Contributions Concerning the Measurements using LabVIEW in Steady State Nonsinusoidal Regime

HORIA ANDREI
Faculty of Electrical Engineering
University Valahia Targoviste
18-20 Blv. Unirii, Targoviste, Dambovita
ROMANIA
COSTIN CEPISCA
Faculty of Electrical Engineering
University Politehnica Bucharest
313 Splaiul Independentei, sector 6, Bucharest
ROMANIA
FANICA SPINEI
Faculty of Electrical Engineering
University Politehnica Bucharest
313 Splaiul Independentei, sector 6, Bucharest
ROMANIA
SORIN DAN GRIGORESCU
Faculty of Electrical Engineering
University Politehnica Bucharest
313 Splaiul Independentei, sector 6, Bucharest
ROMANIA
NICOLAE JULA
Military Technical Academy, Bucharest
ROMANIA
VALENTIN DOGARU
Faculty of Electrical Engineering
University Valahia Targoviste
18-20 Blv. Unirii, Targoviste, Dambovita
ROMANIA

Abstract – **The present paper describes a real time measurement using a LabVIEW application concerns the nonsinusoidal regime at dipolar elements of the circuit. At a later stage, these measurements will be used to final out the energetic values of the nonsinusoidal regime and to improve the optimization of the electroenergetic systems. The results of the measurements have been originally processed in the Lab VIEW software.**

Keywords: – Nonsinusoidal regime, LabVIEW application, dipolar elements.

1 Introduction

In order to identify the nonsinusoidal regime, both the nonsinusoidal generator and the linear as well as nonlinear elements have been measured by using an application of the Lab VIEW software for virtual instrumentation. A data acquisition board NI 6023E has been connected to a PENTIUM III 750

MHz computer whose software is LabVIEW and driver software NI-DAQ under Windows 2000/NT/Me/9x. The NI 6023E board belongs to the Low Cost E series Multifunction DAQ which has high technical performances for a wide range of applications in the field of data acquisition: 200 Ks/s transfer speed, 12 bits resolution, 12 analogue entries [1, 2].

Using this application, the real time behavior has been measured for some dipolar circuit elements (inductance, capacitor) supplied by a nonsinusoidal voltage generator.

Such determinations try to establish the disturbing effects caused by the circuit elements under discussion, results which will be used to raise the efficiency of the energy supplied by the network.

In the end, there will be described some conclusions drown from the analysis of the obtained data.

2 LabVIEW measurements of the dipolar elements

In the electro energetic systems with harmonics pollution, the voltage generator are periodical and nonsinusoidal, being describes by the functions [3, 4, 5]:

$$u(t) = \sum_{k=0}^{n} U_k \sqrt{2} \sin(k\omega t + \alpha_k) = U \sum_{k=0}^{n} b_k \sqrt{2} \sin(k\omega t + \alpha_k) \tag{1}$$

where

$$b_k = \frac{U_k}{U} \tag{2}$$

are the relative values of the k harmonic of voltage which verify the relation:

$$\sum_{k=1}^{n} b_k^2 = 1, \tag{3}$$

the other notations being the usual ones.

The nonsinusoidal generator supplied linear and nonlinear elements of circuits (fig. 1). The measurement of the current and voltage harmonics for the nonsinusoidal generator and for each element of the circuit are made it using LabVIEW application.

A first data set is for generator measurements, which is to be seen in table 2. These are the values of the magnitudes and phases for the first 11 harmonics of the nonsinusoidal voltage, [6].

At the A and B nodes of this generator there have been connected in turn a capacitor with $C = 10\mu F$, and an inductance with magnetic core, with $R = 5{,}2\Omega$, and fundamental reactance $X_{L,1} = 254{,}62\Omega$. Using a LabVIEW application we measure the magnitudes and the phases of the current i(t) and of the voltage u(t), both of them nonsinusoidal., [7, 8, and 9] The nonsinusoidal current can by expressed by the relation:

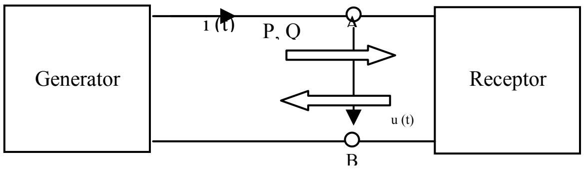

Figure 1. Receptor supplied by a nonsinusoidal voltage generator

Frequency (Hz)	Harmonics of voltage (U_k) (V)	Phase of harmonics α_k (grd)	Relative values (b_k)
50	238,6	0,62	0,9997
100	0,1	150	0,0004
150	3,89	70,8	0,0163
200	0,1	175	0,0004
250	1,52	182	0,0006
300	0,05	150	0,0002
350	3,17	46,2	0,0132
400	0,1	55	0,0004
450	2,50.	199,4	0,0104
500	0,1	240	0,0004
550	0,12	-14,63	0,0005

