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ERROR OPTIMIZATION IN ELECTRICAL POWER QUALITY MONITORING DATA

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Abstract. In the application of electrical power quality control, the necessity for data processing becomes very important. The measurement data obtained is the latest data and measured in real time with good time resolution and with low error. The object of research is the quality of electric power, the research is about ways of measuring quality of electrical power to obtain accurate data in accordance with actual conditions. This method is capable of measuring data of electrical power quality that changes very quickly with a low error. This data is used as a basis for improving the quality of electric power accurately and accurately.

Keywords :Data Measurement, Error, Power Quality, Monitoring, Signal Sampling

1. INTRODUCTION

The high level of harmonic distortion in the electrical power distribution system can result in overheating of the equipment and the conductors, permanent damage for some sensitive electronic equipment, reduced equipment lifetime and cause reading errors up to 17.2% on kWh meters [1]. Apart from the load used by consumers, harmonics can also come from utilities (electrical resources) themselves.Several methods for identifying harmonic sources have been found, such asharmonic identification methods based on Thevenin Theorem, active power method, Norton Theorem method, time-reactive power gradient method, and harmonic and interharmonic estimation methods [2].

Another reason for the decrement in electrical power quality is the occurrence of voltage dip or a momentary voltage interruption. The occurrence of voltagedip for 0.5-3 seconds [3] or more can cause the computer to shut down, loss of data memory, loss of motor as load, trip conditions on variable speed drives, causing disruption to industrial machine operations and losses due to failure of the production process [4]. Flicker in the European standard EN 50160 is defined as a visible change in brightness of a lamp due to rapid fluctuations in the voltage of the power supply.

Provision of good and constant quality electricity can be done by controlling the following parameter: voltage, current, frequency, phase angle, power and harmonic order. Controlling electrical power quality can be done if the value of the existing electrical parameter is measureable continuously and compared with the standard value. While the data value change is fast and the latest data is strongly required, it is necessary to carry out continuous monitoring with a good data acquisition system.

Monitoring the quality of electric power using conventional measuring devices can only obtain limited data [5]. Monitoring the quality of electric power is used as the basis for reconfiguring neural networks in the three-phase system [6]. In the monitoring system must pay attention to good time and frequency resolution, in order to obtain optimal electrical power quality monitoring data [7]. Monitoring is used in the smart grid system to inform in real time about the use of electrical energy and costs to be paid by users [8]. Voltage monitoring using a Neural Network on a distribution system in a remote area is carried out using only signals from the utility substation [9].

In controlling electrical power quality system, the necessity for data collection and processing becomes very important.The obtained measurement data must be up-to-date and measured in real time with good time resolution and low error. The measured data is in the current and voltage waveform with varying forms and with very rapid changes in value due to various disturbances, such as harmonics, voltage dip, flicker and so on.Therefore, a particular method is needed so that these waveform changes can be read and measured completely in accordance with the actual conditions (low error). Real time data will serve as a basis for improving the quality of electrical energy sources.

Numerical methods are used to formulate mathematical problems, so that they can be solved by arithmetic operations. The result is a value that the approximation of actual value with a level of accuracy as desired.In this case there will be an error because the resulting value is not exactly the same as the actual value.One type of error is a truncation error that is related to the number of sampling that is limited to a certain term (n-*th*).Truncation error occurs because it doesn't use all the values in the series, where the number of rows is infinite. This omitted values produces a cutting error.

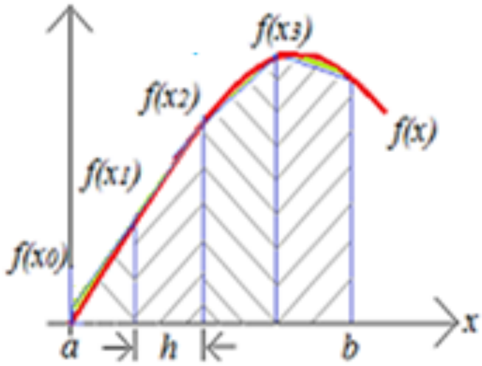

Figure 1. Signal Sampling in Trapezoid

The signal sampling method used in this research is the trapezoidal method, where the signal is copied into the form of a trapezoid with a certain amount of sampling as shown in Figure 1. The trapezoidal method generates series as follows:

$$Y = \frac{(b-a)}{2n}\left[f(x_0) + 2\sum_{i=1}^{n-1} f(x_i) + f(x_n)\right] \quad (1)$$

