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DESIGN AND CONSTRUCTION MONITORING SYSTEM PARAMETERS OF POWER QUALITY

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Abstract- After providing power electronic devices, power quality in the industries more and more was considered. The defined parameters and new standards for power quality, displaying and monitoring of these parameters among the topics are important and significant. The project design and construction of an example of a data acquisition system (data logger) is explained. Firstly, power quality and parameters will be introduced to it. Then the algorithm for finding the harmonic signal analysis is discussed. In this paper, a system is designed that as acceptable quality problems can be identified and measured by sensors Hall effect for sample voltages and current systems. Data acquisition for data transfers to computer and two examples of software by the Lab VIEW and C is designed and used for signal analysis. This system detects voltage and current harmonics up to 121th component's and flicker on voltage detection; diagnosis and records the voltage drop as well as determines the abnormal voltage and current wave form of the harmonics in the power network.

Keywords: Power Quality, Harmonic, Interharmonics, Fast Fourier, Frequency Spectrum, Flicker, Hall Effect.

I. INTRODUCTION

Factors involved in power quality can include the following options:

A. Power Quality

Variance of changes includes the partial displacement of voltage and current and their ideal nominal values. This shift can be effective in the signals amount and frequency value. The variance of changes and the results are production disorder in the harmonic signals.

B. Events

The words such as definite and drastic changes or loss of switching voltages are created occasionally. The most important feature is that they are non-periodic and in the event of certain specified limits (for example, 5 percent or 10 percent nominal) are violated.

In this paper a complete data acquisition and signal processing PC based harmonic power analyzer system is proposed, designed, implemented, and the results are presented. In [3] the system were explain that can show the harmonic spectrum and in system of [4] monitor the voltage drops and harmonics and in [5] monitor and analyses the power fluctuations and in [6] system we able to see current harmonics a THD. But we have designed the system with all of above capabilities and extra monitorings such as calculating of interharmonics, and to 128th harmonics of current and voltage, measuring of lighting flicker with graphic facilities and high accuracy.

II. HARMONIC DISTURBANCES

When we talk about the harmonic to this point, we math "Every Non-sinusoidal alternating signal can be converted through February series into a sinus collection". Thus we have:

$$x(t)=\sum_{-\infty}^{+\infty} A_n \cos(2n\pi .t/T+\phi_n) \quad (1)$$

The amplitude (A_n) and the phase (*jn*), are related to *n*th harmonic. Also, it come from above relation that the frequency of harmonic nth (f_n), is equal to $n\,f_0$ that f_0 main frequency and is equal to 50 Hz. In signal analysis as above can be cited the following issues:

- Disorder harmonic is obvious that for non-sinusoidal or intermittent signals has been proposed. Many articles and essays only confine the limits. There are exceptions of DC component in the case is harmonic.
- Unlike the harmonic frequency with the correct coefficient of the main frequency (50 or 60 Hz are) there are components that have a frequency coefficient non-authentic of main frequency and the between harmonic disturbances are known.
- Under the harmonic components which are less frequency components of the main frequency network we can discuss them in under the harmonic placed between harmonics.
- One of other cases discussed in the harmonics is the voltage flicker or more precisely that voltage fluctuations (flickers) light can cause. Human eye will recognize the oscillations from 1 to 15 Hz.
- Noise includes all signals that unwanted and non-alternative signals.

III. HARMONIC WAVE FROM ABNORMALITIES RESOURCES

In fact, harmonic disturbances by nonlinear elements in the network are existing subscribers loads occur. The main cause of these disorders is produced by electronic equipment in industrial loads such as TV, computers, motor drives and controls of the furnace temperature, etc. [7].

This paper to speed up analysis of discrete-time signals instead of DFT or Fast Fourier and we recommend this method for an example with N = 8 samples fully perused.

