International Journal of Engineering Technology and Scientific Innovation

ISSN: 2456-1851

Volume:02, Issue:03

CAUSES AND METHODS OF ELIMINATING THE DISTURBANCES WHICH OCCUR IN THE NETWORK WHEN SUPPLYING A CONSUMER FROM AN UPS USING VIRTUAL INSTRUMENTATION

Claudiu Nicola, Marcel Nicola, Viorica Voicu, Maria Cristina Nițu, Sebastian Popescu

National Institute for Research, Development and Testing in Electrical Engineering – ICMET Craiova, Romania

ABSTRACT

This paper presents the virtual instrument used to monitor and analyze the behavior of Uninterruptible Power Supplies (UPS) system. The monitoring system includes: Hall effect sensors, data acquisition board, the LabVIEW environment and PC host.

The applications enable the equipment to perform the functions of digital scope and analyze the following parameters: harmonic content, total harmonic distortion THD, RMS value, positive peak value, negative peak value.

For consumers which include interference-sensitive equipment, using passive filters tuned to the frequency of the interference harmonics is recommended.

Keywords: Virtual instrument, Uninterruptible Power Supplies, Harmonic analysis, Instruments, Monitoring, Power system harmonics

1. INTRODUCTION

In an ideal – perfectly clean – power system, the shape of voltage and current curves is perfectly sinusoidal, but in practice non-sinusoidal currents occur if load is non-linear in relation to applied voltage.

In case there is disturbance (distortion) while energizing a consumer from a voltage supply, current passing through the circuit in question increases sharply, reaching values which may cause, in addition to power losses, damage to equipment in the circuit. Increased harmonics lead to deflection of waveforms both in the current and the voltage.

Sources of harmonics are:

a) sources of voltage or current supplying systems which include linear elements; in a power system, these sources are

ISSN: 2456-1851

Volume:02, Issue:03

synchronous generators, for which even under no-load, the terminal voltage is not sinusoidal, and all types of rectifiers;

b) nonlinear or distorting elements, consisting in saturated-core coils and transformers, nonlinear condensers, rectifying apparatus, controlled and uncontrolled semiconductor devices;

c) the simultaneous action of elements type a), b). Distorting elements are classified in two categories:

• 1st category distorting elements (the above mentioned nonlinear elements);

• 2nd category distorting elements (represented in the high current circuits with operating frequency, by coils and condensers).

Harmonic currents are generated by nonlinear loads. They include:

• single-phase loads, for example: switched mode power supplies - SMPS;

• electronic ballasts for fluorescent lamps, small units of uninterruptible power supply (UPS);

• three-phase loads, for example: variable speed drives, large UPS units.

Sources of harmonics in the national power system:

• industrial electrical and electronic equipment of non-linear type: mutators, electrolytic apparatus, arc furnaces;

• generators and network components which by design generate output quantities with non-sinusoidal shapes (synchronous machines, power transformers);

• network components under interference condition (overloaded electric machines and transformers, overloaded power lines due to corona discharge);

• electrical and electronic appliance for household and office uses;

• high voltage and ultra-high frequency devices (e.g. microwave ovens).

2nd (100 Hz), 3rd (150 Hz), 4th (200 Hz), etc. harmonics can occur in a 50Hz system [1].

Normally only odd number harmonics (3rd, 5th, 7th, 9th) occur in a three phase system. The occurrence of even number harmonics implies the existence of faulty converters connected in the system [2-3].

Non-sinusoidal or distorting operating conditions of SEE's represent those conditions where voltage-current curves are periodic, but at least one of them does not vary in time according to a sinusoidal type law.

The distortion of a curve depends on the following factors:

• the nature of harmonics, making mention of their odd/even number. According to their number, harmonics can be classified into higher harmonics (their number is an integer) and sub-harmonics (their number is a proper number).

• amplitude of harmonics (defined as the amplitude of any sine curve). It is expressed either as a percentage of the first harmonic, or as absolute or relative units.

• the value of the displacement of different harmonics (the relative position of harmonics).

Since the disturbance caused by harmonics result in power loss, premature ageing of equipment and even damage, it is necessary to perform their analysis to determine the total harmonic distortion THD allowing adoption of optimum solutions to remedy any possible critical situations.

Starting from the concepts listed above, in this work we conducted the analysis of disturbance in case of power supply to a consumer with an uninterruptible power supply (UPS) [4-7].

There are times when power supply cannot be achieved from a conventional source due to drops in voltage on longer duration of time, and in case of unexpected outages [8], the secondary power supply can be achieved using uninterruptible power supplies (UPS).

Uninterruptible power sources are used on large scale as standby power in case of usage power outage, e.g. computers, medical/life care equipment, and communication systems [9-12].

In general, the function of a UPS is to generate high-quality low distortion alternating current voltage, notably in the case of non-linear loads or sudden load changes [13-15].

The UPS system is characterized by a high harmonic distortion factor (THD), in the case of nonlinear loads, even if filtered, real output voltage may still produce distortion due to the fact that nonlinear load is injected into the harmonic current [16].

In the power system, the variation form of voltages and currents is not sinusoidal because of both the constructive imperfections of generators and the non-linear behavior of some circuit elements. This function rating is called deformant rating and it is characterized by harmonic distortions: continuous components, harmonics, interharmonics, commutation impulses, noises.

A virtual instrument consists of a PC host equipped with powerful application software, cost-effective hardware such as plug-in boards, and driver software, which together perform the functions of traditional instruments. Virtual instruments represent a fundamental shift from traditional hardware-centered instrumentation systems to software-centered systems that exploit the computing power, productivity, display, and connectivity capabilities of popular PC host [17-19].

LabVIEW is an integral part of virtual instrumentation because it provides an easy-

ISSN: 2456-1851
Volume:02, Issue:03

to-use application development environment designed specifically with the needs of engineers and scientists in mind. LabVIEW offers powerful features that make is easy to connect to a wide variety of hardware and other software [20-22].

2. SYSTEM HARDWARE DESCRIPTION

The main hardware components of the monitoring system are the data acquisition systems (DAQ). DAQ acts as the interface between the computer and the outside world. It primarily functions as a device that digitizes incoming analog signals so that the computer can interpret them. The design of a DAQ is influenced by the number of signals to be monitored, their variation speed, the need for input signal conditioning, the precision and resolution of analogic-digital conversion, the real time processing capabilities of the system and the cost.

The hardware components of the monitoring system are:

• voltage transducer LEM LV 25-P;

• current transducer LEM LA 55-P;

• DAQ NI USB-6229;

• PC host.

The block diagram is presented in Figure 1.

