

Building A Transient Disturbances Generator With Graphical User Interface in Matlab

Gabriel Gășpăresc¹, Ciprian Dughir¹

Abstract – This paper describes an implementation method of a transient disturbances generator with graphical user interface in Matlab environment, using an integrated codec or a sound card, the advantages and the disadvantages of this solution, in the actual context of increasing of the interest for ensure power quality and disturbances study which can affect it.

Keywords: transient disturbances, sound card, graphical user interface, power supply quality, electromagnetic compatibility.

I. INTRODUCTION

Transient disturbances represent an important category of disturbances which may affect the quality of electrical energy supply; the last decades were marked by an unprecedented development of electronics and telecommunications, there appeared devices and equipments more sensible to the power quality disturbances and there have increased the electromagnetic compatibility problems [3].

Signal generators are used in the field of electromagnetic compatibility at the immunity/susceptibility equipment tests. The signals of biexponential impulse and amortized sinus are obtained using RC or RLC circuits. The parameters of the test signals are standardized by regulation, for impulses the rise time can be under 1 ns and the required amplitudes are in the range of KV/KA, values hard to obtain [3].

At present most of computer mainboards have integrated codecs or sound card which contain analog-to-digital converters (ADC), respectively digital-to-analog converters (DAC), these operate at maximal sampling frequencies of 44100 Hz or 96000 Hz. These may be used as a cheaper alternative (probably the cheapest) at the acquisition boards used at the numeric processing of signals; the disadvantages are regarding the sampling frequency and the dynamical range of the more reduced input and output signals, but may be used successfully for didactic purposes, inclusively for the generating of transient disturbances with the help of a software application.

The Matlab environment, dedicated to the performing of numeric calculations, graphic representations and the programming in technique grants the access to and the configuring of the resources of the sound codec of the sound card or of the codec integrated on the computer mainboard. These may be used as an acquisition board, and by the building of a friendly interactive graphic interface with the user can be achieved an interactive control of the program execution, depending upon the data registered by the user, using the object oriented programming.

II. TRANSIENT DISTURBANCES

The transient disturbances represent quick variations of the voltage, current or of both and may be of two kinds, impulsive and oscillatory transient. The first category has exponential rise and falling fronts and is characterized by amplitude, rise time (the period in which the signal varies from 10% to 90% from its amplitude) and duration (time period for which the signal is greater than ½ from its amplitude) [3], and in order to generate a biexponential impulse (fig. 1a) there may be used a formula of the kind of the one shown below

$$s(t) = at^b e^{-ct} \quad (1)$$

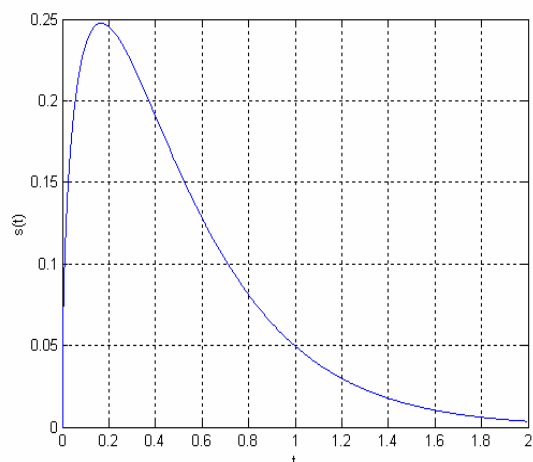
where the parameters a, b and c allow the regulating of the amplitude, of the rise time and the impulse duration. The second category is characterized by the rise time according to the first peak and frequency, and further we have a division into 4 sub-categories: high frequency (>500 KHz), average frequency (5-500 KHz), low frequency (0,3-5 KHz) and very low frequency (<300 Hz) [1], and such a signal may be obtained by multiplying a biexponential impulse (obtained by using the formula (1)) with a sinusoidal signal (fig. 1b) described by the formula (2)