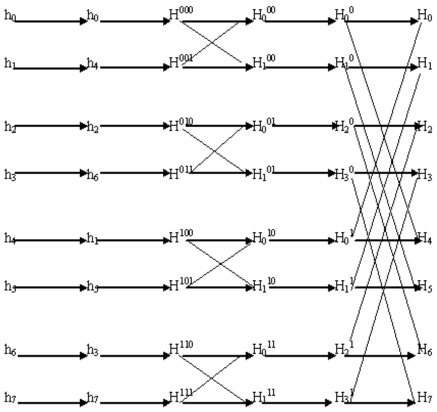

Figure 1. A simple of Billet algorithm for N = 8

A. Interharmonics

This entry form is official and one standard by the IEC-1000-2-1 was expressed as follows:

The harmonic voltage and current: there are some harmonic that coefficients of the proper frequency and major network not only to the spectrum or bandwidth are observed also in the recent revision in the IEC-1000-2-2 interharmonics As such, some definitions have all the harmonic coefficient of frequency of home network is not correct to say interharmonics

B. Mathematical Principles in the Harmonic and Analytic in Fourier

A discussion harmonic topic in principle based on Fourier is expressed. According to Fourier transformation, each signal that the following conditions can be as a total of sinus and cosine of infinity wrote:

The desired function must be a periodic function with period T that is the desired function at a distance $-T/2 < t < T/2$ as a continuous piece and a means that can be counted in points and discontinuous at discontinuity points with some left right and non-infinity. According to discussed analysis of the function $x(t)$ with period T we have:

$$x(t) = \sum_{n=-\infty}^{\infty} C_n e^{jn\omega t} \tag{2}$$

where $1/T$ is the main applied frequency. $C_n(t)$ is nth harmonic coefficient. This shows that a non-sinusoidal signal with an infinite number of harmonic. The fact is important in the Fourier transformation, the signal in frequency domain and time domain with the amount of time is unlimited. To determine the coefficients function for $x(t)$ a computer systems analysis is necessary related to the desired sampled signal. In this case the signal in time domain and frequency domain with the length is limited. If a signal with period T and sampling frequency $1/T_s$ at every cycle take samples N, we will:

$$T_s = T/N$$

$$f(k) = \sum_{k=-\infty}^{\infty} C_k(n) e^{j\frac{2k\pi.n}{N}} \tag{3}$$

$$C_k(n) = \sum_{n=0}^{N-1} f(n) e^{j\frac{2n\pi.k}{N}}$$

where $\omega = \dfrac{2\pi}{T}$ is the angular frequency. Relations of above sampling cycle (N samples) was carried out after every N sample signal is repeated again. Angular frequency accuracy in this case is equal:

$$\Delta\omega = \frac{2\pi}{T} = \omega_1 \tag{4}$$

In above conditions, when $N_\mu T$ is correct then all the signal of main frequency coefficients will be visible. But the data value (N) cycle is proportional to the number of p. In this case $N_\mu pT$ as the angular frequency accuracy is equal to:

$$\Delta\omega = \frac{2\pi}{pT} = \frac{\omega_1}{p} \tag{5}$$

So with regard to more than one cycle of the signal we will be able to have harmonic coefficient of the correct frequencies as the main come. The definition according to IEC between harmonics is the same. In short, it can be expressed by only a necessary condition for the use of the harmonic number of samples in more than one cycle to cover. For example, if we cycle a 5 to frequency 50 Hz, we applied DFT frequency accuracy equal to D_f=50/5=10 Hz. Therefore, we able to detect frequencies 10, 20, 30, … Hz. This example shows that selecting a suitable window size (number of cycles appropriate) to all the harmonics will be corrected. Let the signal have the following:

Frequency of 75 Hz between main frequency and second harmonic and the harmonic one is real. If a sampling of 50 Hz, two cycles to do (window length t = 40ms) in this case would be 25 times the frequency accuracy. Therefore, our 50 and 75 Hz frequency spectrum will have to:

$$x(t) = \sin(2\pi.50t) + 0.5\sin(2\pi.75t)$$

This example is cases of correct selected window showing the sampling. But where there are characteristics that cause leakage and disproportion in the DFT in harmonic spectrum are produced such that they do not exist or value is false. Suppose the example above with the signal applied to the sampling cycle is two (40ms) and expressed with a signal harmonic is 85 Hz. Therefore expressed in the window 3.4 cycle of this signal will be sampled, so in the window will be not fully sampled at the 85 H signal. Thus, signaling by the DFT can be seen other than the actual signal will be produced and this component is unrealistic. In this case the leakage error in the DFT says the relations.

