Engineering Applications
https://publish.mersin.edu.tr/index.php/enap
e-ISSN 2979-9201

Monitoring and assessment of the quality of electricity in a building

Fatmir Basholli *1, **Adisa Daberdini** 2

[1]*Albanian University, Department of Engineering, Tirana, Albania, fatmir.basholli@albanianuniversity.edu.al*
[2]*Aleksander Xhuvani University, Informatics Department, Elbasan, Albania, adisa.daberdini@uniel.edu.al*

Cite this study: Basholli, F., & Daberdini, A. (2023). Monitoring and assessment of the quality of electricity in a building. Engineering Applications, 2 (1), 32-48

Keywords
Electrical
Monitoring
Quality
Tension
Electric current

Research Article
Received: 08.12.2023
Revised: 06.01.2023
Accepted: 16.01.2023
Published: 03.02.2023

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Abstract

The term, "Power Quality" has been applied to a wide variety of many power system phenomena. The increasing application of electronic devices as well as the production and distribution of electricity has increased the interest in energy quality. Today, non-linear loads have increased, mainly with the addition of computer equipment, printers, photocopiers, fans, heaters, air-conditioning systems, refrigerators, elevators, etc. Therefore, it is good to take some measures to reduce the levels of general disturbances, as well as to immunize the sensitive equipment in such a way as to ensure the stability of the electrical installations. To achieve these objectives, it is important to measure and analyze harmonic distortion. For this, the origins and possible consequences of harmonic disturbances in computer equipment and distribution networks of the building or university campus are studied, which is the focus of this study. The paper argues the main precision strategies in an electrical installation applied in a building, in which the biggest loads are computer and laboratory equipment. For this and many other reasons that affect the Quality of Electricity will be argued in the following article.

1. Introduction

In the preparation of our research, we set as a separate task and analysis, the monitoring of electricity in a building of a university environment, consumer with computers and information technology equipment. Since usually schools, universities, etc., are users of many computer and ICT devices, there is a need to do and deepen a study in these facilities where these devices are installed. In the following, we will get to know the quality of electricity in the devices that are included in this study. In order to make it possible to monitor electricity, we will also look at the electrical installation with computer equipment, which serves as a starting point and basis for laying out the foundation issues in solving problems that may occur during the measurement period or other phenomena. Further along this road, we will see the progress of changing the electrical load with the addition of equipment. Rather, we will focus on problems related to the quality of electricity, how this quality changes depending on the electrical load, etc. [1].

2. Material and Method

The qualities of the elements that provide electricity with acceptable parameters.

2.1. Quality of electricity supply

First, let's familiarize ourselves with some generalizations regarding the quality of the electricity supply system to users, the quality of production, and the quality of the system. It is reasonable to know the quality of the above elements as they provide us with a good quality of electricity with acceptable parameters. Interruption of the electricity supply to users, as well as any deviation from the nominal values of voltage and frequency, reduce the efficiency of devices that work with electricity. The great dependence of production and social activity on electricity and the constantly increasing use of sensitive devices such as electronic devices force the Electro-Energy Systems to give special importance to the quality of the electricity supply of their users (customers) [2].

In a more analytical way, the "Electricity supply quality" of users is mainly characterized by the following factors:

a. Continuous supply of electricity.
b. Supply voltage stability.
c. Frequency stability.
d. Cleanliness of the shape of the supply voltage curve.
e. Tendency to have symmetrically clean three-phase system voltages.

Of the above factors (c) does not depend on distribution networks, but on the production system. Factors (b), (d) and (e) depend almost entirely on distribution networks, while (a) mainly on distribution networks.

Absolute provision of uninterrupted power supply to all users, without any interruption of any kind, is practically impossible. Aiming for such a thing leads to huge unjustified expenses. The level of guarantee of uninterrupted supply is evaluated by the "security degree" of this supply. More clearly, the supply rate is expressed by the possibility of uninterrupted supply [3].

2.2. Production quality and electrical system quality

In today's language, the word quality is very usable and is associated with different concepts and colors and has a high degree of subjectivity. It is of course distinct from the relationship with quantitative assessments. It is often taken for granted that a scale of quality values is not a common reference for everyone but is related to each person's personal tastes. In engineering, accurate data, universally accepted, unanimously interpreted and precisely estimated within a given uncertainty zone are necessary. The concept has already been strengthened that in the technical word quality a truth is attached, that is, a certain and determined evaluation. With the advancement of technologies, with the increase of consumer demands, the codified concept according to which quality corresponds to an assessment in accordance with rigorous conditions, although it is not always translated into numbers, is increasingly being proven [4-7].

2.3. The quality of the electrical system

Modern power supply and delivery systems consist of a complex network, such as electrical components, including power supply, transmission, voltage control, power supply with multiple points of use. The complicated interaction of network components leads to temporary changes in power characteristics. In the technical field, when talking about the quality of a certain operating system, it means respecting the norms or specific requirements defined for these systems. Finally, according to the destination of the system, the corresponding rate should be selected. The technical norms related to a system are generally few and have general application value, i.e., they are independent of the sector the system belongs to. They are suitable for any type of production or service activity, as well as for any technical activity from design to implementation [8].

2.4 Power quality definitions

Now let's get acquainted with some definitions of the quality of electricity in a more detailed form, with a more general word.

We often hear the word quality, as for products, goods, services, etc., just like these, electricity also has its own quality. It is said that the quality of electricity is ideal when the dependence of current or voltage on time is a pure sinusoid, that is, when the dependence graph has no deformations, deviations. But this thing is just theoretical enough to be familiar with the terms of the quality of electricity.

The understanding of power quality received a significant expansion or adaptation with the introduction of many electrical loads. In short, it is precisely the impact of these types of electrical loads that lowers the quality of electricity. The loads in question are known as non-linear loads and they have increased a lot recently [9].

The quality of electricity varies at different times for different electrical loads. Through the literature of different types of electrical installations, an "ideal" sinusoidal law of current or voltage is accepted. In reality or in practice this is not accepted because the electrical loads of the electrical system do not respect this legality.

Everything that we receive approximately we do for our own interest and for the study effect, that is to create facilities in the various calculations. In reality, electricity does not have a 100 percent quality. The change in the quality of electricity is directly proportional to the change in electrical loads where they are supplied with electricity [10].

2.5 Two words about the meaning of electricity quality

Quality in electricity supply can be divided into three categories:

1) Reliability (Ability to supply consumers with electricity without interruption). This has to do with the ability of producers and distribution of electricity, to give or supply electricity without interruption at any time and moment. Assessment of the power grid's ability to respond to continuous changes in consumer demand [11].

2) Commercial quality which is related to individual agreements between generating companies and individual consumers.

3) Power quality, which consists in evaluating subjects such as interruptions, harmonics, over/under voltages, connection/disconnection of capacitor batteries, voltage fluctuations, voltage regulation. Quality covers all areas from generating units to the ultimate consumer. It addresses the complex physical interaction of supply equipment and consumer equipment down to the ultimate consumer. It mainly deals with the quality of the power source voltage waveform [12,13].

We often need to be interested in the quality of electricity. This fact comes as a result:

- Increasing awareness on the issues of electricity quality by consumers.
- Because the load equipment has become more sensitive to the requirements of the quality of electricity compared to the past.
- Penetration of non-linear loads, mainly harmonics.
- Increase in applications of variable frequency devices and capacitor banks for improving the power factor, i.e., cosa.
- Increased penetration of "non-conventional" types of generators often connected to the electrical grid through an electronic interface.

2.6 Interest in electrical energy efficiency and grid interconnection as well as automated industrial processes

We are always interested to know how the electricity we use is, to know everything related to it, its parameters, quality, etc. We definitely need to know what a "Good Quality of Electricity" is. We should rather be aware of the electricity we use. In the evaluation of this energy, we present several main stages that must be "passed" by this electricity that supplies us to our consumers in order to have a good and acceptable quality (quality) [14-16].

In order for electricity to be of good quality, the following conditions must first be met:

- Constant sinusoidal waveform with fundamental frequency only.
- Constant frequency forever with respect to time.
- To form a symmetrical three-phase system.
- To have constant effective value, unchanged over time.
- To be unaffected by load changes.
- Reliable, power present when required.