Where:

$$\bar{f}^{(2)} = \frac{\int_a^b f^{(2)} dx}{(b-a)} \quad (2)$$

With the amount of singnal sampling as:

$$n = \sqrt{\left[\frac{(b-a)^3}{12\varepsilon}\bar{f}^{(2)}\right]} \quad (3)$$

And the error will be:

$$\varepsilon_n = \frac{(b-a)^3}{12n^2}\bar{f}^{(2)} \quad (4)$$

2. METHODS

The monitoring system consists of data retrieval programs using LabVIEW software, voltage and current sensors, analog to digital signal converter circuits (ADC), while a personal computer (PC) are being used for displaying the data.The objectivesof the monitoring system are collectingmeasurement data, converting data from analogue into digital signals, displaying and storing data on a PC. Measurement data is processed by LabVIEW software and displayed in real time. Then, the data are sent to the control system. Data processing based on EN50160 standard. While the classification of electrical power quality disturbances is based on the IEEE Power and Energy Society.

The flow of converting analogue to digital signals through several procedures: sampling, quantization and coding. The focus of this research is on the signal sampling process that is related to the selection of the signal sampling method so that the minimum number of sampling is possible with the lowest possible error. The number of signal samplings is very important in order to make an efficient number of bytes needed in ADC process. In this case the smallest number of signal clicks is selected. The algorithm for determining the number of signal flashes in the ADC process is shown in Figure 2. Firstly, the process of determining the number of signal flashes is done by knowing the series function of a waveform (current or voltage) called f(x). Secondly is determining the waveformoperational area that already limited by the magnitude a and b.

As describe above, the measured waveform is close to the sinusoidal shape, therefore this research only uses trapezoidal form for signal sampling method. To determine the number of signal samplings in trapezoidal form (n_1) we need a second derivative of f(x), called $f^{(2)}$ which is calculated using equation (2), while n_1 and n_2 are calculated using equation (3). Then the result of n_1 and n_2 are compared and selected based on the smallest number of signal samplings.

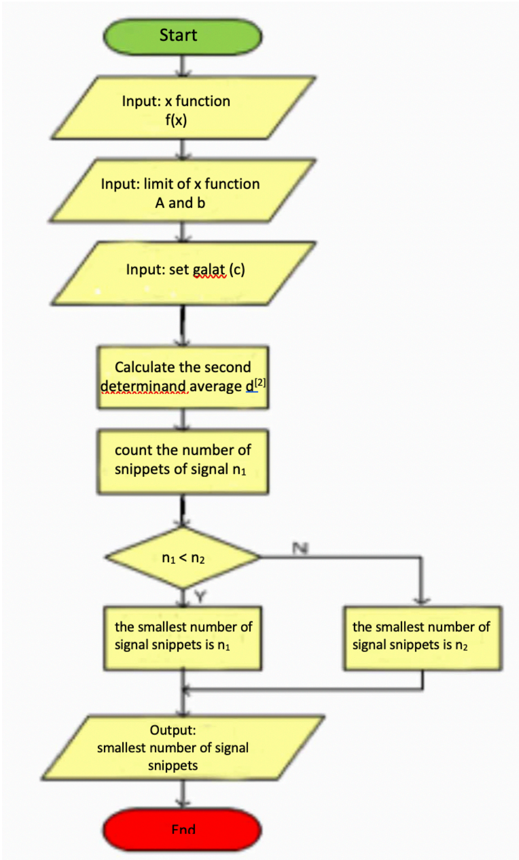

Figure 2. The Algorithm of Optimization Signal Samplings

3. RESULTS AND DISCUSSION

The voltage equation consists of a voltage at fundamental frequency and a voltage at a ripple frequency:

