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# GENERATOR OF ACTUATING SIGNAL FOR LINEAR PNEUMATIC DRIVES

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Abstract: The presented paper deals with application Visual Signal Generator/2, which is focused to generation of actuating signals for control of pneumatics linear units. There is insinuate way of operations with generator inclusive of way of using generated data in environment LabVIEW from National Instruments. There are described equations of implemented actuating signals.

Keywords: signal, generator, sampling, visualisation

## 1 INTRODUCTION

Besides the control algorithm, the generator of the actuating signal for positional and velocity control is needed. The generator generates the desired value, which can change its value in time. The actuating signal describes way of the change of the position or velocity of the motion piston of the pneumatic drive.

Commonly available applications for automatic control contains the signal generator, but often did not meet all requirements of users. Especially it is, for example, comfort of work, number of signals and their combinations.

Therefore the author of the presented paper decided to produce own generator. During development process, simple operation and flexibility of application was taken into account. Next it was remembered possibility of generator accompanying by absent kind of signal.

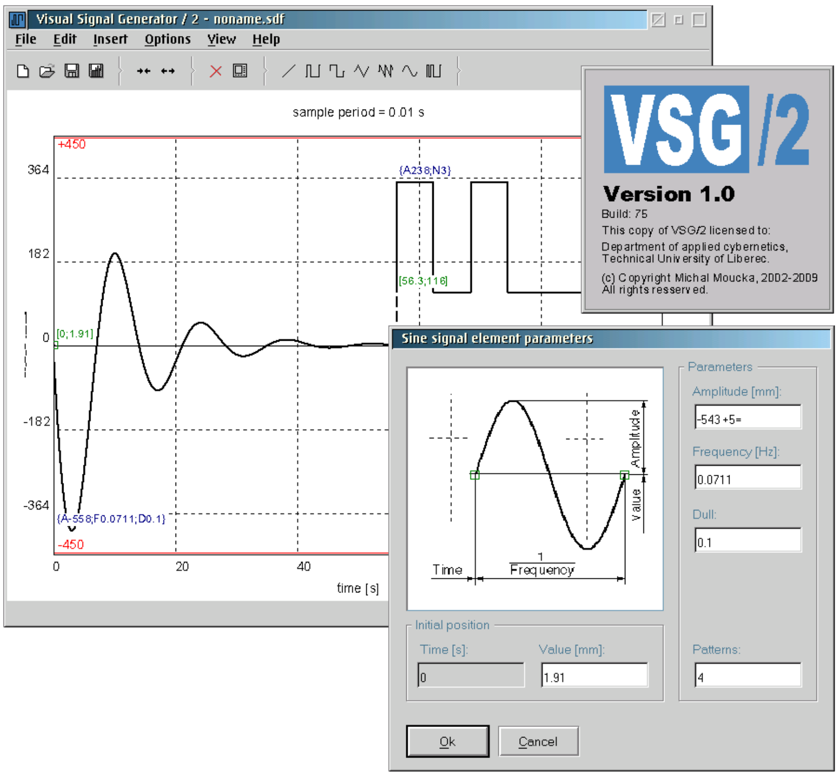


Fig. 1 – Visual Signal Generator/2

The signal generator was developed in C language as Open32 application. Strictly speaking, it is application, which can be used with operation system Microsoft Windows 2000 or IBM OS/2 4.0 or alternatively on their new versions. The generator was named as Visual Signal Generator/2 because it was designed as a visual. The Visual Signal Generator is shown in the figure 1 .

The library of functions for operations with generated signal was also implemented for LabVIEW development environment

## 2 GENERATOR REVIEW

The philosophy of work with Visual Signal Generator /2 consists in definition of course of actuating signal from basic shape elements. The group of the elements includes line, pulse, rectangular, triangle, sawtooth, sinus and two points pseudo-random binary signal shape.

The elementary shapes can be flexibly inserted or deleted. The shape of elements can be formed by mouse or it is possible to exactly enter concrete parameters in dialogue window, if it is necessary. A small calculator is implemented in all enter fields for simply work of application users. The equations can be written directly into the enter field. The press of the button “=” cases computation. The automatic limiter of the extreme of the defined signal is also implemented to the generator. The limit values are set in relevant dialogue window.

At the end, the final defined signal can be sampled with user freely selected sample frequency, respective sample period.

Both the sampled signal (in two formats) and the signal definition for next usage by application user can be saved to the file.