One of the best generators of harmonic is cycle-convectors. The harmonics produced by cycle-convectors following relationships are obtained:

$$f_i = (p_1 n \pm 1) f + p_2 n f_o \qquad (6)$$

In which

p_1: Number of single pulse destination instrument;
f: frequency power source (network);
p_2: Number pulse output section;
f_o: output frequency of cycle and converter ;
n: the numbers are correct [8].

IV. HARDWARE OF PROJECT

In this section we introduce equipment and instruments for measuring machine and sampling system, which it will include:

1- Hall effect sensors which as CT for the sampling are used.

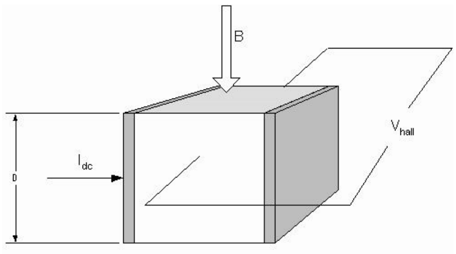

Figure 2. Hall Effect in semiconductor wafer

For sampling of voltage and current signals it is required to use of converters with linear magnetic characteristics have no saturation phenomenon. For this purpose the Hall effective converts used voltage and current in interest lies.

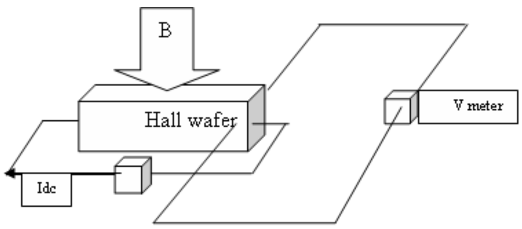

Figure 3. Hall generator diagram

2- Data acquisition cards as an intermediary for the sampling of analog signals are used.

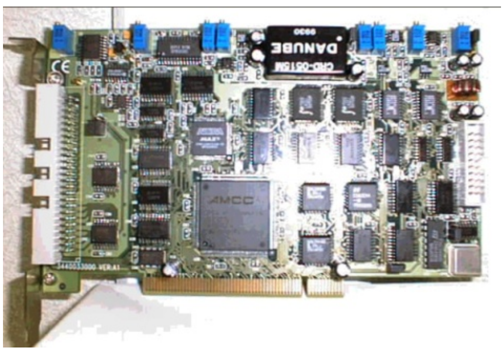

Figure 4. The DAQ card used

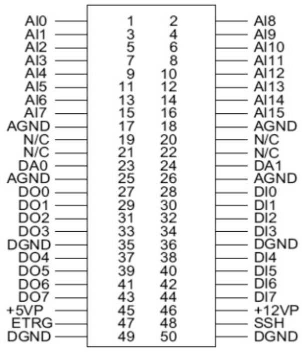

Figure 5. Connector 50 pin of DAQ card

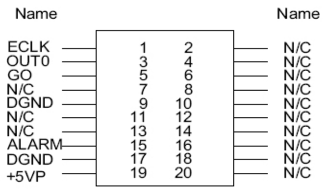

Figure 6. Connector 20 pins of DAQ card

3- Serial ports

4- Personal computers for the program have been used in construction

5- Auxiliary circuit for sampling

As previously mentioned, signal analysis program Lab VIEW software has been designed in a Lab VIEW Graphical Programming Environment and on this basis all program operations through the block diagram of such building which is built is done. Thus the entire operations plan as a form of construction is shown. Program designed to include two front panels and block diagram. All about looking through the front panel are provided. Parameters of the desired information in two categories and the moment have been divided into periodic information. Because of this classification is all the calculations done in each cycle increases the computing time and hence the data loss of some cycles can be saved and the volume of information required is the space above the Memory Stick. Our software front panel divided into three main sections that each has its own information desk. This section contains settings information moment and finally the data is periodic.