So, for the quality of electricity to be acceptable or in other words for electricity to be of good quality, the above conditions must be acceptable, which we briefly analyze below.

The voltage waveform should only be sinusoidal with respect to time. This waveform of the food source must not be broken for one reason or another. The change in voltage affects the quality of electricity.

The frequency (f) should not change with time but be constant and unchanging at the right value that for our country and European countries this value reaches 50hz. Even frequency has its own impact on power quality.

In order to use good quality electricity, the three-phase system that serves as a source of electricity for consumers must generally be symmetrical, in Figure 1.

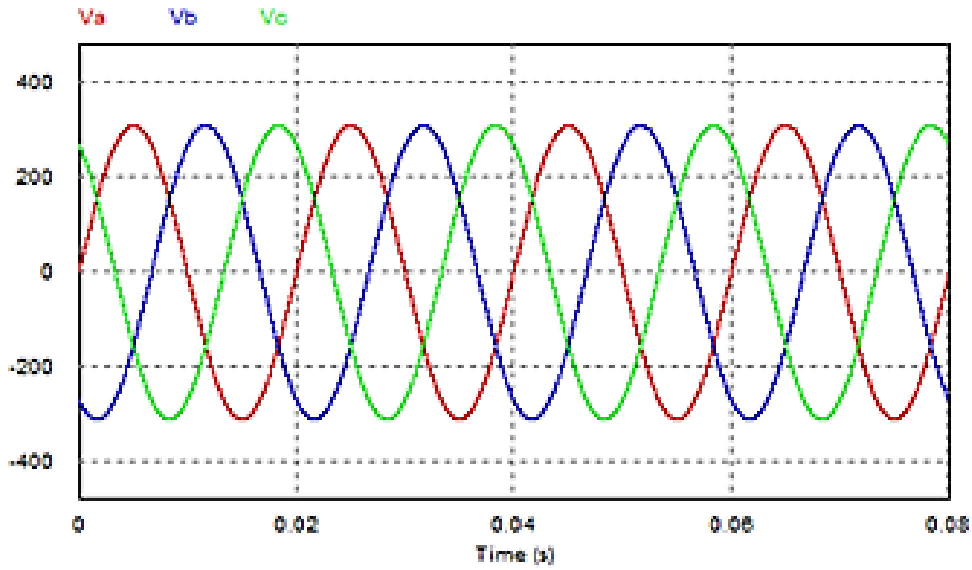


Figure 1. Ideal curves of the three-phase system

So, in order to maintain this symmetrical system, it is necessary that the three phases of the same electrical system have the same amplitude, the same voltage magnitude, the same frequency for all three phases, and their phasing in time must necessarily be 1200 Likewise, for electricity to have acceptable parameters, that is, for the quality of electricity to be high, it is reasonable that the electrical load "connected" in this electrical system does not change. In other words, we are interested in realizing the independence of the quality of electricity from the change of the electric load [17].

But this is not really possible for many reasons. Since electrical loads, whether domestic electricity consumers, industrial ones or other loads change very quickly. For short periods of time, even thousands of electrical loads can be switched on every second, and many other loads can be taken out of normal operation. So electrical loads are added or subtracted to the electrical system at any time. From what we said above, since we are in the conditions of changing electrical loads that are supplied by the electrical system we are analyzing, there will be changes, fluctuations, that is, a drop or rise in voltage. This is due to the change in the load, be it of any kind. It is worth mentioning that the increase in electrical loads has always affected and is still affecting the quality of electricity [18,19].

Now it is not difficult to understand the relationship that exists between the quality of electricity and the change in electrical load. As we have said above, the quality of electricity does not maintain the same value as the load change, even if the latter is of a small value. Finally, with voltage fluctuations, with the character, type, quantity, and even the quality of electrical loads, it must be said that we have variable energy quality. Everything we presented above, let's reflect and illustrate it now with a voltage waveform, to show the quality of electricity, see Figure 2. In the following we will show a graphical representation of the voltage as a function of time (t) for a single-phase system. Where T is the period, or the inverse of the frequency, which in physics is known as the distance between two peaks or two troughs, as shown graphically below.

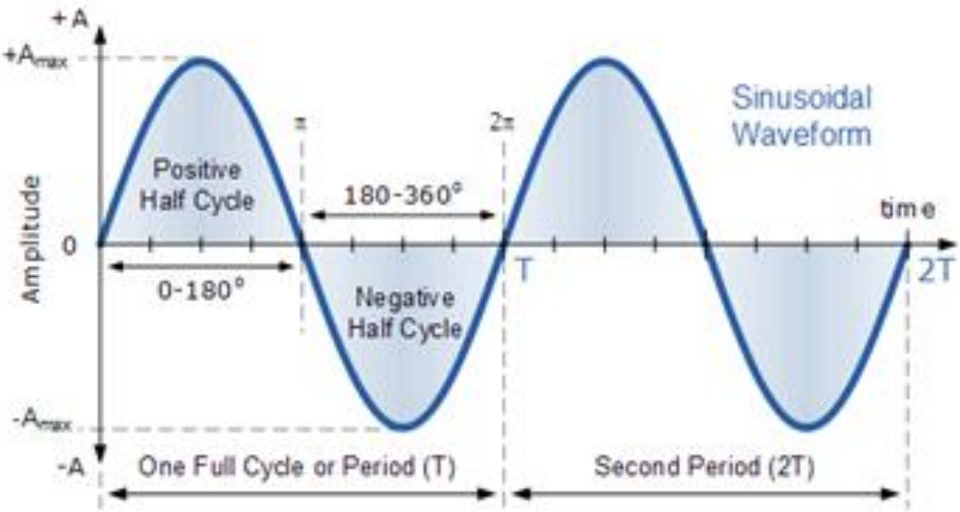


Figure 2. Ideal curves of a single-phase system

Units of periodic time, (T) include: Seconds (s), milliseconds (ms) and microseconds (μs).

We say that the quality of electricity is "ideal", because there is no deviation from what we really want to have. However, with the development of technologies, with the introduction of many loads of different types of electricity, the quality of electricity received a general expansion, so it was detailed and defined more detailed than before [20]. So, it was better understood what effect these electric charges gave to the sinusoidal shape. In other words, the quality of electricity was analyzed more precisely. It is precisely these loads in question that bring damage to the current or sometimes even the voltage curve. These electrical loads are known as "non-linear loads".

2.2.4. The efforts made for the quality of electricity, as well as the problems related to it

It is often reasonable and necessary to know the quality of electricity. Our goal in this presentation is to know the quality of electricity in a university environment. The electric charges in question have increased the interest in this problem, especially with the new technologies that have been added to the engineering laboratories. Since these loads directly affect this quality of electricity, it became possible not only to understand the characteristics of the loads, but also to study this problem in more detail, arising from these various electrical loads.

Even recently, many users of electricity spend a lot and invest as much as possible so that the electricity they use has the desirable and satisfactory parameters for a more developed and modern technology. Also today, great efforts are made to reduce the losses of electrical networks, especially when we have long electrical lines and large electrical transmissions. So considerable economic efforts are made to increase the power factor, cosa. As we discussed above, at any moment, why not in the flow of time, at every second, those interested in the quality of electricity watch the progress of this quality through monitors of different types, where the character of the load is understood.

The quality of electricity is not constant with respect to time, but depends on the electrical loads, the quantity and sometimes even the quality of these electrical loads. Electrical loads, that is, electricity consumers are built for certain nominal parameters. The quality of work of electrical consumers depends on the quality of electricity and on the properties of these consumers themselves. In some cases, the same results can be achieved both by improving the quality of electricity and by changing the properties of consumers. It is usually more reasonable from the economic point of view to improve the quality of electricity [21].

In addition, the improvement of the quality of electricity also affects the improvement of the technical and economic indicators of the electric power system. The quality of electricity supply to consumers depends on the properties and operation of the electrical network. It is therefore recommended that it be designed and used with care. In order to ensure quality indicators, it is allowed in some cases to change the parameters of the electrical network or to use special installations. In the design phase, the most economical solution should be found to achieve the allowed sizes of quality indicators that are given in the implemented norms and standards. In addition, it should be taken into account that quality indicators change over time as a result of load changes.