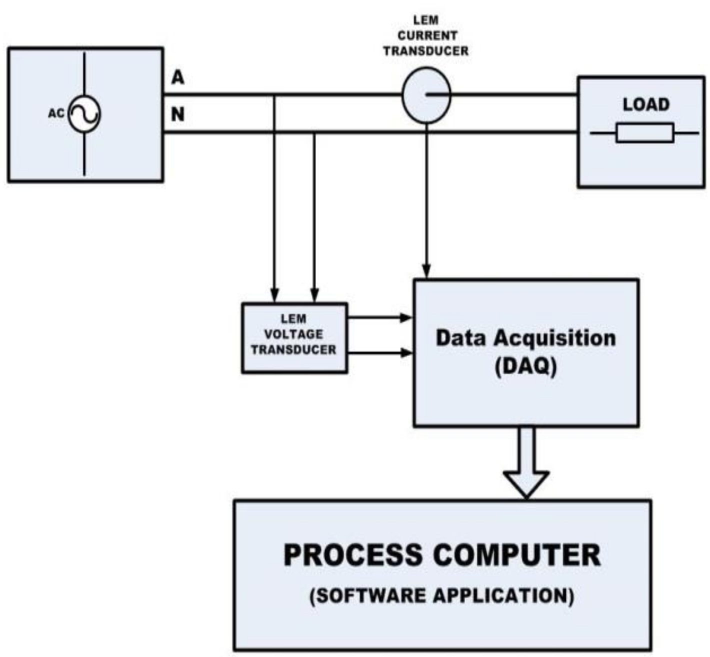

Figure 1. The block diagram of the monitoring system

ISSN: 2456-1851

Volume:02, Issue:03

The main characteristics of the NI USB-6229 DAQ that we used are the following:

• 32 analog inputs, 4 analog outputs, 48 digital I/O, and 32 bits counters;

• single channel maximum 250 kS/s;

• DAC resolution 16 bits;

• timing resolution 50 ns;

• input range ±0.2 V, ±1 V, ±5 V, ±10 V DC.

For on-line measurement of voltage and current signals [3], we will use Hall effect sensors that are based on the Hall effect, which is the ideal solution for this type of measurements.

The Hall element [17] is made of a thin plate of conductive material. The output connections for these transducers are carried out perpendicularly to the direction of the current flow and under the influence of a magnetic field, the current generates an output voltage proportional to the magnetic field strength. The voltage output is generally very low in the range of microvolts and additional electronics are required for useful output levels. A Hall Effect sensor is achieved by combining the Hall element with the associated electronics. The integrated circuit chip containing the Hall element and the signal conditioning circuit diagram is the core of every Hall Effect device [18].

Both the current and the voltage transducers have as output scalable signals in DC voltage for the analog input for the data acquisition systems. The current and voltage transducers used in the virtual instrument are externally powered by a ±15V power supply.

3. SYSTEM SOFTWARE DESCRIPTION

Software is the most important component of a virtual instrument. We decided to use LabVIEW graphical programming [19-20] developed by National Instruments. It is a powerful and versatile analysis and instrumentation software system for measurement and automation.

LabVIEW is designed to facilitate data collection and analysis, and provides many display options. With data collection, analysis and display combined into a flexible programming environment, the PC host functions as a dedicated measurement device. LabVIEW contains a comprehensive set of VIs and functions for acquiring, analyzing, displaying, and storing data, as well as tools to help us troubleshoot our code. The two LabVIEW windows are the front panel (containing controls and indicators) and block diagram (containing terminals, connections and graphical code). The front panel is the user interface of the virtual instrument. The code is built using graphical representations of functions to control the front panel objects. The block

ISSN: 2456-1851

Volume:02, Issue:03

diagram contains this graphical source code [21].

The main input signals into the program were two sine waves, one for the voltage and one for the current of phase of the transformer. For each of these voltage and current signals we calculate Total Harmonic Distortion, harmonics, RMS value, positive peak value, negative peak value, power supply frequency, power factor, active power, reactive power, on-line apparent power.

To perform the measurement of voltage and current we followed these steps:

• create and start the task ;

• configure the channel properties (limits, timing, and triggering);

• read and transfer the samples to PC host memory;

• stop and clear the task.

To calculate the full harmonic analysis, the fundamental frequency modulation, harmonics, the fundamental frequency, all harmonic amplitude levels, and the total harmonic distortion (THD) we use the harmonic distortion analyzer VI.

The application software has an option for storing the data that we calculate. Data files are important and we save the measurements data to a text file and we have the possibility of setting the writing time.

The software interface and the block diagram from LabVIEW of the monitoring system is presented in Figure 2 and 3.