## 3 TYPES OF SUPPORTED SIGNALS

Following equations describe the course of implemented elementary shapes.

a) Line shape

The form of the line shape is described by the known equation

$$u(t)=\frac{A}{T}(t-t_0)+u_0 \quad , \qquad (1)$$

where $t_0$ is the initial time and $u_0$ is the initial value $u$ of the sampled signal. Parameter $A$ is the change of the signal in time $t_0 + T$ from value $u_0$. For illustration you can see the figure 2.

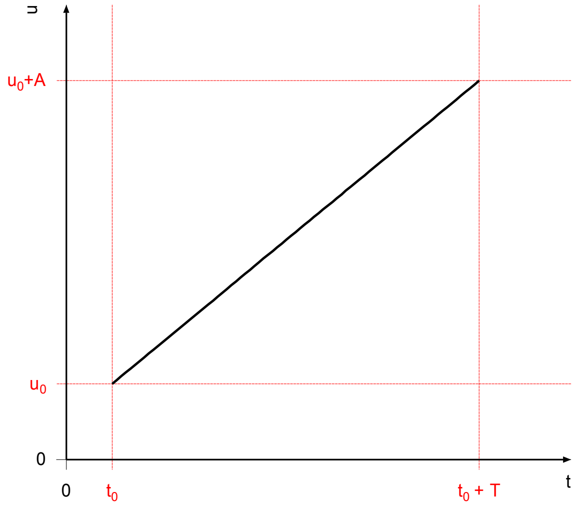


Fig. 2 - Line shape

b) Rectangular shape

By using of Fourier series the equation which describes square shape can be written. The sum of the all terms of the series is given by equation

$$u(t) = \frac{4A}{\pi}\sum_{k=1}^{\infty}\frac{\sin((2k-1)2\pi f(t-t_0))}{(2k-1)}+u_0 \quad . \qquad (2)$$

The $f$ in the equation is the frequency of the repeating of the shape. Rectangular shape is shown in the figure 3.

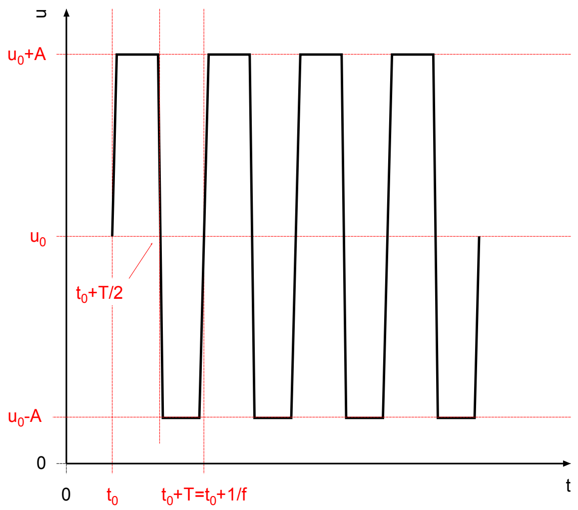


Fig. 3 - Rectangular shape

c) Triangle shape

The similarly as equation (2), triangle shape (figure 4) can be described by using of Fourier series according to the formula

$$u(t) = \frac{8A}{\pi^2}\sum_{k=1}^{\infty}\sin\left(\frac{k\pi}{2}\right)\frac{\sin(2\pi k f(t-t_0))}{k^2}+u_0 \qquad (3)$$

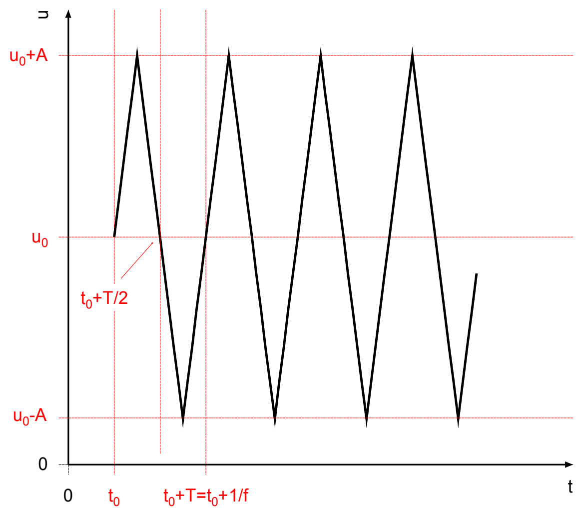


Fig. 4 - Triangle shape

e) Sawtooth signal

The sawtooth shape is described by the equation

$$u(t)=\pm A\frac{2}{\pi}\sum_{k=0}^{\infty}\frac{\sin(2\pi k f(t-t_0))}{k}+u_0 \quad , \qquad (4)$$

where $b$ is the dumping coefficient. The sawtooth elementary shape is shown in the figure 5.