2.2.5. The influence of non-linear electric loads on the quality of electricity

Non-linear loads distort the shape of electrical network quantities, such as current, voltage, frequency, etc. Modern industrial facilities are characterized by the widespread application of many nonlinear loads. Most of the time the loads considered as non-linear are electronic converters that allow the adaptation of the source (mains power, batteries, equipment sources etc.) towards the load requirements. These loads can constitute a significant part of the total load of the object and fill harmonic currents in the quality of the system, causing harmonic distortion in the voltage. Commercial loads are characterized by a large number of small harmonic and productive loads. Depending on the diversity and types of different loads, these small harmonic currents can add phase or cancel each other [22]. Harmonic currents produced by non-linear loads can interact negatively with the utility supply system. So, we don't have a true sine wave form of current or voltage. Non-linear loads contribute by adversely affecting power quality.

2.2.6. Voltage and current curves, true real electricity curves

In Figures 1 and 2 we saw a representation of the graph of this form, a curve without deformations, clean and without distortions. For study effect, the comparison between two curves, a true sinusoid and a deformed curve also highlights the quality of electricity. The Figures 1 and 2 show the effective value, since the amplitude is Umax=1.41*Ueffective.

While in the presentation above we showed a waveform that we really want to have, but in reality, it happens differently. Regarding the quality of the electricity, from the Oscilloscope observation, we notice that the voltage and current curves suffer deformations.

Of the forms we often get through various measurements, these depending on the time present deformations, compared to the pure form of the desired wave. This fact tells us that the quality of electricity varies significantly in these wave curves [23].

3. Results

3.1. Power Sight Apparatus

The constant change of the electrical load in the electrical network causes the constant change of voltage drops and losses in them, as a result the quality of the electricity also changes.

In our study, we will deal with one of the devices that enables the analysis of the above actions. The most practical, most usable device that enables this is Power Sight, power monitor 250.

The Power Sight family of power analyzers enables the measurement and analysis of all parameters, sizes of the electrical power network such as currents, voltages, active power, reactive power, frequency, full power as well as energy in KWh.

The view of this device with its accessories that enables the above actions to be performed, is presented in Figure 3.

Figure 3. Power Sight apparatus and other measuring accessories

This Power Sight device is connected to the computer as well as to the three-phase system where we want to make measurements related to the quality of electricity. In order to evaluate and analyze the quality of electricity, the device must be simultaneously connected to the computer and the three-phase system, where in our case with the three-phase transformer. It is reasonable to know how these connections are made.

3.2. Power Sight Manager program

With the help of this device, we make possible the graphic representations of the sizes of the electrical network. But in order to make this possible, there must be a computer program previously installed on the computer that collects the measurements made by this device. The program in question is known as Power Sight Manager. With the help of this program in question, all the sizes of the electrical network are displayed on the monitor, now presented graphically in relation to time. It shows how these sizes change over time. But the most important thing is that it also shows the time when problems and changes in the forms of graphs etc. occurred in the system. This software is installed on the computer where we want to make the measurements. It is important as it makes it possible to observe all the magnitudes of the electrical network parameters presented graphically. So, it gives the dependence of current, voltage, power, frequency, energy consumed depending on time, etc.

Through some views that we benefit from the Power Sight Manager program, this program that, as we said, must be installed on the computer, we make it possible to view the electrical quality on the computer monitor. The quality of electricity is evaluated by graphs, curves of electrical quantities such as current, tension, power, frequency, etc. So, it gives the dependence of current, voltage, power, frequency, energy consumed depending on time, etc. It is necessary to first know how the device and its program works and is used. In the following, the stages through which the progress of the work passes, up to the collection and processing of data [24] are given.

3.3. Connecting the device to the transformer, the connections to the electrical network and the computer

This Power Sight device that we showed above is connected to the computer, as well as to the three-phase system where we want to make measurements regarding the quality of electricity, in Figure 4.

After the electrical connections to the transformer are made, in order to make it possible to complete the measurements, the device must be connected to the computer, which serves for data collection. Let's see how these connections are made. While the connection of the device in a schematic way is shown as follows:

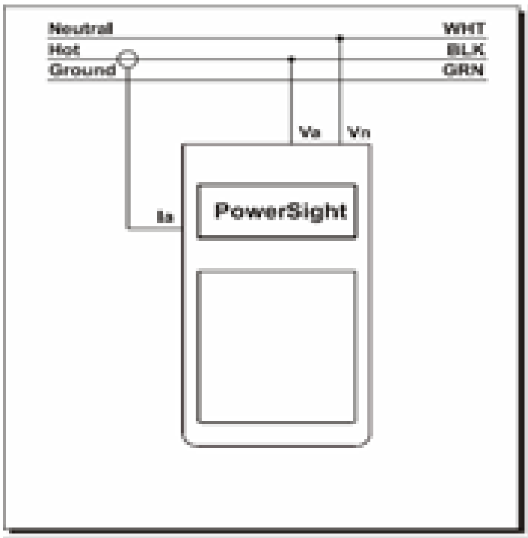


Figure 4. Schematic connection of the device to the single-phase electrical network

The device in question is also connected to the three-phase electrical system. This Power Sight apparatus that we showed above is connected to the computer, as well as to the three-phase system where we want to make measurements related to the quality of electricity. Let us show this schematically as follows:

A clearer picture of this figure is shown schematically in Figure 5:

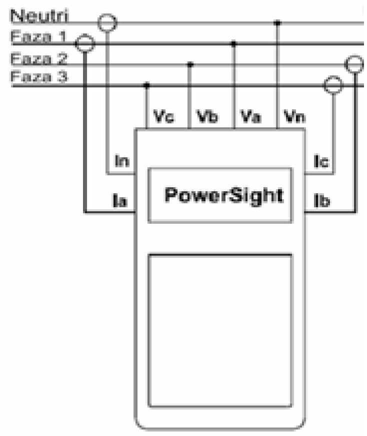


Figure 5. Connecting the device to the three-phase electrical system

3.4. Development of measurements

Since our goal is to "monitor" the quality of electricity in a university environment for a period of one week, there is a need to determine all the parameters of the electrical network, already displayed on the computer screen. So, in short, let's look at the progress of the change in the quality of electricity and this at different times. After making the possible electrical connections that make the measurements, the measurement process begins, which is made possible by the Power Sight device. It was considered reasonable to take measurements no more than twice a day. The first group of measurements recorded by the device were made from 10:00 in the morning, when the electrical load was maximum, in other words, the equipment was put into normal use. While the second measurements are made from 15:00, which means that the electrical load is minimized, or in other words the electrical system is not very loaded. These measurements at different times were performed twice a day. The progress of the measurements continued for a period of one week. This time is enough to make a proper analysis of the quality of electricity [25].

We also noticed the changes in the graph of the electrical system parameters at different measurement times. Rather, we will focus on the changes in the current and voltage curves, the way they change. So, eventually we will analyze the quality of electricity in this environment. Even more so in the case when the electrical system has a large load, as well as in the case when the electrical load is small. The measurements were performed at the three-phase transformer that supplied part of the university environment. At the periphery of this power transformer there was also the Power Sight device, as well as the computer that collected the data, already connected between them. Finally, after the measurement process, the data obtained from them are grouped, systematized and finally results and conclusions are drawn, always understood based on the quality of electricity. From the apparatus that makes it possible for us to monitor the electricity, the corresponding graphs were obtained for each size of the electrical network.

3.5. Measurement results

From the analysis we did in the university environment, precisely to see the quality of electricity in the equipment that was there, it must be said that we made it possible to evaluate this quality. So, in other words, we observed the distribution of currents in these computer devices. All dimensions of the electrical network were analyzed, starting with the most important ones, which are current, voltage, power, etc. We also saw how the currents were distributed through the three phases. In order to see the current absorption of the electrical equipment, which were located in this environment that we analyzed at the university, we carried out a one-week work of measurements. Electrical loads, as they are known, are computer loads in this environment where the measurements were carried out.