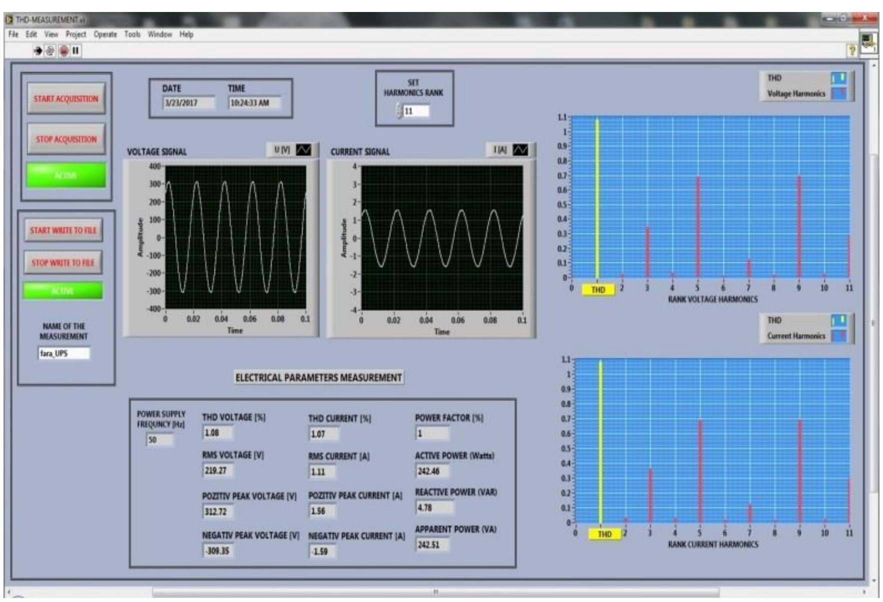

Figure 2. The software interface of the monitoring system

ISSN: 2456-1851
Volume:02, Issue:03

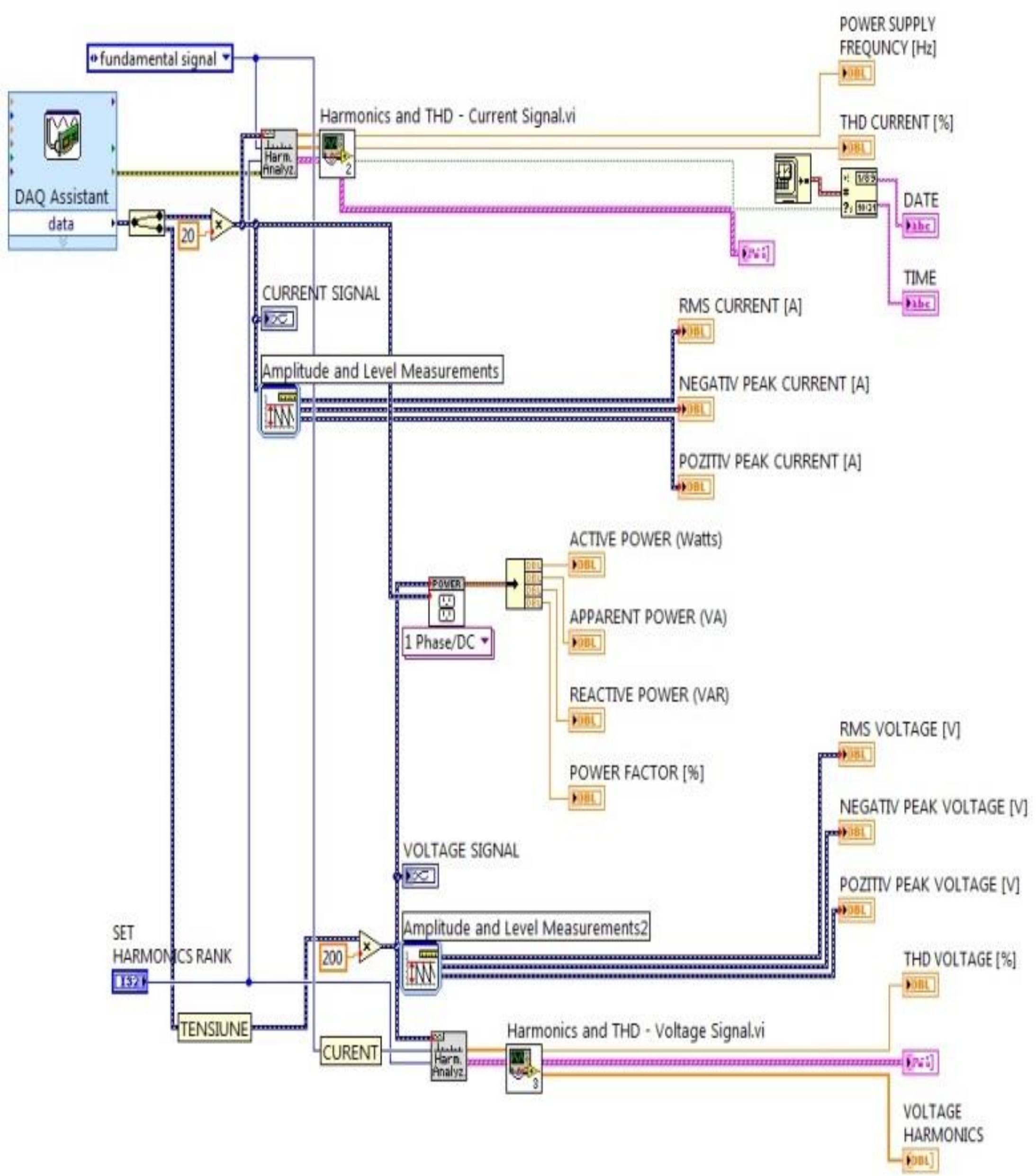

Figure 3. The block diagram from LabVIEW of the monitoring system

The software interface and the block diagram from LabVIEW for analyzing the voltage and current THD, and allows the comparison of data recorded on the consumer supply with and without UPS is presented in Figure 4.

ISSN: 2456-1851

Volume:02, Issue:03

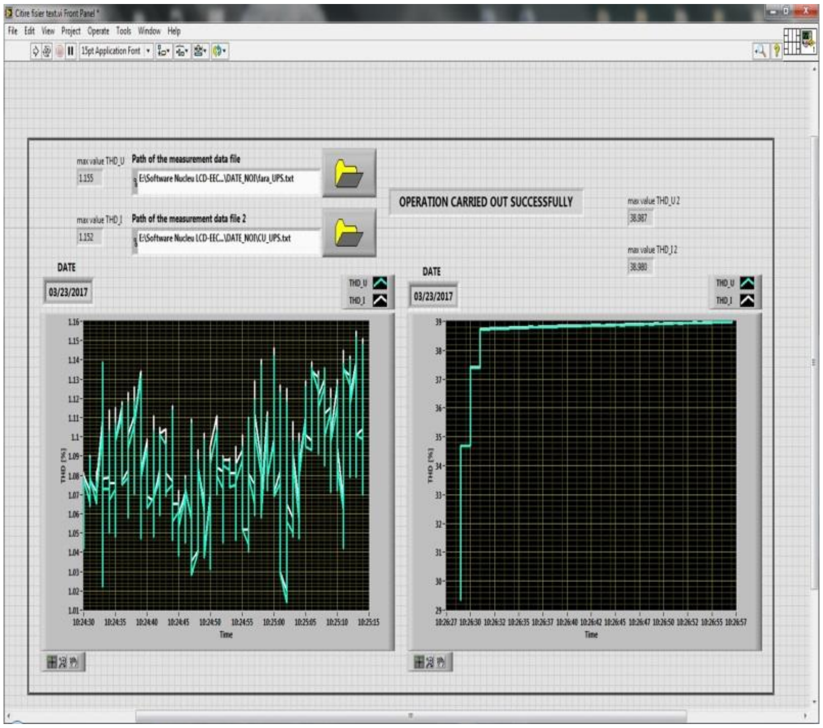

Figure 4. The software interface for analyzing the voltage and current THD

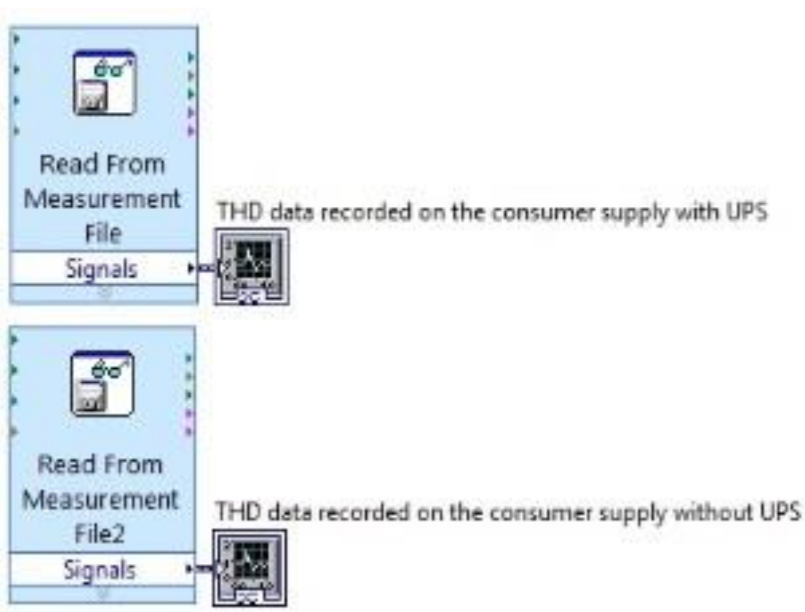

Figure 5. The block diagram from LabVIEW for analyzing the voltage and current THD

ISSN: 2456-1851

Volume:02, Issue:03

4. MEASUREMENT RESULT

As a result of on-line measurements carried out on the proposed circuit, the disturbances generated by uninterruptible power source (UPS) could be determined. In the first stage on-line measurements were carried out when the consumer was powered directly from the network, and in the second stage, the measurements were performed when the consumer was powered by a UPS.