In Information of moment menu all the information that a moment can be calculated as is shown. Figures 5-6 show the connectors pin information of the chips. Figure 7 shows the view menu of moment information which information menu in the menu periodic information is as periodic calculation is shown.

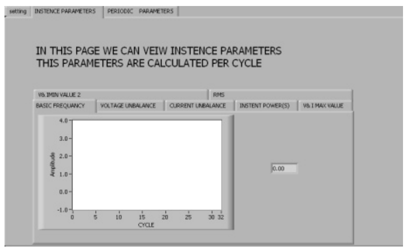

Figure 7. Menu of moment information

V. INTRODUCES SUBPROGRAM OF SYSTEM

In this section we introduce relations used to achieve the standards expressed in the parameters. Calculation is done in the general case of two harmonic calculation and calculation of divided parameters. View program in Figure 8 is part of the arithmetic operations are carried out. View program in Figure 9 is also part of the operation of data entry is done.

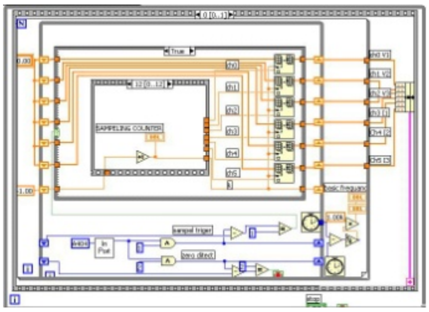

Figure 8. The main plank of the sampling operation

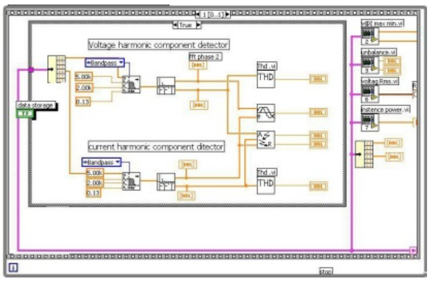

Figure 9. Part of the program that will do arithmetic operations

A. Program Calculated Harmonic Frequencies

The main part of calculations, including harmonic components is calculated. Already in the second season we completely talk about on how to calculate the components of harmonics through the FFT algorithm. According to discussion in Part III through the FFT algorithm the harmonics can be calculated to high speed signals to achieve the coefficient. The block diagram of program design in Lab VIEW is shown in Figure 10.

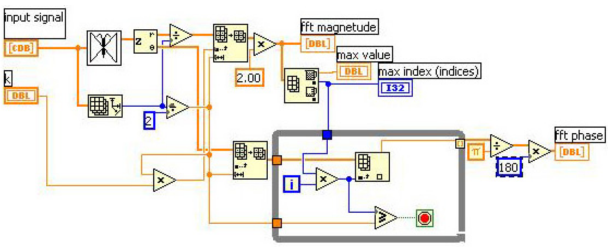

Figure 10. Block diagram to calculate the FFT

The program shown in the block diagram is the butterfly computation operation. Butterfly algorithm is a recursive relationship is done and ultimately the amount of amplitude which the phase is determined. Domain license must be obtained from the algorithm in the number of samples to be classified into one cycle effective value of each harmonic component obtained. The results of this program shows under the frequency range of 1 Hz frequency carefully.

B. Computing Power Quality Parameters

After the main stage calculations including calculations FFT, having a sample voltage, current and harmonic components is done. They can be all about power quality parameters including the amount of active power and reactive power, etc. To more introduce of these outlines, the voltage and current values and their maximum of the moment are showing how the signals form.

Figure 11 shows the maximum amount of voltage and current. The moment value in Figure 12 shows how a moment for the three phases separately. Figure 13 shows the block diagram of the programs related to maximum voltage and current values.