$$V_{inv} = V + V_k$$

$$V_{inv} = V_m \sin\theta + V_{mk} \sin k\theta \qquad (5)$$

If the voltage in equation (5) is copied n-times with the trapezoidal shape at the boundaries a = 0 and b =, then the voltage equation is obtained as below:

$$V_{inv} = \frac{\pi}{2n}\left[(V_m \sin\theta_0 + V_{mk} sin\ k\theta_0) + 2\sum_{i=1}^{n-1}(V_m \sin\theta_i + V_{mk} sin\ k\theta_i) + (V_m \sin\theta_n + V_{mk} sin\ k\theta_n)\right] \qquad (6)$$

the second derivative f(x) with k-odd numbers is:

$$\bar{f}^{(2)}(V_{inv}) = \frac{-2}{\pi}[V_m + kV_{mk}] \qquad (7)$$

After obtaining the average of second derivative, the voltage signal sampling error can be calculated based on equation (4):

$$\varepsilon_V = \frac{-\pi^2}{6n^2}[V_m + kV_{mk}] \quad (8)$$

And the number of signal samplings (n) for a particular error value is:

$$n = \left[\frac{\pi^2}{6|\,\varepsilon_V|}[V_m + kV_{mk}]\right]^{1/2} \quad (9)$$

After obtaining the number of signal samples based on equation 9, a graph of the relationship between the number of sampling signals is made with the measured voltage (Figure 5).In addition, errors also occur as a result of sampling signals using equation 8 and graphically as illustrated in Figure 6.Data was taken on MDP power panels for five classes of the Electric Laboratory and four classes of the Politeknik Negeri Jakarta Electrical Workshop (Figure 3). The waveform as the results of signal samplings is shown in Figure 4, where the waveform will approach the actual shape if the number of samples is very large.

The measured voltage is less than the reference voltage when sampled with an amount of less than 80.The value of this voltage increases as the number of signals increases (Figure 5). This affects the error that occurs with an average voltage error of (-0.02843), where the error decreases as the number of signals increases (Figure 6).