In the first stage sine waves were achieved, and in the second stage high disturbance occurred (high harmonic content) which distorts both current and voltage waveforms. Distortions of waveforms resulting from the UPS are considered as disturbance in power quality.

In case the circuit to be analyzed is energized directly from the power supply, it reaches a voltage of approx. 220 V AC and a current of 1.11 A, see Figure 6 and 7:

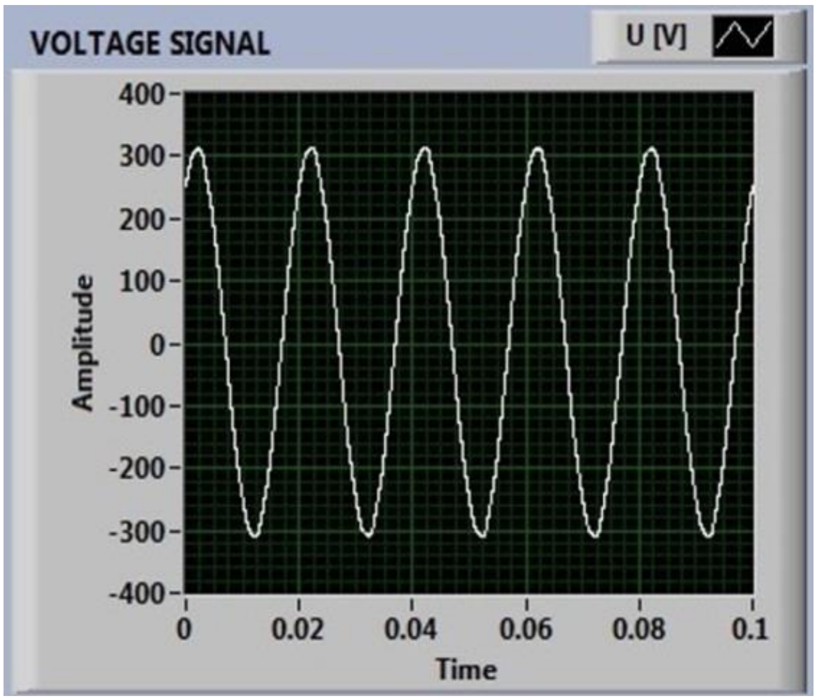

Figure 6. The waveform of voltage signal

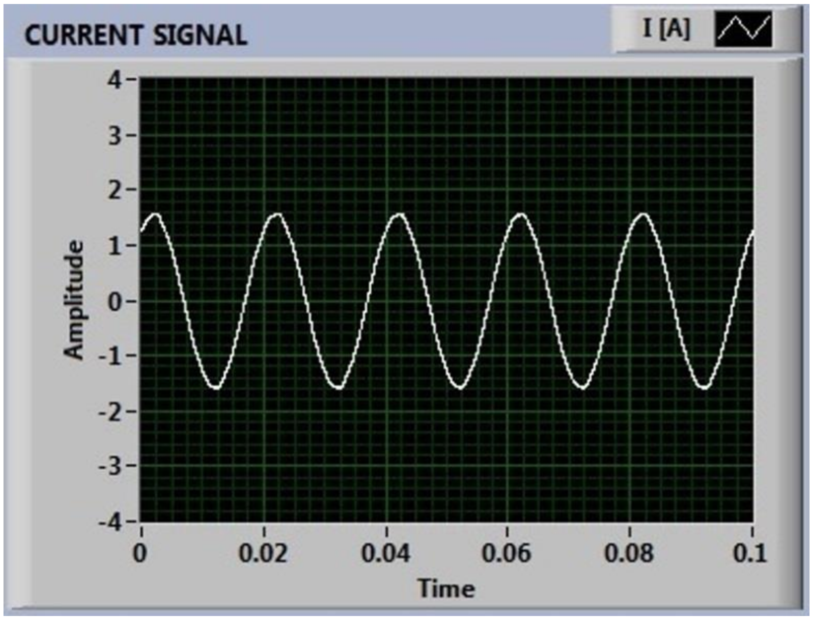

Figure 7. The waveform of current signal

In Figure 8 and 9 we can observe the current and voltage harmonics, which reached lower values, and they cannot disrupt current and voltage waveform. The Fig. 10 shows the time evolution of THD [%], THD of the current registers values up to 1.155 and the maximum THD of the voltage is of 1.151.