Table 2. The nonsinusoidal generator measurements

$$i(t) = \sum_{k=0}^{n} I_k \sqrt{2} \sin(k\omega t + \beta_k) = I \sum_{k=0}^{n} a_k \sqrt{2} \sin(k\omega t + \beta_k) \tag{4}$$

where

$$a_k = \frac{I_k}{I} \tag{5}$$

is the relative values of the k harmonic of current which verify the relation:

$$\sum_{k=1}^{n} a_k^2 = 1, \tag{6}$$

the other notations being the usual ones.

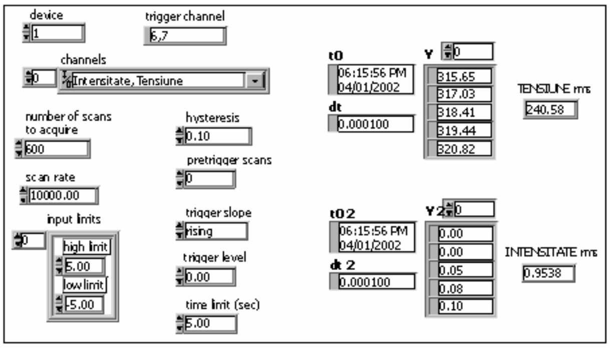
device: 1
trigger channel: 6,7
channels: 0 Intensitate, Tensiune
number of scans to acquire: 600
hysteresis: 0.10
pretrigger scans: 0
scan rate: 10000.00
input limits: 0
high limit: 5.00
low limit: -5.00
trigger slope: rising
trigger level: 0.00
time limit (sec): 5.00
t0: 06:15:56 PM 04/01/2002
dt: 0.000100
Y: 0
315.65
317.03
318.41
319.44
320.82
TENSIUNE rms: 240.58
t02: 06:15:56 PM 04/01/2002
dt 2: 0.000100
Y2: 0
0.00
0.00
0.05
0.08
0.10
INTENSITATE rms: 0.9538

Figure 3. The LabVIEW application for capacitor

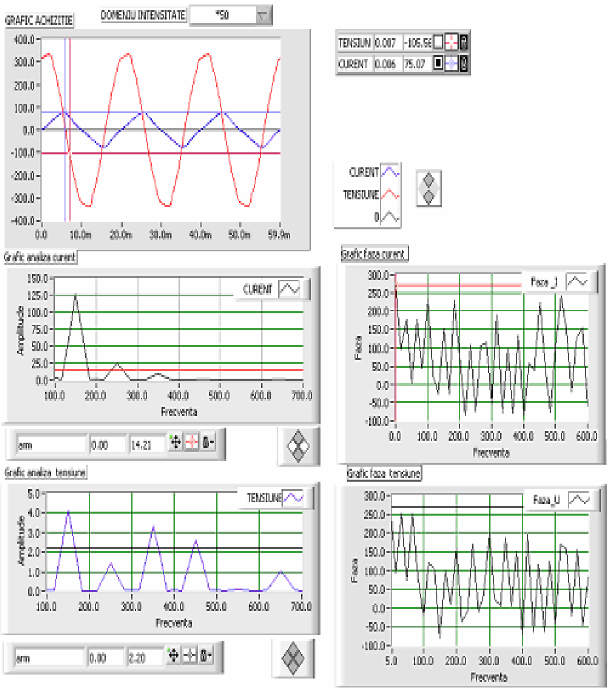

Figure 4, a, b, c, d, e. The characteristics of voltage and current for capacitor

By using the described LabVIEW application- for capacitor shown in figure 3 and for inductance shown in figure 5 - there have been determined: the simultaneous variation in time of the voltage and current at the poles of the capacitor (fig.4, a) and inductance (fig. 6, a), the amplitudes of the first 11 harmonics of the current and the voltage at the poles of the capacitor (fig.4, b, c) and inductance (fig. 6, b, c) as well as the phases of these harmonics, for each of the dipolar elements which have used, as seen respectively in figure 4, d, e and 6, d, e.