This instrument enables the user to maintain the main characteristics of the quality of the electrical network, while also giving many calculation values and many functions to the process with the highest standards.

The installations of the Department of Engineering building, on the four floors, include many classrooms, cabinets, laboratories, offices, personal computers, printers, video projectors, etc. Since in this environment, where we focused to analyze the quality of electricity, most of the electrical equipment is computer equipment, there is a need to group these electrical loads, as well as to make differences in terms of features of them, so it was observed how the currents are absorbed. Let's divide these loads into two groups and it is necessary to analyze them. The analysis focused on Power Quality [26].

3.6. Analyzing measurements

3.6.1. Computers and accompanying loads

Voltage and inhaled electric currents were monitored for the most important loads in this multifunctional building. The Figure 6 shows the voltage and electric currents inhaled for specific electronic loads.

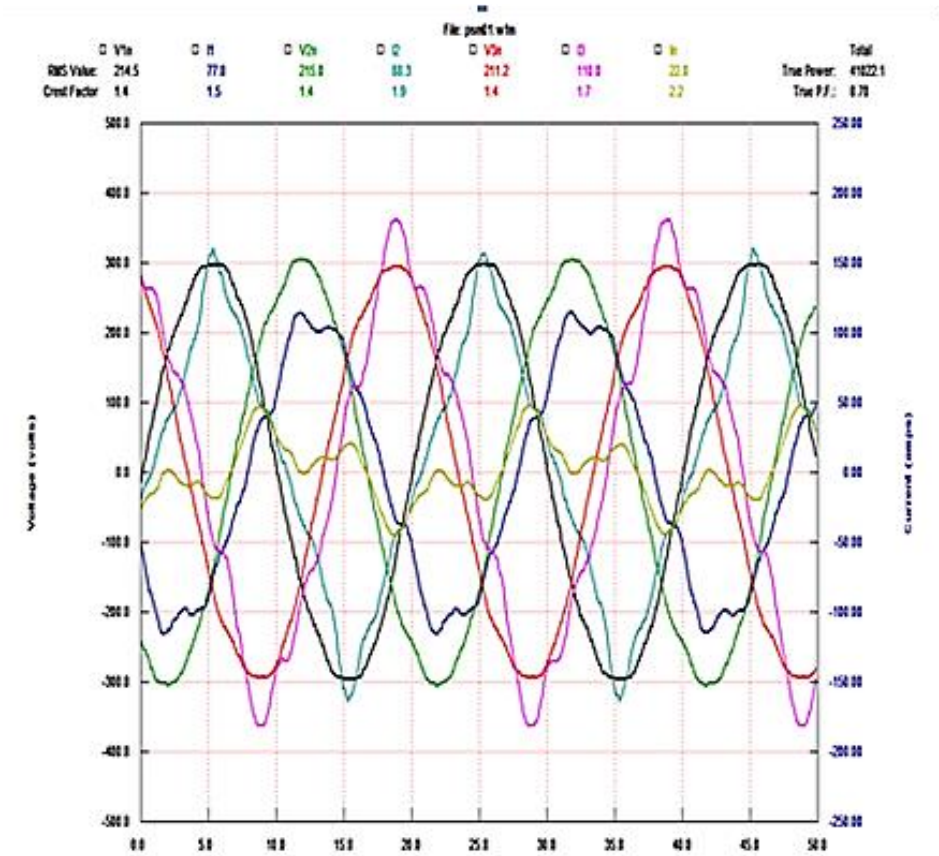


Figure 6. Voltage and electric currents

A high level of harmonics was recorded in these loads. The characteristic amplitude of the harmonic components for all loads is 3. The 3rd harmonic becomes an important issue for current-flow systems in the neutral and produces two typical problems: neutral overload and telephone interference. These are also some reports of the device malfunctioning. Harmonics greater than third, e.g., the seventh have an amplitude of, which is about 50% of the main value for personal computers.

3.6.2. Other loads, lighting equipment, etc.

A similar analysis was performed for loads other than ignition. The Figure 7 shows the voltage and currents drawn for the rest of the loads, such as printers, photocopiers, video projectors, etc. As it was supposed to occur the voltage distortion value at this point of the distribution network is identical to the previous point. In the periods of the day, the absorption current takes the highest value, but this does not correspond only to the periods of the lowest load factor. There are also situations when these absorption currents take the maximum values for half of the maximum daily load. We must note that the absorbed currents never reach values less than 15%, as it is in the period where the absorbed electric current corresponds to the maximum current. Let us show the absorption of currents and voltages as follows:

When there are disturbances in the electrical power system, as will be defined in the next section, i.e., voltage distortions. When these distortions exceed certain levels, equipment outages or damage can result "somewhere". It must be said that these deviations of the shape of the sinusoidal voltage, especially when they occur instantaneously, for a sensitive electronic device, put it out of use. These devices must be connected to protection, which can be used to protect consumers from their effects. Because there are devices that, for an increase in voltage above the permitted one, i.e., above the nominal one, not only can this device be out of use, but for one reason or another it can also have "explosive" capabilities.

While in a special way, we show the voltage and electric current obtained from these electrical loads in one phase, which in this case is the first phase. This is to make more detailed the difference of the change of forms of these electrical parameters.

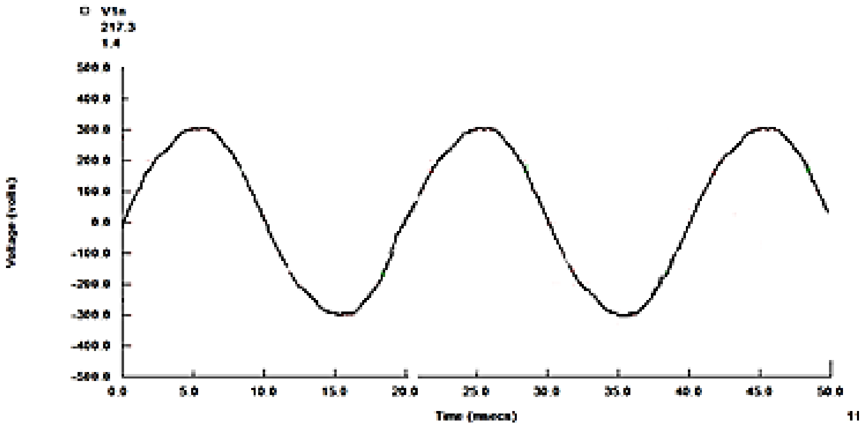


Figure 7. Voltage graph for the first phase, the amplitude is also indicated, which marks the value of 217.3v

Above we saw the voltage that the loads receive, that is the food for these loads. Now let's see the current that these computer loads take.

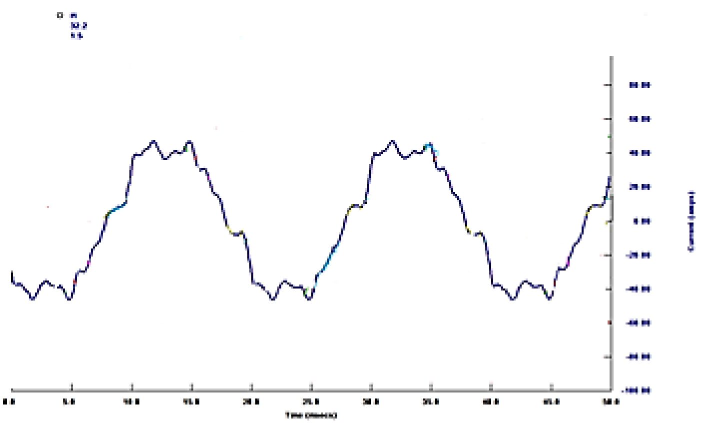


Figure 8. Current diagram for the first phase, the current value is clearly visible, which is 32.2A.

It is easy to see that the biggest changes in the curves of these parameters are precisely those of the current. Since the electrical system is three-phase, for ease of study, we have presented the voltage and current of one phase that absorb the loads, precisely the voltage and current of the first phase. It is reasonable to observe the change of the curves of the graphs of currents and voltages, respectively at different times.