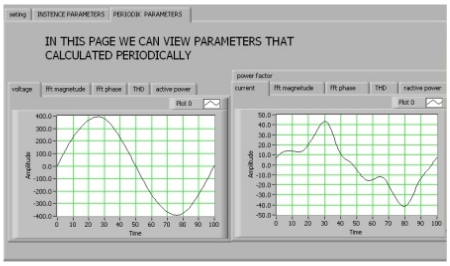

Figure 11. Display signals sampled

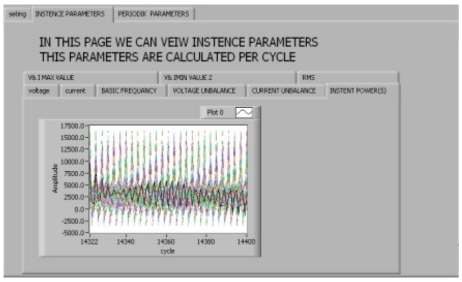

Figure 12. Display apparent power moment

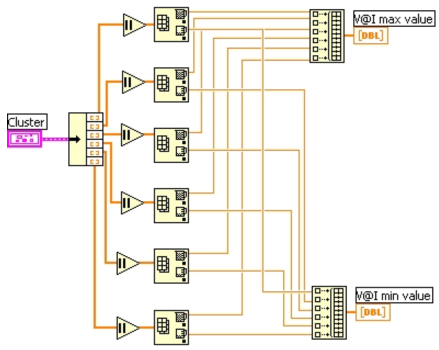

Figure 13. Block diagrams of maximum values of signals

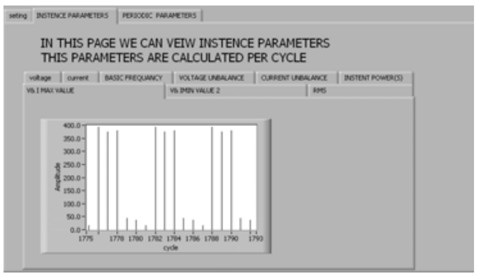

Figure 14. Display the maximum amount of voltage and current moment

C. Measuring Voltage Drop

In this case by applying a high voltage and a low voltage as kind drop voltage, including voltage drop due to the incident or the voltage drop switching can be determined. Of course, proportional to the desired standard the necessary changes in this part of the program will be possible (Figure 15).

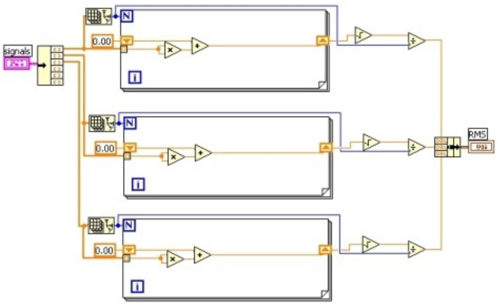

Figure 15. RMS value calculated under the program and the voltage drop

D. Measuring Lighting Flicker

When the voltage lighting flickers is in the network voltage then the voltage is analyzed by a frequency modeling. Therefore, the effective amount of voltage will be different in successive cycles following. Also the value of effective voltage for each cycle and plotted results on wave form causes we recognize there flicker.

E. Measuring Unbalanced in Voltage and Current Signals

From the cases in the program which are measured and considering the sampling moment is done with gathering signals with moment values and divided into three phases, they can be on classified to three levels measured unbalanced moment. Figure 16 shows the block diagram of calculation of the unbalanced voltage and current. Display of this parameter is shown in Figure 17.