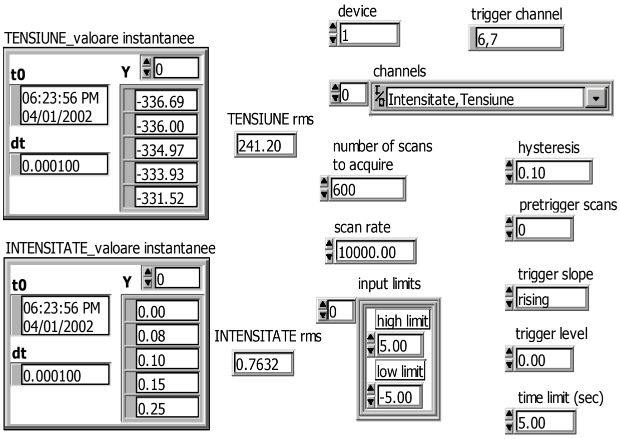
TENSIUNE_valoare instantanee
t0 06:23:56 PM 04/01/2002
dt 0.000100
Y 0
-336.69
-336.00
-334.97
-333.93
-331.52
TENSIUNE rms 241.20
INTENSITATE_valoare instantanee
t0 06:23:56 PM 04/01/2002
dt 0.000100
Y 0
0.00
0.08
0.10
0.15
0.25
INTENSITATE rms 0.7632
device 1
trigger channel 6,7
channels 0 Intensitate,Tensiune
number of scans to acquire 600
hysteresis 0.10
pretrigger scans 0
scan rate 10000.00
input limits 0
high limit 5.00
low limit -5.00
trigger slope rising
trigger level 0.00
time limit (sec) 5.00

Figure 5. The LabVIEW application for inductance

The same Lab-VIEW application has helped to represents the magnitudes values, the relative values, and the phases of the harmonics of current and voltage for each receptor [10].

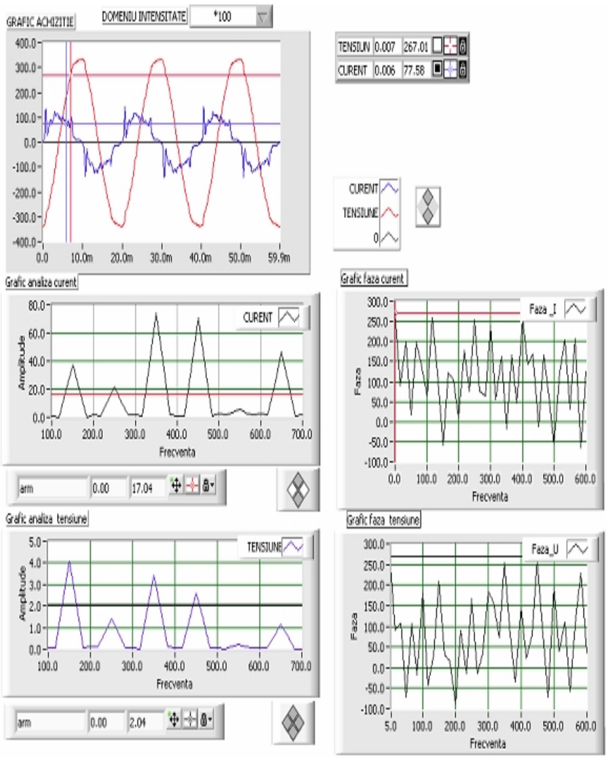

Figure 6, a, b, c, d, e. The characteristics of voltage and current for inductance

The measurements results for capacitor are shown in table 7. We observe the important values of the magnitudes and relative values of odd harmonics of current, which demonstrate the nonlinear behavior of capacitor [11]. For the even harmonics the values are very small. The nonlinear behavior the capacitor is also manifest in the phases difference between the voltage and current harmonics, it being close to 90^0 just for a few even values (50, 200, 250, 400 and 500 Hz).

Freq (Hz)	U_k (V)	α_k (grd)	b_k	I_k (mA)	β_k (grd)	a_k
50	241	-72	0,999	739,58	50,1	0,9692
100	0,05	175	0,0002	0,05	70	0,00006
150	4,1	210	0,0169	37,51	-59,4	0,0491
200	0,2	-80	0,0008	0,05	20	0,00006
250	1,42	167	0,0058	21,87	254	0,02866
300	0,1	180	0,0004	0,05	230	0,00006
350	3,43	254	0,0142	74,41	-17,5	0,09752
400	0,05	150	0,0002	0,05	250	0,00006
450	2,61	259	0,0108	2,61	-12,7	0,00342
500	0,05	200	0,0002	0,05	-55	0,00006
550	0,2	-57,3	0,0008	0,2	30	0,00026

Table 7. The magnitudes values, the relative values and the phases of the capacitor voltage and current harmonics

The measurement results for inductance are shown in table 8. We observe the important values of the magnitudes and relative values of odd harmonics of current, but smaller compared by the same values of capacitor, which prove that the nonlinear behavior of inductance in nonsinusoidal regime is smaller compared with the capacitor [12]. For the even harmonics, the values are very small. The same kind of observation is also true for the phase's difference entered by the inductance [13, 14],