Therefore, below we are showing the currents and voltages that the electric loads receive, exactly at 14:00.

3.7. Time dependences of electrical system sizes

3.7.1. Presentation of currents

In a more concise way, we present in Figure 9 both the currents and the voltages that we get in the electrical loads and this for the three phases as well as for the neutron.

Here they seem more reflected and more meaningful, the more we are convinced that the currents are always more "sensitive" to deformation and deviation. The voltages where their curve keeps its shape the same as the voltage of the food source.

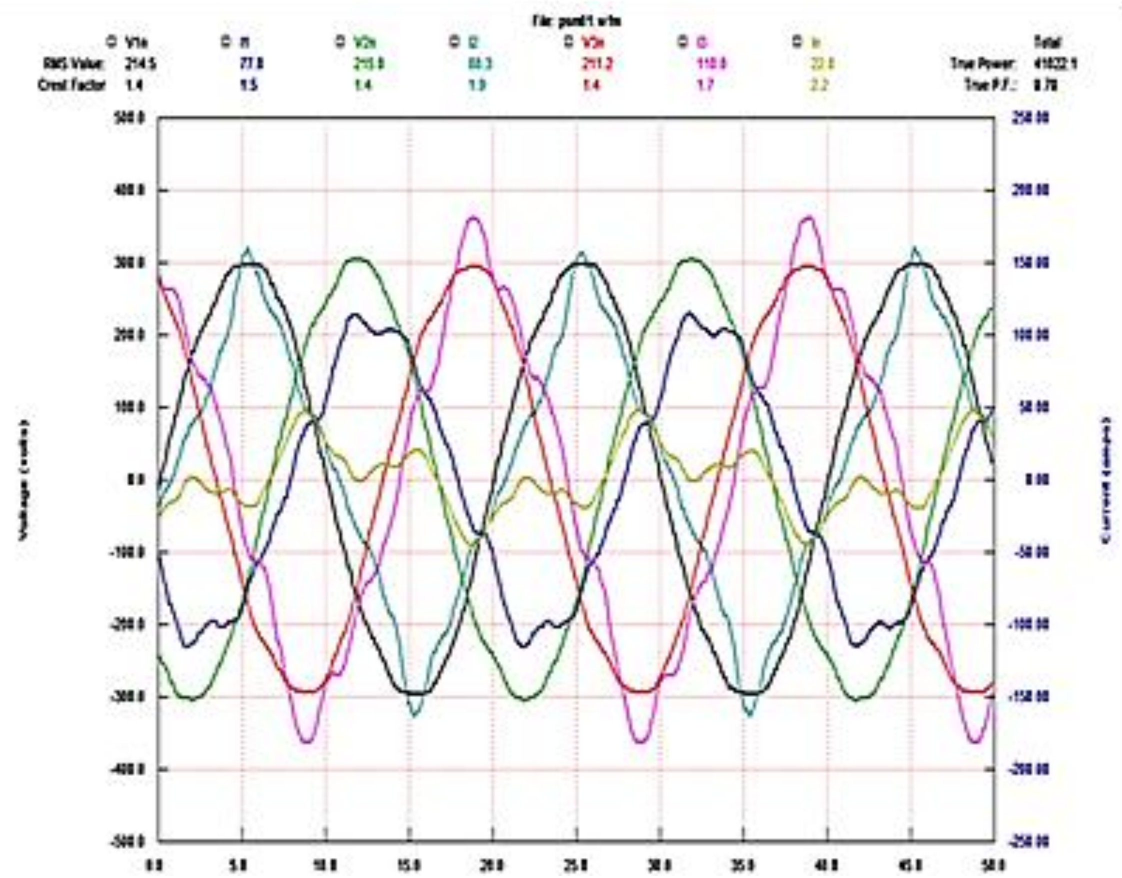


Figure 9. Currents and voltages absorbing electric charges

The presentation of the tensions in the first, second and third phase is shown graphically. As can be seen from the Figure 10, the voltage curves are not deformable. It is also clear that the amplitude of the voltage is 217.3V, this is for the first phase. In general, the voltage curves do not break their shape. The most sensitive to deformation are the current curves, while the frequency graph is a straight line, which passes at the value of 50. This shows that the frequency is constant with time at the value of 50Hz. In any case of failure, the frequency may fluctuate above or below the value of the constant 50hz, but it is still stabilized at the allowed value.

In summary, the currents and voltages for the three phases are given, as well as their respective amplitudes.

Now let's show these same graphs, which we talked about a little while ago, but now at the next measurement hour, at 10:00. We do this to see more clearly the changes in the shapes of the current and voltage curves. These tests will inform us more about the assessment of the quality of electricity as well as the dependence of this quality of energy on electrical loads. So, we make it possible to distinguish between these graphs at different times. In other words, we will see in which of the examined cases the electricity has good quality.

Let's show the case when the measurements are made at 10:00. Below are the corresponding graphs.

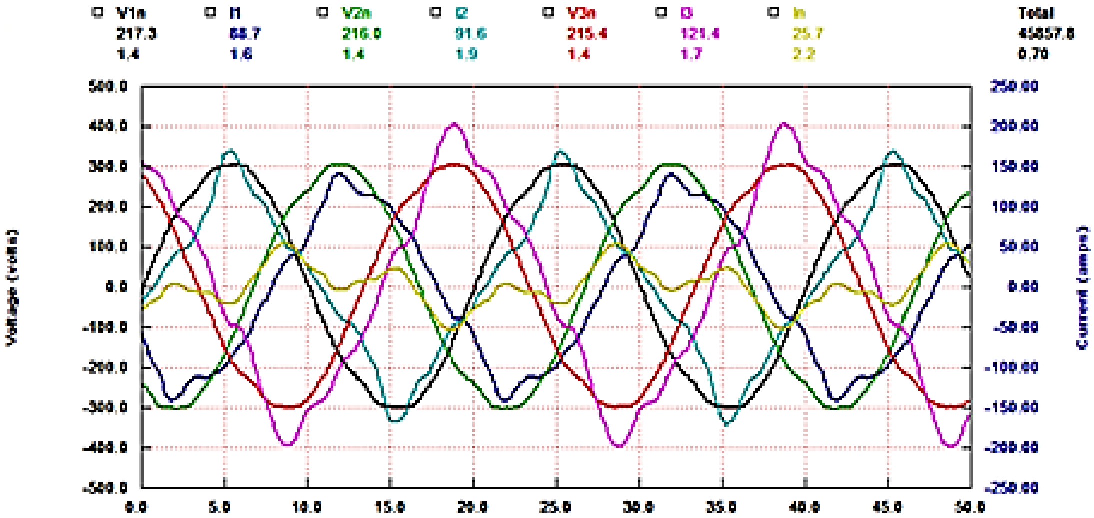


Figure 10. The graph of the forms of voltages and currents for the three phases

Above are shown graphically the presentation of current and voltage depending on time (t). It is understood that since we are dealing with a three-phase electrical system, the Figure 11 also shows the curves for the three phases a, b, c. It is clear that the current graphs are more deformed than the thesis graphs. It is known that the maximum values of currents and voltages are also marked on the graph. The largest current value is marked 32.2A and this value is in phase a of the three-phase electrical system. Here the electric currents drawn by the electric charges are shown. It is clear that they do not belong to a sinusoidal form. But this contradicts our interest since we want a sinusoidal shape of the current wave. This fact tells us that it is always the currents that have the biggest deformations. From here we say that the quality of electricity is poor [27].

In order to further deepen the idea that electric currents have more deformations in the form of waves, below we analyze the representations of the currents of the three-phase system. It seems clear that we are not dealing with sinusoidal forms of currents. In fact, we do not have a known a priori law or a certain dependence of the current on time.