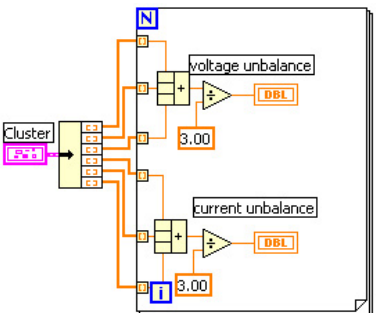

Figure 16. Block diagram of calculation unbalanced of voltage and current signal

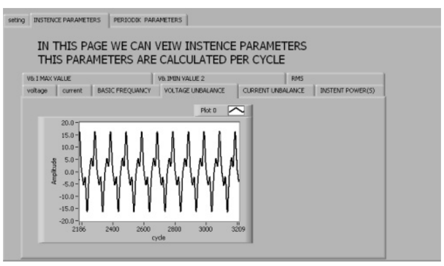

Figure 17. Display of the unbalanced voltage

F. Measurement Frequency Basis

Base frequency of some parameters must be measured in each cycle. Because a voltage signal to the base circuit of the signal is passing through zero acts referred to it, so by measuring the time difference between two basic pulse frequency synchronization circuit (in the hardware the circuit described) the basic frequency will be determined. Figure 18 shows the block diagram of the basic frequency determining.

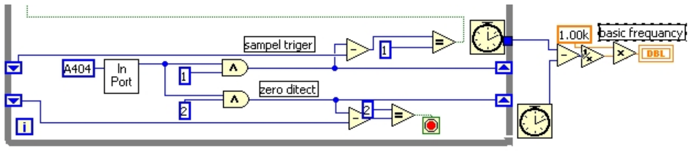

Figure 18. How to determine the basic frequency

G. Active and Reactive Power Calculation

Considering the value of f was calculated directly, so the calculation of moment of active and reactive power will not have any problem using the following relations for this purpose. Block diagram for calculation of active and reactive powers using described relationship is shown in Figure 20. Figure 21 shows the calculated active and reactive powers.

$$P = \sum_{i=1}^{L} V_i I_i \cos\phi_i \qquad Q = \sum_{i=1}^{L} V_i I_i \sin\phi_i \qquad (7)$$

Figure 19. Display of basic frequencies

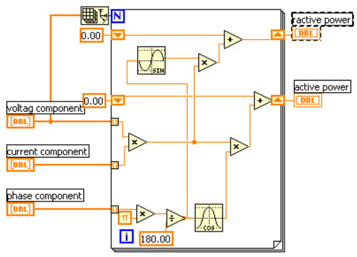

Figure 20. Block diagram under the program can calculate the active and reactive

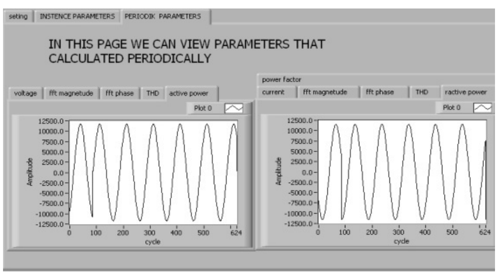

Figure 21. Display active and reactive power

H. Measurement and Display of Harmonics

In this section the main part of calculations is shown. The calculated harmonics as moments to do are not specific time period can be defined which are carried out. Figures 22 and 23 show the amounts of harmonic amplitude and phase components.

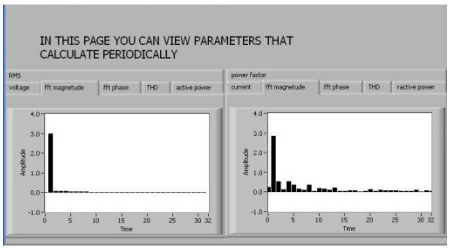

Figure 22. Value range of harmonic components

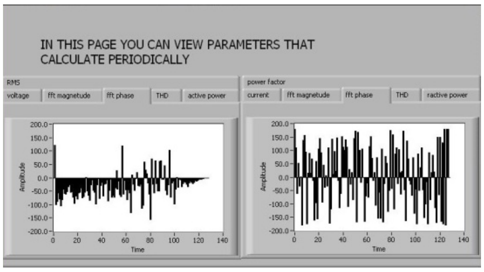

Figure 23. View-phase harmonic components

I. Measurement THD

THD parameter is the harmonic talk to when it is paid. With amplitude waveform harmonic, it can be used to calculate the amount of normal relations. Figure 24 shows the block diagram of the THD calculation. How to view this parameter in relevant menu is as Figure 25.