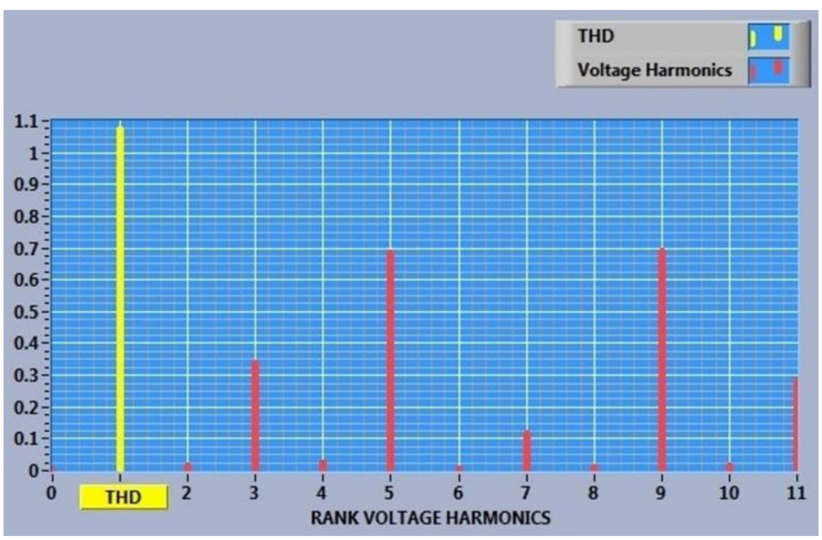

Figure 8. THD and voltage harmonics

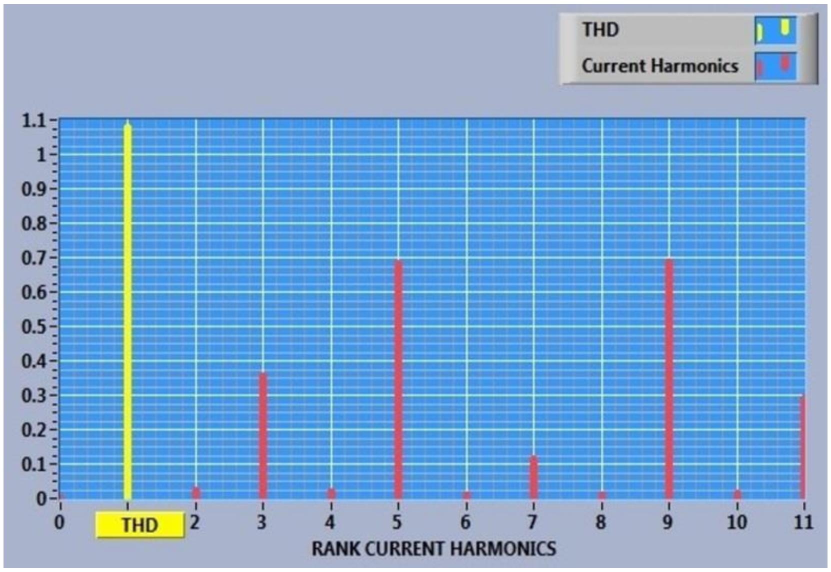

Figure 9. THD and current harmonics

Figure 10. The evolution of the voltage and current THD

When supplying the consumer with a UPS, major disturbances occur both in current and voltage (See Fig. 11 and 12).

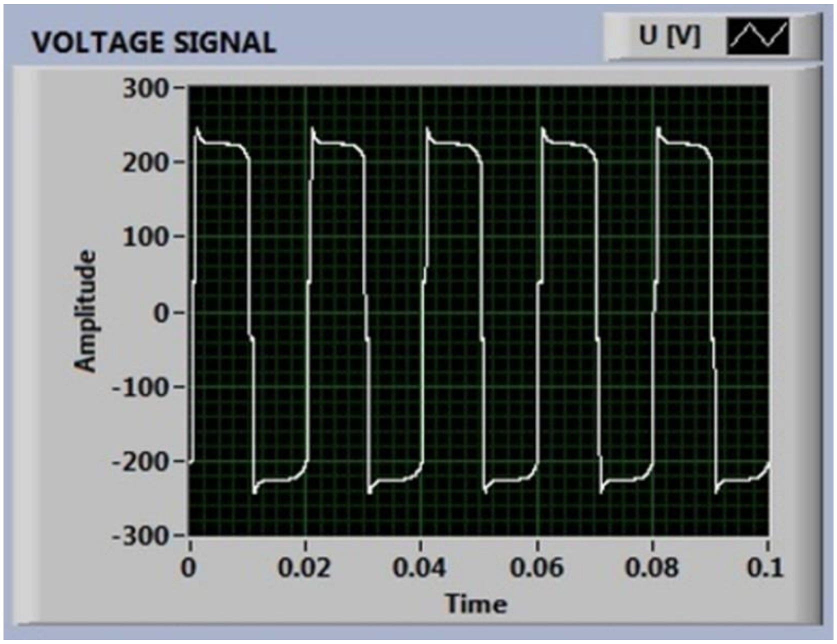

Figure 11. The voltage signal

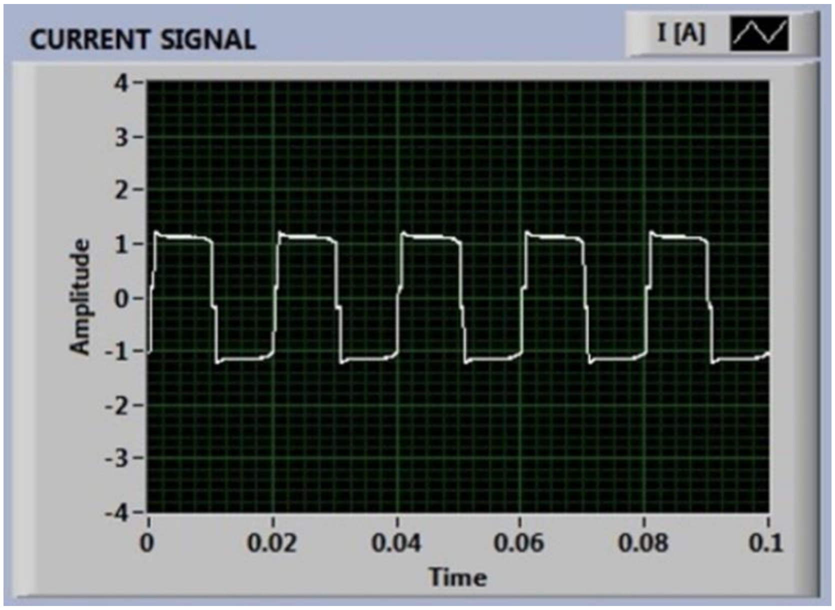

Figure 12. The current signal

Current and voltage harmonics exceeding the value of 40% can be observed in Fig. 13 and 14. The Fig. 15 presents the time evolution of THD of [%],THD of the current registers values up to 38.987 and the maximum THD of the voltage is of 38.980.