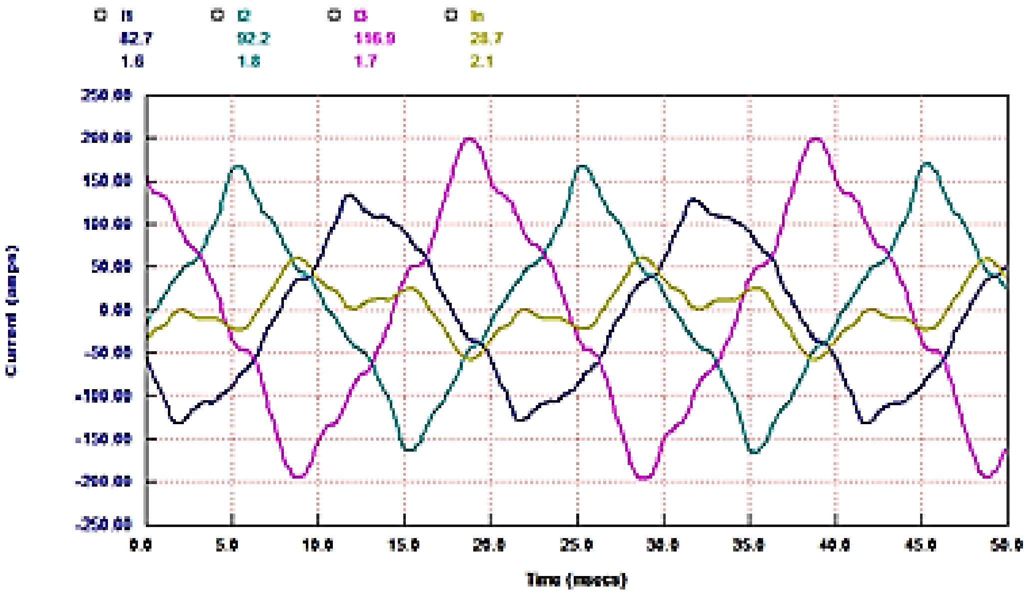


Figure 11. Current graph of the three-phase system

While in another form we reflect the presentation of the currents in the following way. The amplitudes of the currents are also clearly visible in the Figure 12.

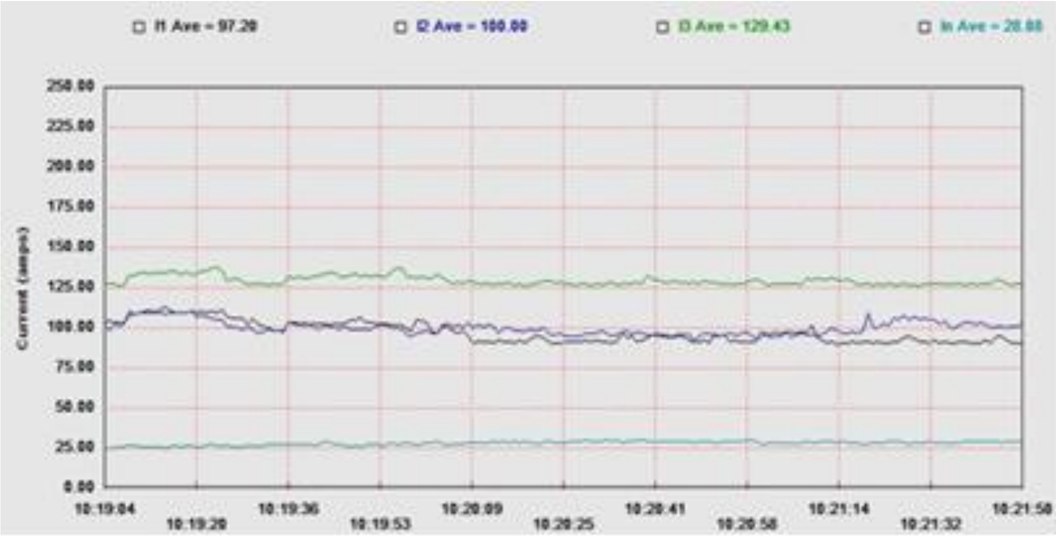


Figure 12. Graph with current amplitudes of the three-phase system

3.7.2. Stages tensions

From what we have explained above, now let's show the graphical representation of the three-phase the tensions, i.e., the voltages that serve as a food source for computer equipment (Figure 13).

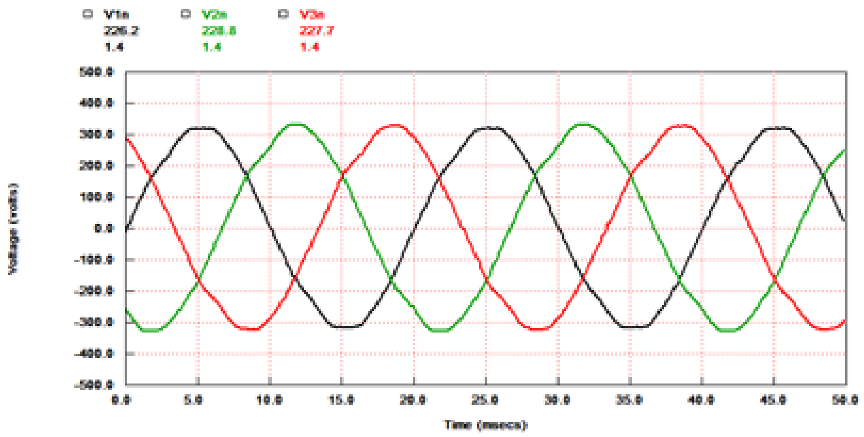


Figure 13. Graphs of theses of the three phases

Here, the voltage absorbed by the connected loads in the university environment, where we made the measurements, is given in Figure 14. We see that the voltage curve is almost sinusoidal, which means that there is generally no distortion in the voltage curve.

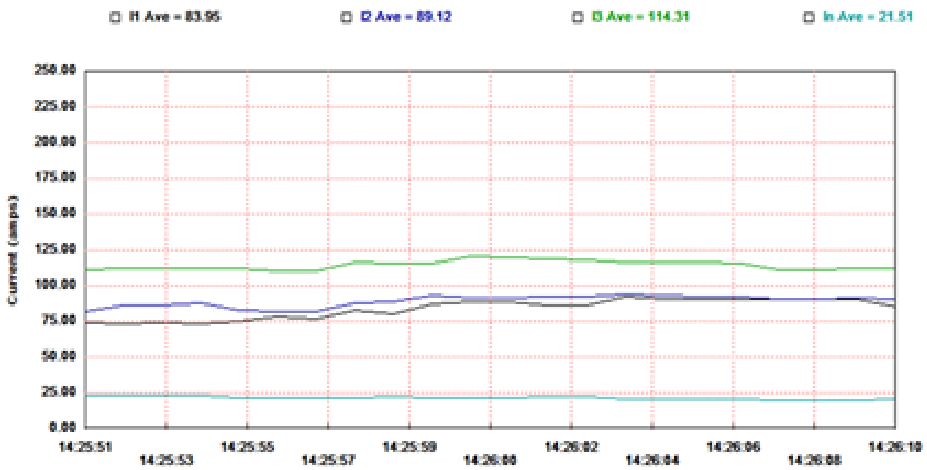


Figure 14. The graph with the deformations of the three phases

Here the phase currents of all three phases of the electrical system are given, understood together with the neutral current. The value changes of the currents are also clearly visible graphically. So, for every four seconds we have other current values. All changes in value come as a result of voltage fluctuations.

3.7.3. Electric network frequency

The frequency is one of the sizes of the electricity grid. It plays an important role in electricity systemization, especially in the production of electricity, in the distribution of the same energy, as well as in transmission to the final consumer. At every moment of the time the frequency should not change, it should be kept constant, as it can present serious risks to both equipment in general and in people's lives. In our country, the frequency is worth 50 Hz. According to interests, many countries around the world do not have 50 Hz this frequency. For example, in North America the frequency is the value of 60 Hz.

This has an effect or plays a major role on electrical charges in general. Since an electrical device has its nominal parameters of use. When these parameters are not preserved, then we have the malfunction of the device up to its destruction. Therefore, for these and other reasons, it is recommended that in our country the frequency be at the value of 50hz.

Now we graphically see the progress of the frequency change in the equipment of the university environment, where we performed the measurements.

The change of frequency depending on the time is given in Figure 15.