Freq (Hz)	U_k (V)	α_k (grd)	b_k	I_k (mA)	β_k (grd)	a_k
50	239,9	-90,5	0,999	942,7	-17,4	0,991
100	0,05	225	0,0002	0,08	-10	0,00008
150	4,06	64,2	0,0169	125,3	-170	0,1317
200	0,05	58	0,0002	0,01	160	0,00001
250	0,7	-159	0,0029	26,54	-150	0,0279
300	0,05	-52	0,0002	0,01	200	0,00001
350	3,13	15,7	0,0130	10,17	105	0,09752
400	0,1	-78	0,0004	0,01	-70	0,00001
450	2,5	171	0,0104	1,43	38,4	0,00150
500	0,1	100	0,0004	0,01	-45	0,00001
550	0,12	-114	0,0005	1,22	80	0,00128

Table 8. The magnitudes values, the relative values and the phases of the inductance voltage and current harmonics

3 Conclusions

In order to identify the nonsinusoidal regime, both the nonsinusoidal generator and the linear as well as nonlinear elements have been measured by using an application of the Lab View software for virtual instrumentation. The Lab-VIEW application used for the measurements is very efficient.

The two dipolar elements of circuit- the inductance with magnetic core and the capacitor- are supplementary sources for nonsinusoidal regime within the electroenergetic network under discussion. They preserve the voltage and current harmonics in the network and make bigger the magnitudes of the current and voltage harmonics.

The nonlinear characters of the dipolar elements of the circuit are used in the analysis of the electroenergetic circuits, to which they belong, as well as in the simulation of the other distortion elements.

We can thus draw same theoretical and practical conclusions about improving the functioning of the electroenergetic networks in a nonsinusoidal regime.

References

[1] G. Johnson, *LabVIEW Graphical programming,* McGrew-Hill, 1996.

[2] National Instruments, *LabVIEW Reference Manual*, 1998.

[3] A.P. Schwartz, *Computer aided design of microelectronic circuit and system*, Academic press, London, 1987.

[4] S. Franco, *Electric Circuit Fundamentals,* Sanders College Publishing, Harcourt Brace College Publishers, N. Y ., London, 1995.

[5] H. Andrei, C. Cepisca, *Calculation method of the Relative variation in Electroenergetic Steady - State Circuits,* Proceedings of Third Romanian-Japanese Joint Seminar on Applied Electromagnetics and Mechanic – RJJSAEM, September 11-15, 2001, pp.1-6.

[6] *** *IEEE Standard Definition for the Measurement of Electric Power Quantities under Sinusoidal, Nonsinusoidal, Balanced, or Unbalanced Conditions*, IEEE Std. 1459-2000.

[7] H. Andrei, F. Spinei, C. Cepisca, *A new method to determine the relative variation in electric power systems*, Rev . Roum . Sci. Techn.Serie Electh. et Energ Romanian Academy, 2001, 46 (4), pp. 445-453.

[8] F. Spinei, H. Andrei, *Effects of the reactive Power Compensation with Capacitors in Nonsinusoidal Regime*, Rev . Roum . Sci. Techn. Serie Electh. et Energ., Romanian Academy, 2003, 48 (2-3), pp. 277-282.

[9] H.Andrei**, C.** Cepisca, G.Enciu, *Mathematical techniques for optimization of the power factor in energy processing systems*, in Proceedings of the IEEE - TTTC International Conference on Automation, Quality and Testing, Robotic - AQTR, Cluj_ Napoca, Romania, May 2004, Tome I, pp. 230-234.

[10] V. Dogaru, C. Cepişcă, H. Andrei, M. Ionel, *Power measurements with LabVIEW,* Proceedings of 2004 IEEE - TTTC, International Conference on Automation, Quality and Testing, Robotic, Tome I, pp. 489-491.

[11] L. O. Chua, P. M. Lin, *Computer Aided Analysis of Electronic Circuits,* Prentice Hall, Englewood Cliffs, New Jersey, 1975.

[12] H. Andrei, C. Cepisca, F. Spinei, V. Dogaru, S. D. Grigorescu, N. Jula, *Mathematical Method for Frequency Analysis of the Non-Linear Circuit Elements,* WSEAS Transactions on Circuits and Systems, April 2006, pp. 120-126.

[13] *** *Measurement guide for voltage characteristics. Electricity product and electromagnetic compatibility,* EURELECTRIC, July, 1995.

[14] Joint Working Group CIGRE C4.07/CIRED, 2004, *Power Quality Indices and Objectives- Final WG Report.*