$$THD = \frac{\sqrt{\sum_{n=1}^{N-1} (A_n)^2}}{A_1} \quad (8)$$

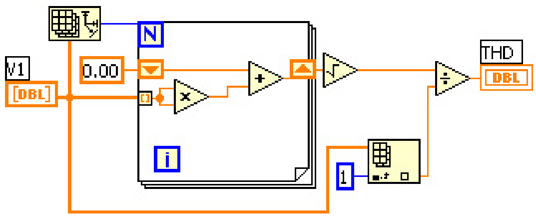

Figure 24. Subprogram to calculate the THD

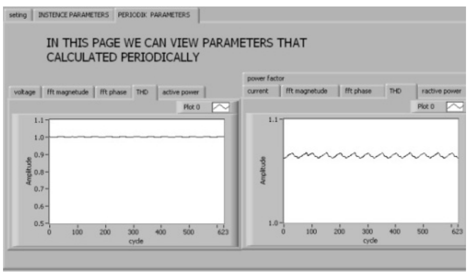

Figure 25. Display THD value for successive cycles

VI. RESULT OF SAMPLING AND ANALYSIS FOURIER

A. Results of Sine Waveform

Samples data are made by computer analysis. This system includes the waveform of 50 Hz per cycle, 256 samples and the desired calculations on the samples. In this case, the sampling frequency would be 12.8 kHz. Therefore, nocuous frequency is equal to 6.4 kHz and will be able to in action to harmonics up to 128 calculated components. Harmonics, but only up to 31th components have a reasonable standard will be considered.

The results of sampling are in the next section .The first image in the form of an actual signal with a wave form oscilloscope sample are given. Range of frequency spectrum value is given in the second row and third row of the phase spectrum frequency.

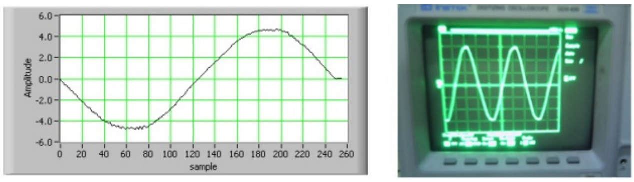

Figure 26. Sine wave applied to the bar and sample wave

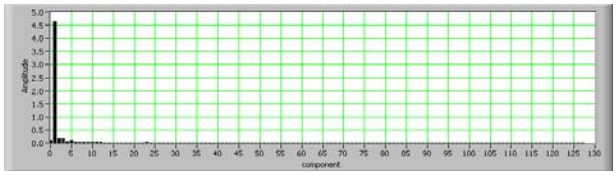

Figure 27. Amplitude harmonic components of Figure 27

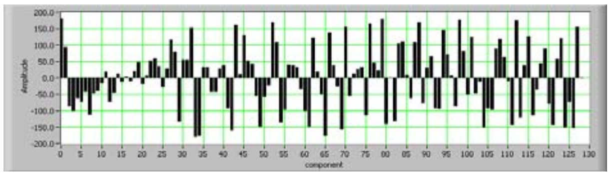

Figure 28. Phase harmonic components for Figure 27

B. Square Waveform

The output signal of the circuit has been passing through zero in the following figures.