$$s_s(t) = A \sin(2\pi ft + phase_i) \quad (2)$$

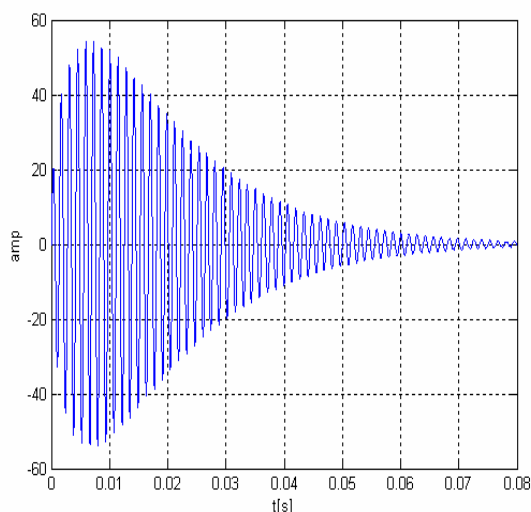
¹ Facultatea de Electronică și Telecomunicații, Departamentul Măsurări și Electronică Optică, Bd. V. Pârvan Nr. 2, Timișoara 300223, e-mail: gabriel.gasparesc@etc.upt.ro ; ciprian.dughir@etc.upt.ro .

where A is the amplitude, f the frequency and $phase_i$ the initial phase.

Typical causes that lead to the producing of the transient disturbances are: thunder and lightning, short-circuits, burning of fuses, connecting and disconnecting of some consumers, connecting of the condenser batteries.



a) impulsive transient



b) oscillatory transient

Fig. 1. Transient disturbances

III. INTERFACE TO THE USER AND EXPERIMENTAL RESULTS

The control of the program running is achieved by an interactive graphical interface (GUI – Graphical User Interface) based on programming object oriented, where the running of the commands chosen by the user is achieved by the selecting of the meant interface elements with the mouse. For an easy using it is important that at the GUI design, to be considered some principles: simplicity (using of the strict necessary elements), coherence (for various applications to use the same moods of placing the interface elements facilitates the passing from one to

the other) and familiarity (the use of some suggestive elements grants a more quicker learning of the using) [5].

The right part of the interface (fig. 2) has five areas with suggestive labels, the first in the upper part for inserting the parameters of the sinusoidal signal (amplitude, frequency, sampling frequency, whose maximum value is of 44100 Hz, number of desired periods), over which may be overlapped a transient disturbance, the second for transient impulse (characterized by the constants a , b , c from the formula (1)), the third for oscillatory transient (where the amplitude and frequency are specified), the fourth for selecting the desired output signal (undisturbed sinusoidal, disturbed sinusoidal with impulsive or oscillatory transient), where if the signal amplitude is higher than in module than 1, a normalization is achieved, the range of the output voltages at the sound card being of $[-1V, 1V]$. The last zone allows the starting/stopping of the sound card and the closing of the program. The left side allows the visualizing of the output signal wave shape.

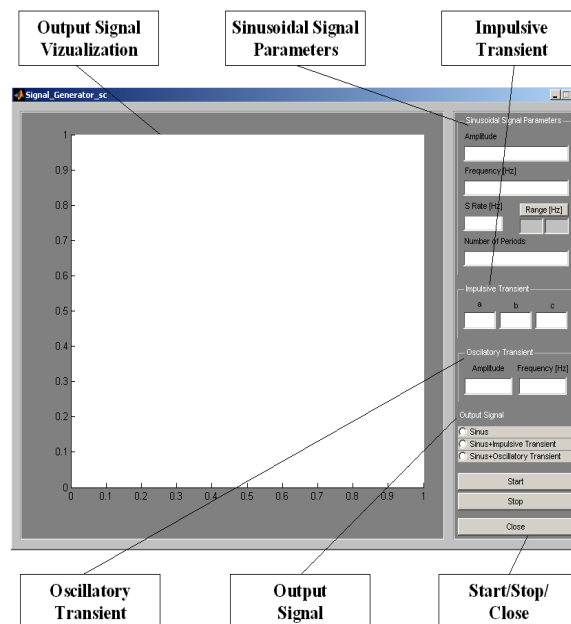


FIG. 2 Graphical user interface

The application structure is modular, between the functions corresponding to the elements of the graphic interface are transmitted the parameters inserted by the user for the generating of the desired output signal, at the activating of the sound board after setting the sampling frequency of the codec. Its value is chosen in the interval supported by the hardware, the minimum value being of 8000 Hz for most of the sound boards, and the maximum value of 44100 Hz or 96000 Hz at the more recent performance boards. Using the Range button of the interface, the minimal and maximal value of the supported sampling frequency will be displayed. At the choosing of this value there must be also considered the frequency of the generated sinusoidal signal, in order to observe the