ISSN: 2456-1851

Volume:02, Issue:03

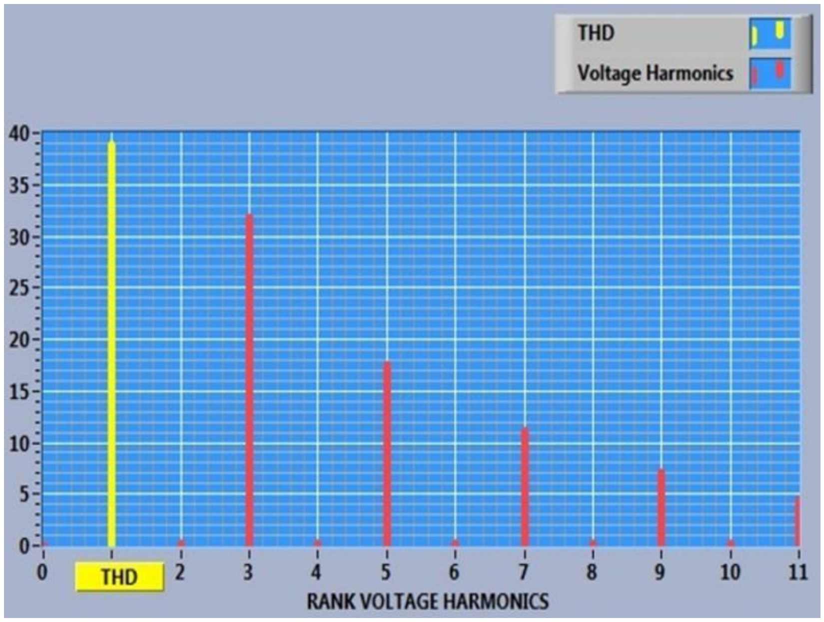

Figure 13. THD and voltage harmonics

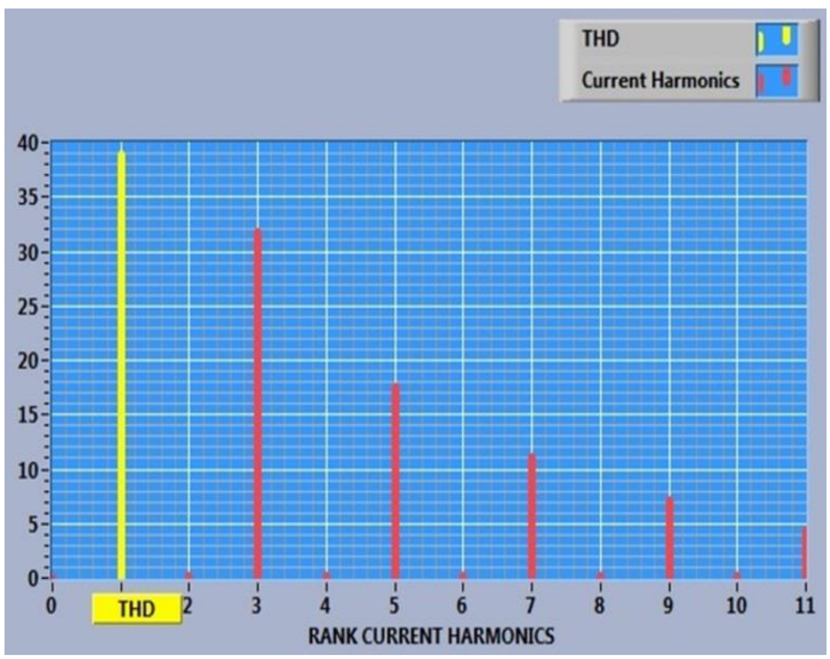

Figure 14. THD and current harmonics

ISSN: 2456-1851

Volume:02, Issue:03

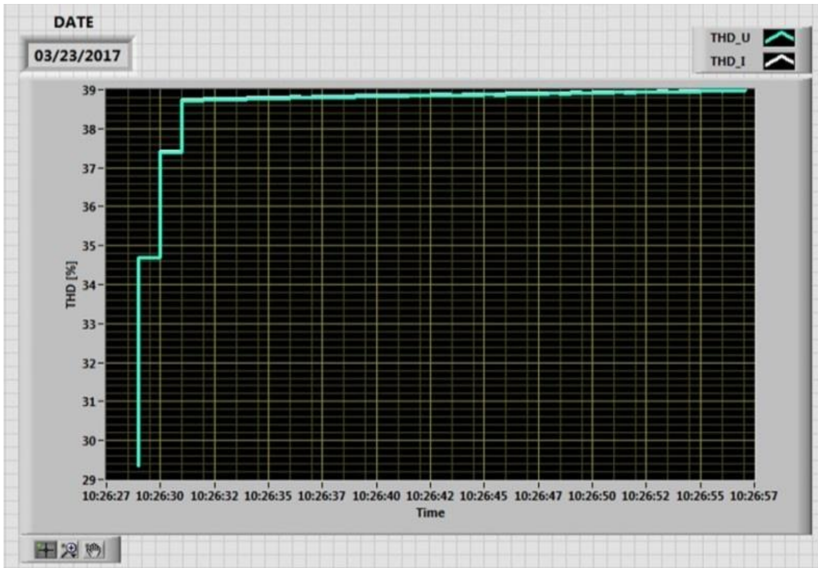

Figure 15. The evolution of the voltage and current THD from UPS

In the case of consumers which include interference-sensitive equipment, using passive filters tuned to the frequency of the interference harmonics is recommended. In order to improve the measured perturbed signal we will filter the 3rd, 5th, 7th harmonics as follows:

• 3rd harmonic filtering;

Figure 16 shows the current signal after filtering of the 3rd harmonic, there is an improvement in the signal, and the THD value of the current decreases to 23.21% (see Figure 17).

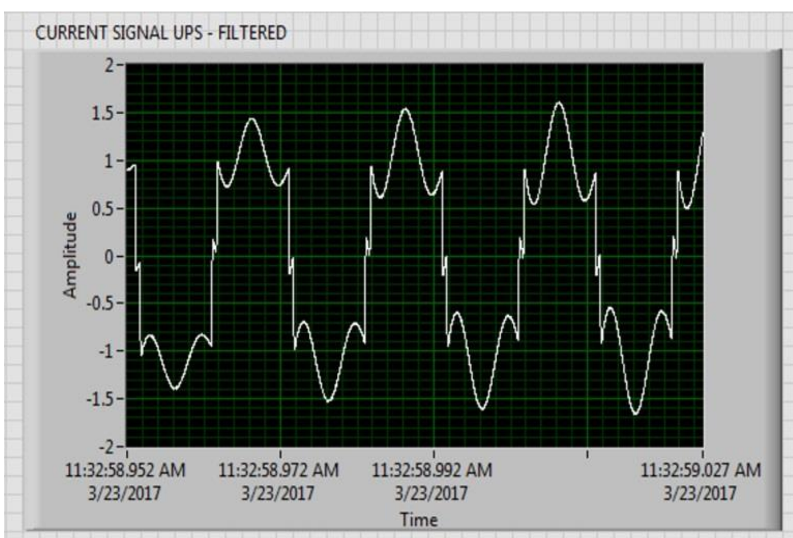

Figure 16. Filtered current signal – 3rd harmonic

ISSN: 2456-1851

Volume:02, Issue:03

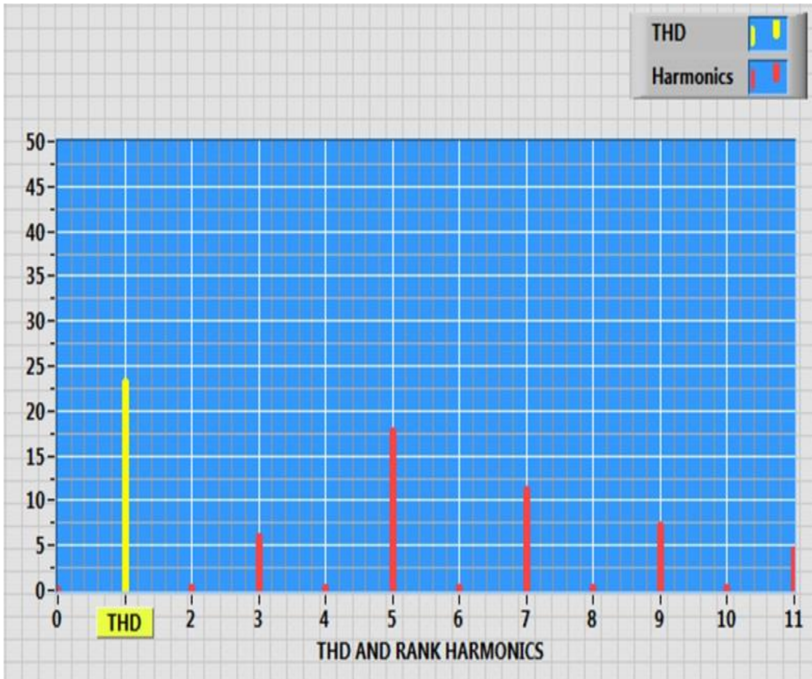

Figure 17. THD and current harmonics after filtering 3rd harmonic

• 5th harmonic filtering;

Figure 18 shows the current signal after filtering of the 5th harmonic, there is an improvement in the signal, and the THD value of the current decreases to 34,85% (see Figure 19).