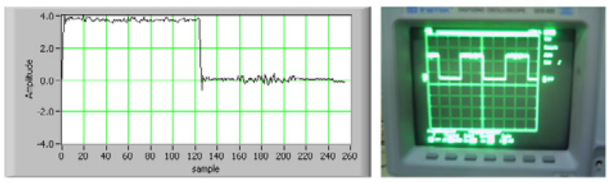

Figure 29. Square wave applied to the load and sampled wave form

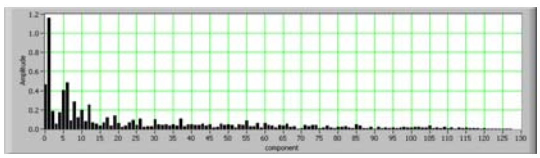

Figure 30. Amplitude harmonic components of Figure 30

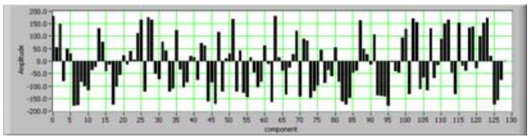

Figure 31. Wave direct current instrument three-phases all wave all controlled 60 degree angle fire

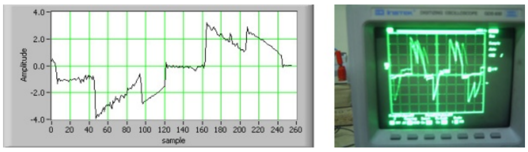

Figure 32. All-wave rectifier current wave form control with all the fire angle of 60 degrees

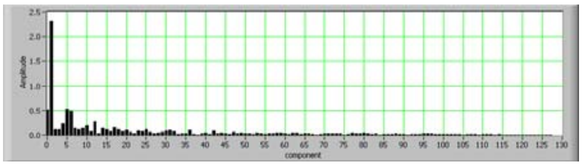

Figure 33. The range of harmonic components for Figure 10

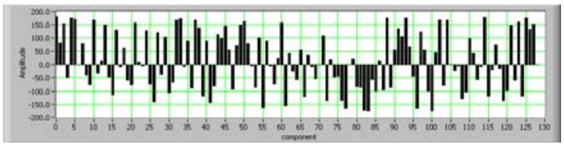

Figure 34. The phase of harmonic components for Figure 10

C. Waveform of Three-Phase Controlled Rectifier with a 90-Degree Angle of Fire

It is seen that the wave form showing in Lab VIEW windows is very similar to actual wave form and spectrum of harmonic to 128th harmonic of current is shown in other window of program.

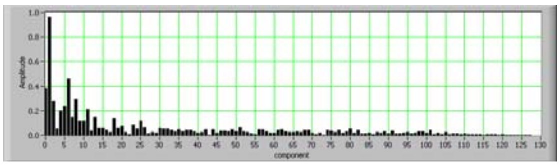

Figure 35. Wave form of three-phase rectifier all controlled with a 90-degree angle of fire

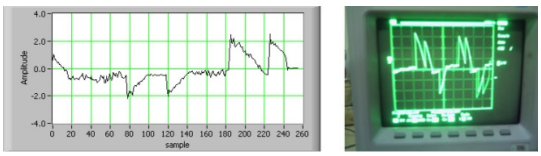

Figure 36. Range harmonic components for Figure 13

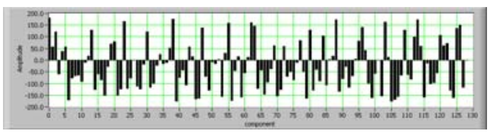

Figure 37. Phases of harmonic components for Figure 13

VII. CONCLUSIONS

In this article we use the circuit design and system of data acquisition and computer processors were able to spot a sample of 256 from 50 Hz to have a waveform using the FFT improved algorithm and actually harmonics up to 121 components. Then the harmonics can also be calculated. Of course, this level of accuracy is far beyond what the standards that has been expressed. High-frequency sampling using high speed processors and ultimating the improved FFT in the system becomes a data logger system is suitable for use in power networks.

For this purpose, the first step will reduce the volume of system operation using the DSP processors and the use of EEPROM will be possible. In this case we can hope that this system will be able to maintain its capability, smaller size and higher efficiency in power systems and industrial centers. Features of this system are calculation of 128th harmonics is done with high accuracy that can be used in sensitive units for monitoring and eliminating harmonic. Another advantage of this system is calculating interharmonics and measuring of lighting flicker. Systems will be also able to export this information to databases and also to record data in several times.

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