sampling theorem [4], and to be able to rebuilt the signal from its samples (3)

$$T \leq \frac{1}{2f_m} \quad (3)$$

where T is the sampling period, and f_m the maximum frequency from the range of the signal spectrum to be sampled.

If we choose a value of 44100 Hz for the sampling frequency, that means that each second at the output are produced 44100 samples, meaning an important amount of samples that need a suitable memory volume, so that in order to use less memory, it is more convenient to choose a reduced amount of periods for the output signal, that are generated and produced repeatedly at the audio output in the desired time period (using the Start and Stop buttons), than to generate a signal of desired duration with a high amount of periods to be memorized and afterwards to be produced at the output.

The next table presents the necessary memory volume (*Memory*) in order to produce a signal of a frequency of 50 Hz at the audio output, regarding the sampling frequency (F_s) and the number of signal periods (*NP*). We can see that at the growing of the sampling frequency from 8000 Hz to 44100 Hz, when $NP=2$, the used memory volume grows 2.5 times, and for $F_s=44100$ and $NP=100$ in comparison with $F_s=8000$ and $NP=2$ the growth is 5.5 times. Continuing the remark from the previous paragraph, regarding the choosing of a lower amount of signal periods, for the reducing of the necessary memory volume, there may be also used a lower sampling frequency.

Table 1

F_s [Hz]	NP	Memory [B]
8000	2	16384
8000	100	32768
16000	2	20480
16000	100	65536
32000	2	40960
32000	100	131072
44100	2	40960
44100	100	180224

The experiments have been performed using a PC computer with a mainboard having an integrated audio codec, an analogical oscilloscope for visualizing the signals and a probe to link the audio output and the oscilloscope input (fig. 3).

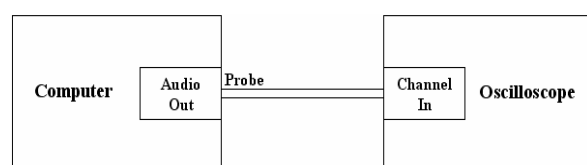
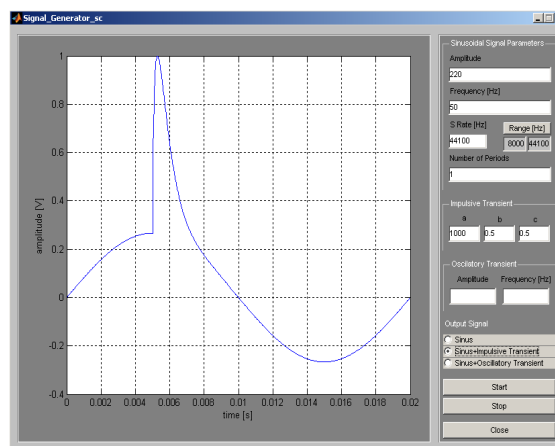
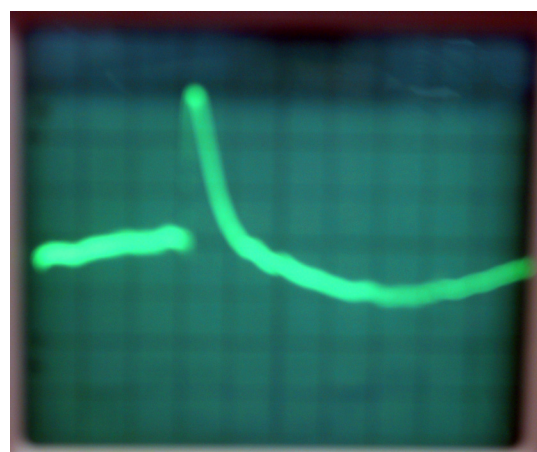


FIG. 3 Connection computer – oscilloscope

The signal from fig. 4 a) is obtained introducing for the sinusoidal signal the parameters amplitude, frequency, sampling frequency, number of periods, with values of 220, 50, 44100, 1. The parameters a, b, c of the biexponential impulse have the values 1000, 0.5, 0.5. Fig. 4 b) shows the signal obtained at the audio codec output after selecting a time base suitable for the visualization only of a period of the output signal, in order to distinguish the details of the wave shape.