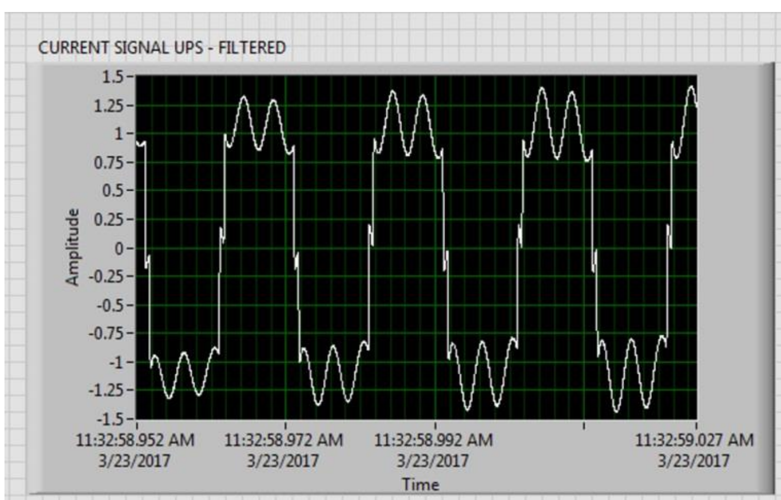

Figure 18. Filtered current signal – 5th harmonic

ISSN: 2456-1851

Volume:02, Issue:03

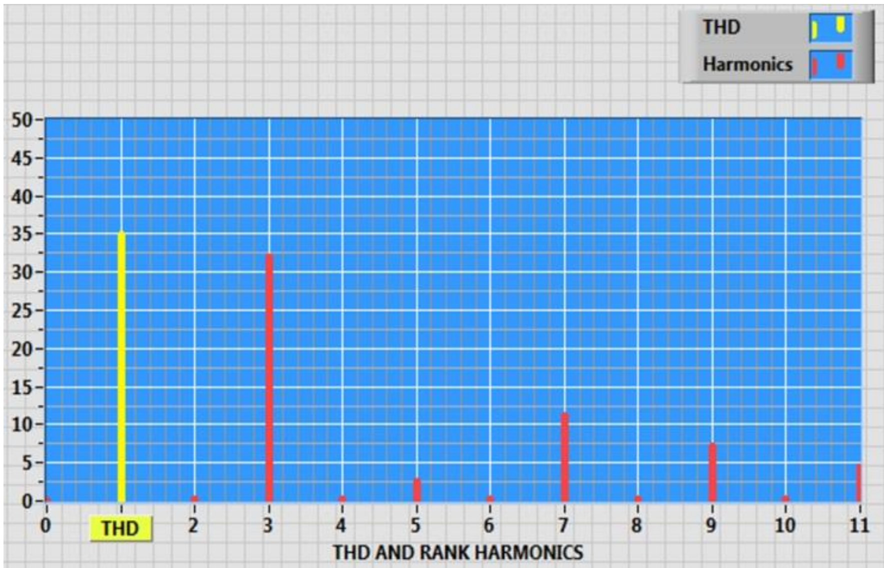

Figure 19. THD and current harmonics after filtering 5th harmonic

• 7th harmonic filtering;

Figure 20 shows the current signal after filtering of the 7th harmonic, there is an improvement in the signal, and the THD value of the current decreases to 37,41% (see Figure 21).

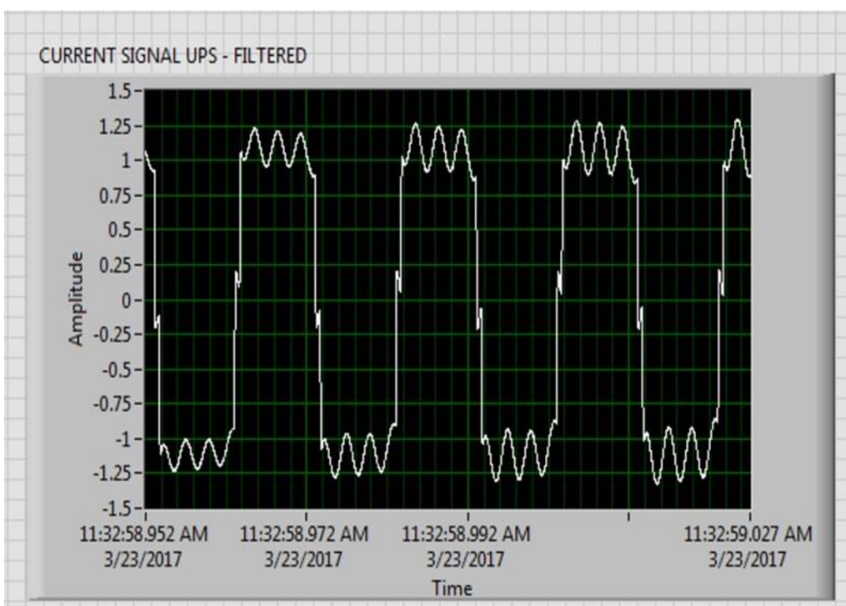

Figure 20. Filtered current signal – 7th harmonic

ISSN: 2456-1851

Volume:02, Issue:03

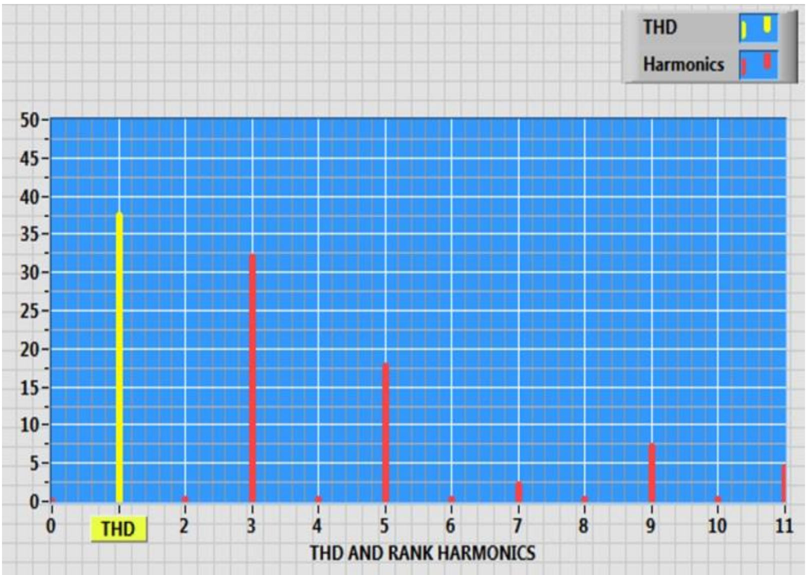

Figure 21. THD and current harmonics after filtering 7th harmonic

5. CONCLUSION

This paper aims to analyze disturbances induced in the network when a consumer is supplied from an UPS.