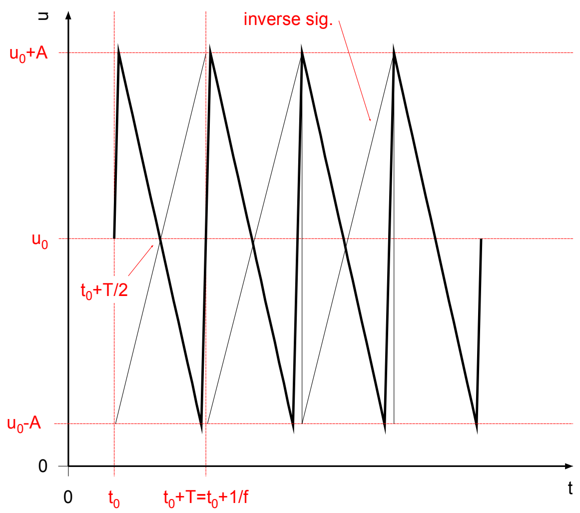


Fig. 5 - Sawtooth shape

f) Sine signal

The sine shape is described by the equation

$$u(t)=A e^{-b(t-t_0)}\sin(2\pi f(t-t_0))+u_0 \quad , \qquad (5)$$

where $b$ is the dumping coefficient.

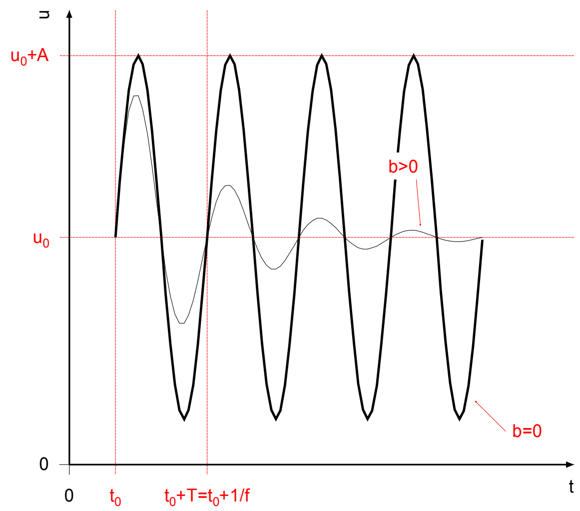


Fig. 6 - Sine shape

g) Pseudo random binary signal

The pseudo-random binary signal (PRBS) has value 0 or amplitude $A$. The PRBS shape is described by the equation

$$u(k)=A\left(c_1 u(k-1)\oplus\ldots\oplus c_2 u(k-n)\right)+u_0 \quad , \qquad (6)$$

where $k$ is the step, an $\oplus$ is the operator *mod2*. For operator *mod2* these operations are valid

$$0\oplus 1=1\oplus 0=1 \quad , \qquad 0\oplus 0=1\oplus 1=0 \quad .$$

The coefficients $c_1$ to $c_n$ are selected for concrete order $n$ from this table

| ***n*** | **09876543210** |
|---|---|
| 3 | 1011 |
| 4 | 10011 |
| 5 | 100101 |
| 6 | 1000011 |
| 7 | 10000011 |
| 8 | 1000010001 |
| 9 | 10000001001 |
| 10 | 10000001001 |

The PRBS shape is shown in the figure 7.