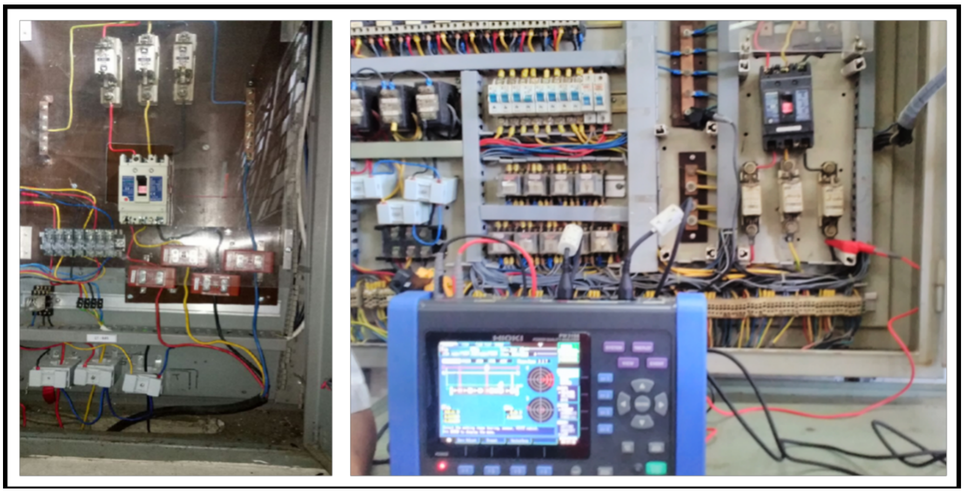

Figure 3. Electrical power quality measurement location

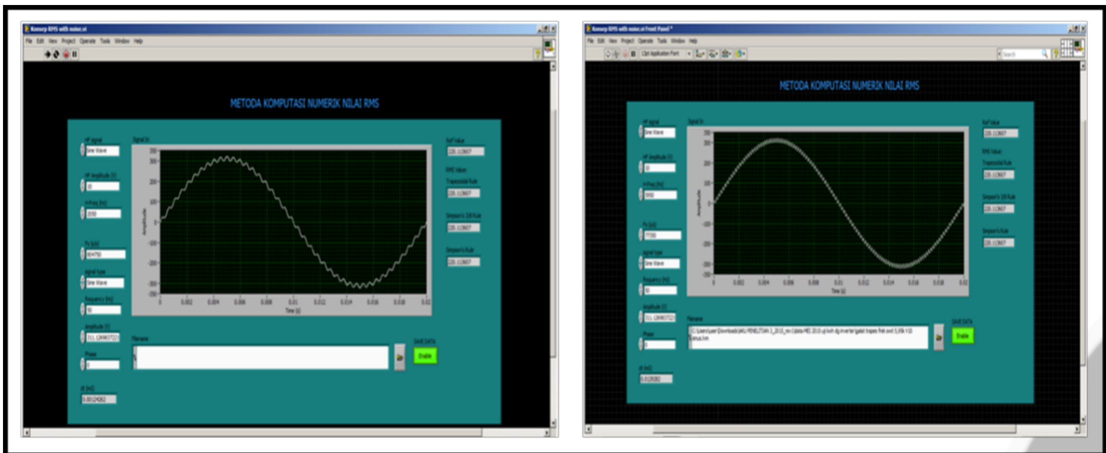

Figure 4. Signal Sampling for Sinusoidal

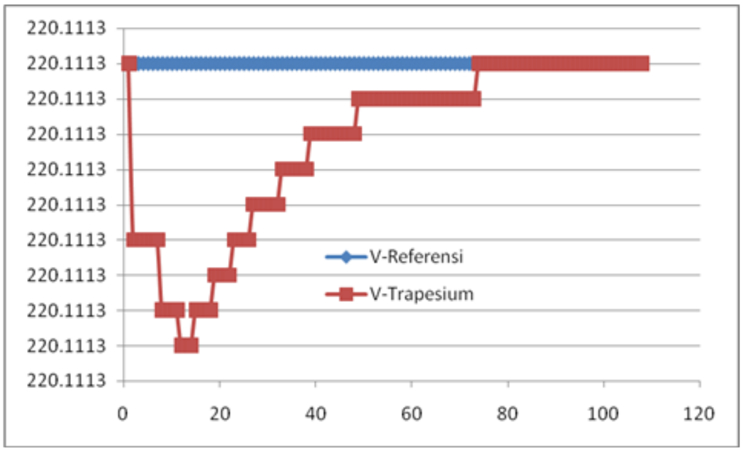

Figure 5. Number of signal samplings for measured voltage

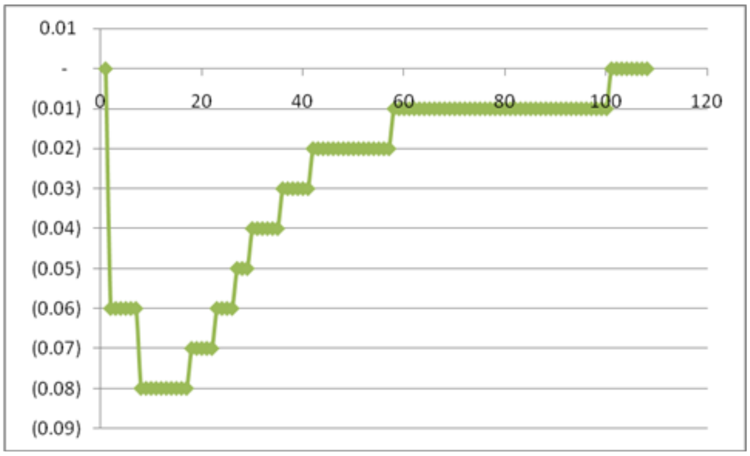

Figure 6. Graphic of error as a result of signal samplings

4. CONCLUSION

Based of result and discussion above, the conclusions of this research are:

a. The voltage equation consists of voltage at the fundamental frequency and voltage at the ripple frequency. If the voltage is taken as many times as the trapezoidal shape, an error will occur
b. The measured voltage is less than the reference voltage when sampled with an amount of less than 80. The value of this voltage increases as the number of signals increases
c. The amount of signal sampling affects the error that occurs with an average voltage error of (-0.02843), where the error decreases as the number of signals increases

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