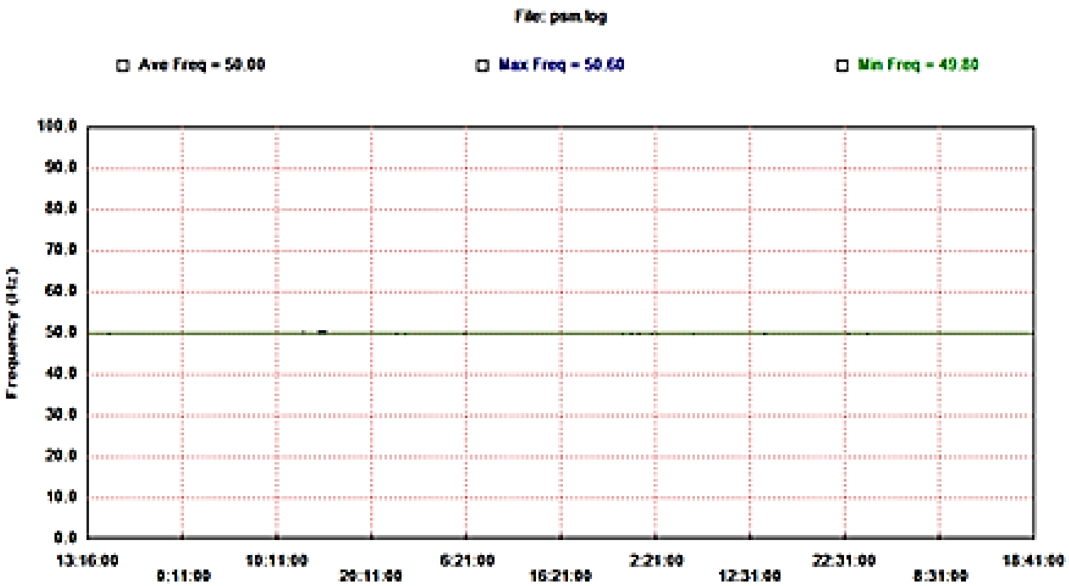


Figure 15. Frequency change graph depending on time

It is worth mentioning that the frequency graph is nothing but a straight line, which has the value of 50Hz, as it should be actually. But the graph also shows very clearly the fluctuations that the electrical system has had in terms of frequency. It is not always determined that the frequency is at 50Hz fixed value, but as a result of "oscillations", changes that the electrical system may undergo, the frequency fluctuates in very small values, as shown in the figure.

3.7.4. Wasted energy

While here the energy for each phase of the electrical system is shown, as well as their summator, i.e., the total. We see that we do not have overlapping graphs (Figure 16), which in engineering language says that the energy is not distributed equally in the three phases of the system.

Let's graphically show the active power for the three phases of the system. Respectively, they are given in color, while their summator, i.e., the full total power, is shown in blue. The amplitude of this magnitude reaches the value of 48797.9 W as shown in the Figure 17. Algebraically, the total power for all three phases is given as: $P=u_1*i_1+u_2*i_2+u_3i_3$ (W).

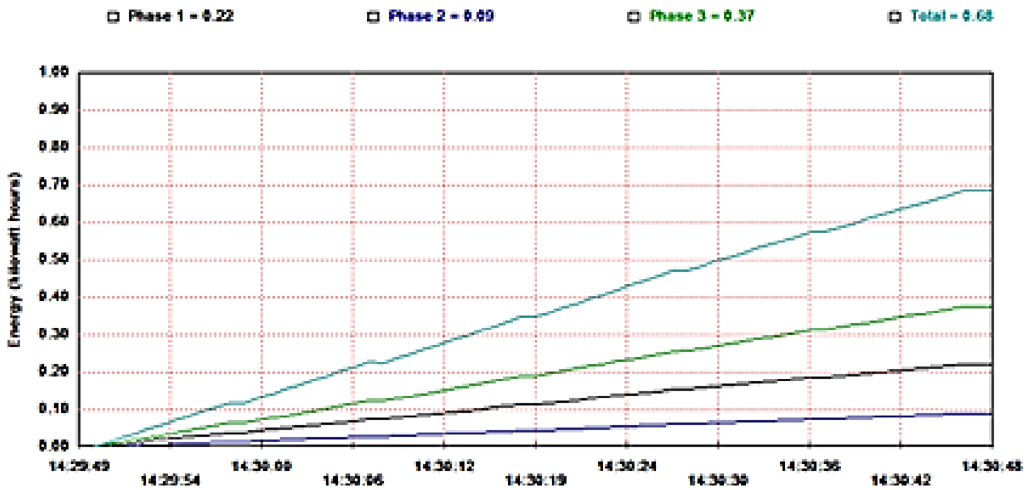


Figure 16. Graph with the adder of three phases

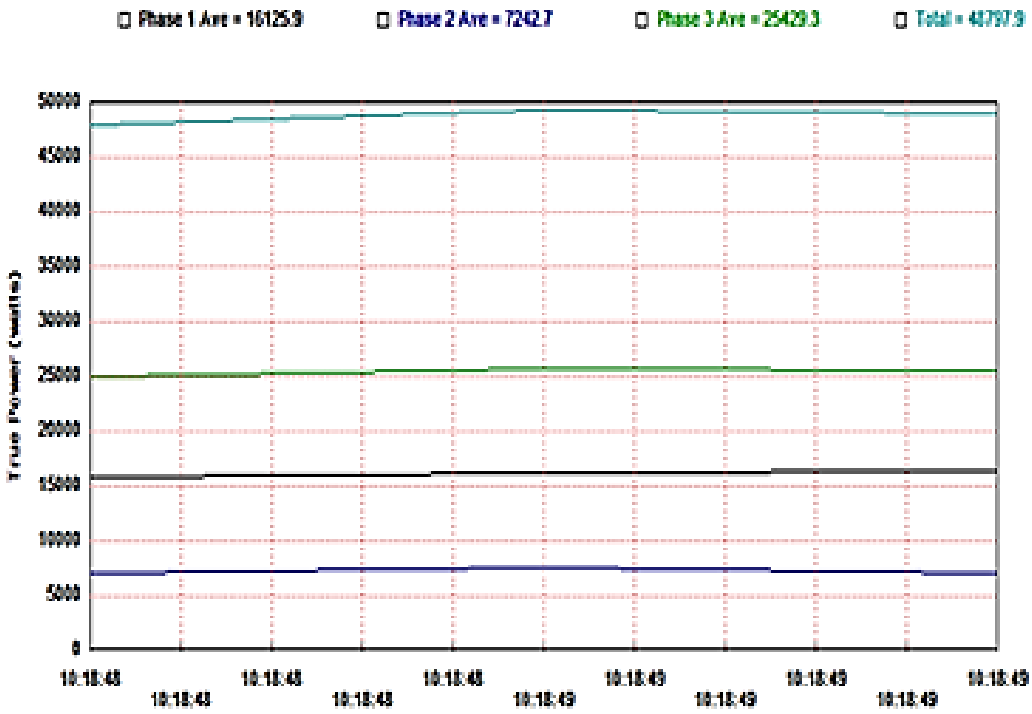
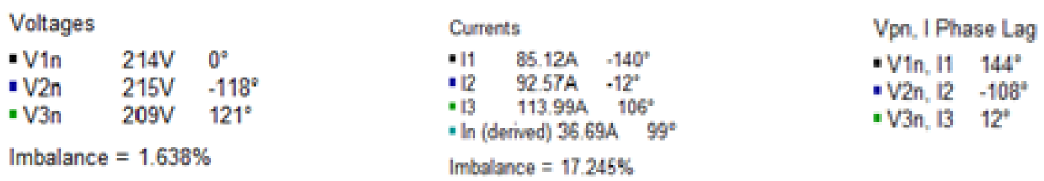


Figure 17. Graph for the three phases of the active power system

The following figure shows the reactive power as a function of time. The black color shows the power for the first stage, while the other color shows the total power. We see that there is no constant value, but it changes gradually, there are fluctuations.

In the graphic representations of voltages and currents we also saw their corresponding sizes. Summarizing their amplitudes as follows, then we will finally have:



The phasing between current and voltage is shown above. This fact lets us know that, in this case, we are not dealing with a symmetrical three-phase system. Since, as we know, for an electrical system to be symmetrical, it is enough that the amplitudes of each phase must be the same, but also their phasing in time must be 120^0.