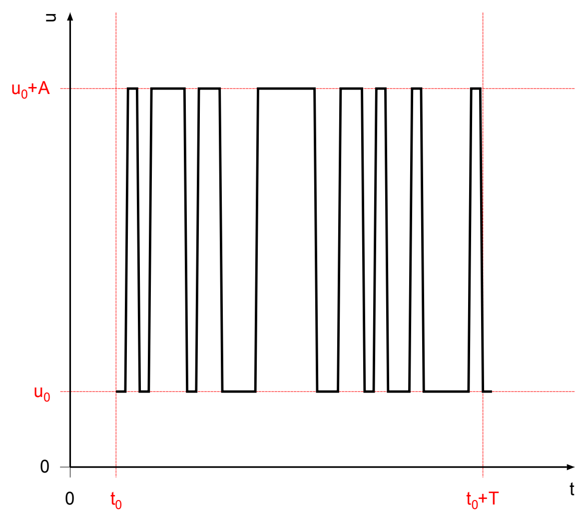


Fig. 7 - Pseudo-random binary shape

## 4 LABVIEW LIBRARY

The sampled data are used by author in control applications. Especially, it is application for control of position and velocity of piston of pneumatic linear units. The applications are developed in programming environment LabVIEW. A small library of functions was developed for easy utilisation of sampled data in LabVIEW applications. The library was developed in programming language C. The library includes only two functions. The first function is GetFileName (GFN) function for obtaining name of the file, which contains sampled data. The second function is GetSampleFrom1DTFile (1DT) function for data reading. It is necessary to say that function GetSampleFrom1DTFile returns only one sample per question. In the next figures there is shown connection of individual pins of mentioned functions.

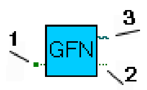


Fig. 8a - Function GFN

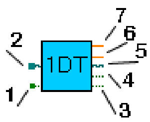


Fig. 8b - Function 1DT

The connection plan of the function GetFileName is shown in the figure 8a. The dialogue window for file name selection is activated by TRUE value on pin 1. The success of operation of function are signalised by pin 2. The value on pin 2 is FALSE in case of error. The name of selected data file is available on pin 3.

The connection plan of the function GetSampleFrom1DTFile is shown in the figure 8b. The function of reading is activated by TRUE value on pin 1. It means that samples are gradually obtained from data file, which name is lead on pin 2. The samples are on pin 7. The sign of the end of the file is possible to determine on pin 4. It the case of the end of file it returns value FALSE. The name of opened file is on pin 5. Sample period of signal is on pin 6. Pin 3 returns the value which is on pin 1.

Example of practical connection of library function is shown in the figure 9. This application illustrates reading of individual samples of signal from selected data file. The samples are consecutively display in a time chart. It is obvious from the front panel of application, see figure 10.

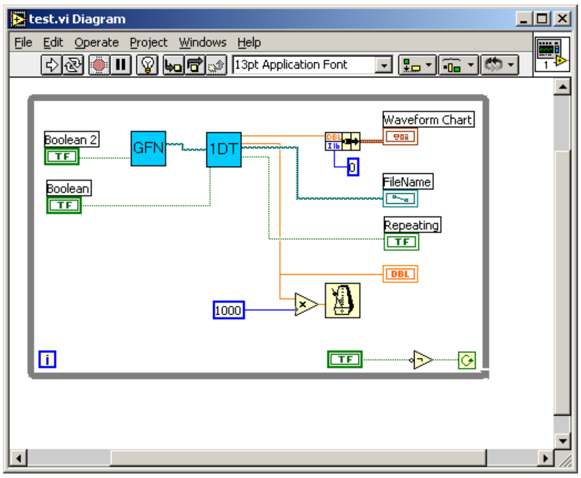


Fig. 9 – Programme of application using library

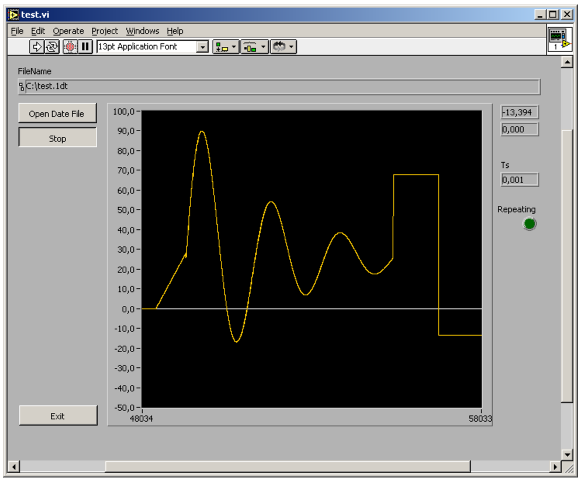


Fig. 10 – LabVIEW application

## 5 CONCLUSION

In this paper it was described application for generation of actuating data. There was also presented a library for operations with sample data. This library is designed for programming environment LabVIEW by National Instruments. In this time, addition Visual Signal Generator/2 with other shapes as parabolic and three-positional pseudo-random signal is planned.

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## REFERENCES

Rektorys, K. (1995). *Přehled užité matematiky, díl 1.* Nakladatelství Prométheus. Praha.