of the instrument “ISFq.vi”

5. RESULTS AND CONCLUSION

In conclusion, the advantage of using the LabView medium in a multitude of application of the signals theory consist of the rapidity and the facility which can performed the various virtual devices by the implementation some functions and characteristics that to be easy modifiable, sometimes even during the simulation. Use of the LabView programming medium lead to:

- decreasing of the designing period of a physical system;
- a better operating to take some adequate decisions regarding the kind of hardware implementation of this;
- an efficient control of a measuring process and of this hardware and software components;
- a bigger work speed;
- the availability and adaptability for other measurement types.

Also, the practical performing of electronics devices or the measuring systems can be preceded by the performing and the check by the simulation of other same virtual instruments. The last ones can replace with success the first ones.

The obtained results in this paper are very useful in the signals synthesis and analysis both in the laboratory applications and in the various technical applications. We will be mentioned some instruments used in these applications, as follows:

- virtual instruments and virtual electronics devices needed by synthesis of signals which provide from the acquisition equipments (for example: the signal generator "SFA.vi", the signals generator "GS3C.vi", the derivation-integration modulus "SDI.vi", etc);
- virtual instruments and virtual electronics devices needed to accomplish the spectral analysis of the determinist signals and the structure analysis of the non determinist signals (for example: "Ferestre temporale.vi", multiplexer "MUX 4x1.vi", numerical-binary converter "Sel 3.vi", the calculus module of the frequency spectrum "ISFq.vi", the visualisation interface "OSC1C.vi", the virtual device for the signals synthesis and analysis "AnSpec.vi", the analyzers for the structure signals "Analiză structură.vi" and "Statistică.vi", etc.) .

REFERENCES

[1] *** - *LabView Analysis Reference Manual* , Edition Part No. 320541-01, 1993;

[2] *** - *NI-DAQ Function Reference Manual for PC Compatibles* , Edition Part No. 320499B-01, sept.1994.

[3] Mateescu, A., - *Semnale, Circuite şi Sisteme* , Editura didactică şi pedagogică, Bucureşti, 1984;

[4] Frank., R., – *Understanding Smart Sensors* - second edition , Artech House INC., Boston, London 2000;

[5] Garett, P. H., - *Advanced Instrumentation and Com puter I/O Design: Real* - Time System Computer Interface Engineering, The Institute of Electrical and Electronics Engineers, Inc., New York – 1994;

[6] Posdărăscu, E., - *Contribution regarding signals' acquisition from multisenzorial systems* , doctorate's paper, mars 2003, Politehnica University of Bucharest, Romania.