4. Discussion

Monitoring and evaluation of the quality of electricity in the energy consuming building, where mainly the consuming units are computer units.

The term "Power Quality" has been applied to a wide variety of many power system phenomena. The increasing application of electronic devices as well as the production and distribution of distributed electricity generation has increased the interest in power quality in recent years, and this has been accompanied by the development of a special terminology to describe "phenomena" in direction of evaluation of the quality of electricity supply.

In recent years, non-linear loads have increased in size mainly with the spread of computer equipment, printers, fans, heaters, air-conditioning systems, refrigerators, elevators, etc. Most of the time the loads considered as non-linear are electronic converters that allow the source to be adapted to the load requirements. Today these converters are used in a large number of industrial or household appliances, mainly computers and peripherals. However, the use of these devices in electrical installations contributes to the quality of the supplier's electricity, in particular the operator of the distribution system. These converters are sources of connection of high-order harmonics that in certain cases aggravate or cause malfunction of consumer devices sensitive to the quality of the power supply.

In the paper, the monitoring of electricity in a part of the building of a university environment, namely the building of the Department of Engineering at the Albanian University, was considered and analyzed separately. This choice for monitoring was made because usually schools, universities, etc., are users of many computers' equipment and Information Technology.

Power Network Analyzer "Power Sight 250" which still serves to measure/monitor and analyze the quality parameters of the power network. It includes many important measuring/monitoring and analyzing functions, within a single instrument. Combined with the "PowerSight Manager PSM" application program, the instrument enables an in-depth "off-line" analysis of the quality parameters monitoring process.

The family of power quality analyzers enables real-time measurement and monitoring of all analog power grid quantities such as voltage and current waveforms, frequency, active, reactive and total power, energy and power factor. The PS250 analyzer is used for case studies and monitoring of power grid parameters. PS250 is designed for communication with a PC interface and then processing and analyzing this data through the PSM program. In this way, it is possible to visualize the waveform of voltage, current, the angle of displacement between them, these data, after being processed by the program, enable spectral analysis of harmonics, vector diagram, fluctuations, interruptions, asymmetry of voltage, voltage/current, etc.

Figure 18 shows the viewing window of the form of currents and voltage for the monitored three-phase system. Here, two complete cycles of sinusoids with a time of 50 mS are triggered by the process. From the visual inspection, we noticed that the shape of the sinusoids deviates from their ideal shape. This deviation is visually more noticeable for the curves that present the law of current change, and especially with the naked eye it is noticeable that the curve of the neutral conductor current is much more deformed than those of the phase currents, while those of the voltages appear in a form much more regular compared to current curves.

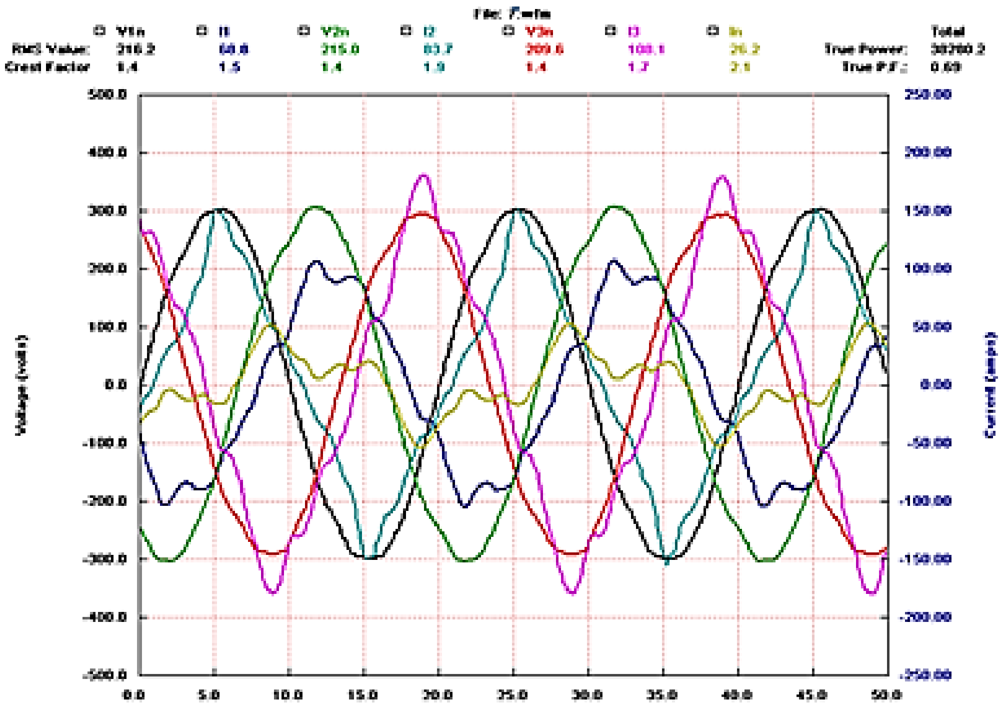


Figure 18. The graphic presentation of analog voltage / current quantities for the three-phase system

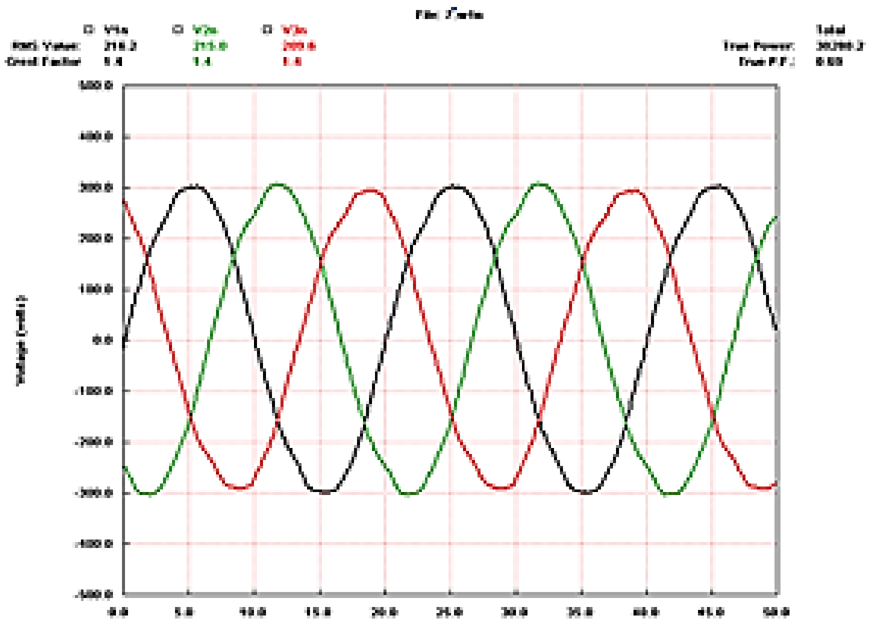


Figure 19. Graphical presentation of analog values of the three-phase voltage system at the 0.4 kV level

5. Conclusion

Disturbances such as voltage drop, under voltage, over voltage are present only in 3% of the monitoring window and do not constitute concerns for the computer and ICT equipment in the monitored building.

In the case of the monitoring carried out by us, the data analysis process was carried out exclusively by the "Power Sight 250" measuring/monitoring instrument.

The sinusoidal waveform of the observed voltage does not consist only of the fundamental harmonics. The data collected during the monitoring period were analyzed and provide the necessary information regarding the performance of the quality of the electricity supply to the building of the Engineering Department.

For minimum load the symmetry is preserved, while for the peak load the symmetry is broken. The voltage profile is affected by the load change. The effective value of voltage and frequency for the minimum load period is within the permissible limits.

Acknowledgement

This study was partly presented at the 5th Advanced Engineering Days [28].

Funding

This research received no external funding.

Author contributions

Fatmir Basholli: Conceptualization, Methodology, Software, Validation, Writing-Original draft **Adisa Daberdini:** Data curation, Visualization, Investigation, Software, Validation, Writing-Reviewing and Editing

Conflicts of interest

The authors declare no conflicts of interest.

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