The purpose of the study was achieved by making a comparison between the results achieved for the consumer supplied directly from the network and those achieved in the case of the consumer supplied with UPS.

It has developed a software application that enables real-time visualization of signals and facilitates the analysis.

Data acquisition boards with multiple input channels represent a useful tool for measuring and monitoring electrical energy parameters. Using the desired virtual instrumentation, users develop their own instrument, implementing both the front panel and the functionality to fully meet their needs.

LabVIEW is a programming environment used primarily for making measurements and monitoring of automated processes.

The virtual instrument can be used for various laboratory works regarding single phase electrical network analysis, such as: the study of the parameters for the electrical lines and transformers, particular operating conditions of transmission lines.

This method is a low cost solution in comparison with using a power analyzer and our solution is based on LabVIEW and has a lot of capabilities for data processing and storage, and for comparative analysis.

To solve the practical problems of AC circuits, it is necessary to use the same digital instruments with an adequate hardware and software.

ISSN: 2456-1851

Volume:02, Issue:03

The implementation of applications into the LabVIEW graphical programming environment, has been achieved based on theoretical aspects and experimental results in the laboratory using accurate devices.

As noticed, after filtering of the measured perturbed signal, the 3rd harmonic has a great share in its disturbance, as a result of the experiment carried out, we recommend the use of passive filters tuned to the frequency of the interference harmonics for the consumers which include interference-sensitive equipment.

REFERENCES

[1] R. Singh and A. Singh, "Aging of distribution transformers due to harmonics," Harmonics and Quality of Power (ICHQP), 2010 14th International Conference on, pp. 1-8, 2010.

[2] IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems, IEEE 519/2014.

[3] Normativ privind limitarea regimului nesimetric deformant in retelele electrice - Aprobat cu Decizia nr.76/1994- Regia Autonoma de Electricitate Renel, PE 143/94.

[4] A. Ortiz, C. Gherasim, M. Manana, C. J. Renedo, L. I. Eguiluz, and R. J. M. Belmans, "Total harmonic distortion decomposition depending on distortion origin," IEEE Transactions on Power Delivery, vol.20, pp. 2651-2656, 2005.

[5] L. Băjan, "Total current harmonic distortion analyses of industrial UPS's with SCR input converter working in redundant mode," Electrical Machines (ICEM), pp. 1-4, 2010.

[6] M. H. Abbas, "Total harmonic distortion analysis simulation,", Power System Technology, vol.3, pp. 1631-1634, 2000.

[7] N. Stanciu, D. Stănescu, P. Postolache, and W. Szabo, " Voltage sags and Total Harmonic Distortion monitoring in power systems. A case study," International Symposium on Advanced Topics in Electrical Engineering (ATEE), pp. 1-6, 2000.

[8] D. Kottick, Power Quality monitoring system – voltage dips, short interruptions and flicker, Elect. Power Qual. & Utilisagion Magazine vol. 3, issue 2, August, 2008.

[9] I. V. Blagouchine and Eric Moreau, "Analytic Method for the Computation of the Total Harmonic Distortion by the Cauchy Method of Residues," IEEE Transactions on Communications, vol.59, pp. 2478-2491, 2011.

[10] X. Hu and Y. Liu, "Principle and running maintenance on UPS power supply," Electronic and Mechanical Engineering and Information Technology,vol.9, pp. 4721-4723, 2011.

[11] F. Vatra, A. Poida, and C. Stanescu, "Data system for the monitoring of power quality in the transmission substations

ISSN: 2456-1851

Volume:02, Issue:03

supplying big consumers," International Conference on Electrical Power Quality and Utilisation, pp. 1-5, 2007.

[12] D. Rusinaru, L. G. Manescu, M. Merfu, and P. Postolache, "Power quality general levels in distribution networks," International Conference on Harmonics and Quality of Power (ICHQP), pp. 58-62, 2014.

[13] R. Alves et al., "Development of an Electrical Power Quality Monitor based on a PC," 35th Annual Conference of IEEE, Industrial Electronics IECON '09, pp. 3649-3653, 2009.

[14] A. N. Gowda, D. L. Girijamba, G.N. Rishika, S. D. Shruthi, and S. Niveditha, "Control4 Smart Home System using LabVIEW," International Journal of Engineering Science and Innovative Technology (IJESIT), vol. 2, Issue 3, pp.200-205, May 2013.

[15] M. C. Nițu, C. Nicola, V. Voicu, S. Popescu, M. Nicola, "Analysis using virtual instrumentation of perturbations induced in the network to supply a consumer from a UPS," in Applied and Theoretical Electricity (ICATE), 6-8 Oct. 2016.

[16] T. Radil, P. M. Ramos, F. M. Janeiro and A. Cruz Serra, "PQ Monitoring System for Real-Time Detection and Classification of Disturbances in a Single-Phase Power System," IEEE Transactions on Instrumentation and Measurement, Vol. 57, pp.1725-1733, 2008.

[17] L. M. Stancu and V. Dogaru-Ulieru, "Data Acquisitions in Systems Lighting," International Journal of Engineering Science and Innovative Technology (IJESIT),Volume 3, Issue 3, pp.73-78, May 2014.

[18] G. Vincent, S. Sasitharan, M. K. Mishra, and K. Karthikeyan, "A dsp-based integrated hardware set-up for a dstatcom: Design, development, and implementation issues," IETE JOURNAL OF RESEARCH, vol. 56(1), pp.11-21, 2010.

[19] R. Bitter, T. Mohiuddin, and M. Nawrocki, LabVIEW: Advanced programming techniques - SECOND EDITION, September, 2006.

[20] H. P. Halvorsen, Introduction to LabVIEW, March, 2014.

[21] J. Jovitha,Virtual Instrumentation Using Labview, January, 2010.

[22] K. N. Jadhav and N. Sarwade, "Comparative Review Study of 4-Channel Data Acquisition System using Lab VIEW," International Journal of Engineering Research & Technology, 2014.