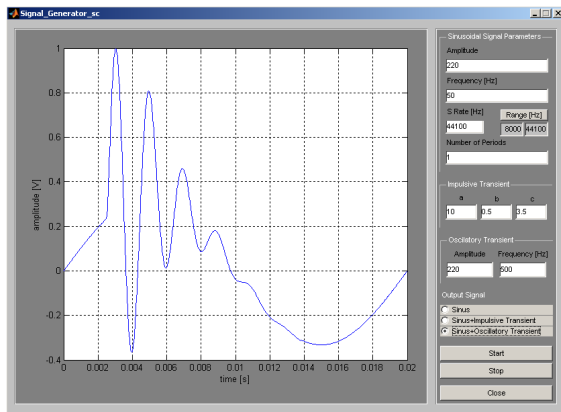
a)



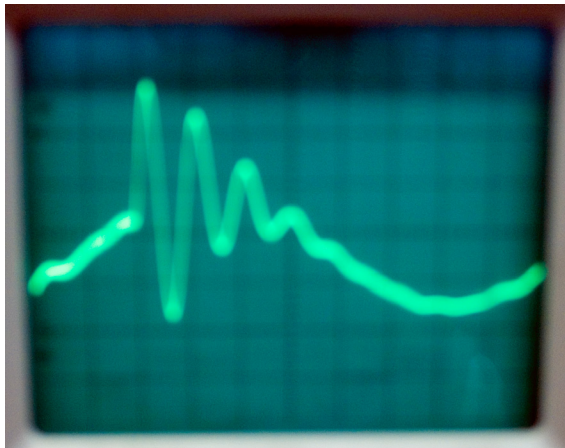
b)

FIG. 4 Generating of a disturbed sinusoidal signal with impulsive transient

Further, in order to obtain the signal from fig. 5 a), the parameters amplitude, frequency, sampling frequency, number of periods of the sinusoidal signal, upon which is overlapped the transitory disturbance, have the same values as at the previous output signal, the amortized sinus has the amplitude and the frequency with the values 220, 500, and the biexponential impulse has the parameters a, b, c with the values 10, 0.5, 3.5 and the signal obtained at the output of the audio codec is shown in fig. 5 b).



a)



b)

FIG. 5 Generating of a disturbed sinusoidal signal with oscillatory transient

IV. CONCLUSIONS

Using the Matlab environment and an audio codec integrated on the main board of a computer or a sound card, there may be achieved a transient disturbances generator, which allows the visualizing of the sinusoidal signals affected by such disturbances, at very low costs, that may be used at their study. The friendly interactive graphic interface allows the easy selecting of the parameters for the desired output signal, the selecting flexibility being restricted only by the input/output range limited at $[-1V, 1V]$ and by the maximum sampling frequency. In order to obtain signals with higher amplitudes there may be used an amplification circuit.

BIBLIOGRAPHY

- [1] M. Azam, F. Thu, K. R. Pattipati, R. Karanam, "A Dependency Model Based Approach for Identifying and Evaluating Power Quality Problems", *IEEE Transactions on Power Delivery*, vol. 19, No. 3, pg. 1154-1166, July, 2004.
- [2] G. Găspăresc, "Analiza wavelet a perturbațiilor tranzitorii de tip impuls biexponențial și sinus amortizat", sesiunea de comunicări științifice "Doctor ETC 2005", pg. 34-39.

- [3] A. Ignea, *Introducere în compatibilitatea electromagnetică*, Editura de Vest, Timișoara, 1998.
- [4] A. Mateescu, N. Dumitru, L. Stanciu, *Semnale și sisteme, aplicații în filtrarea semnalelor*, Editura Teora, București, 2001.
- [5] www.mathworks.com.