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Identification Disturbance on Transformer using Wavelet Transformation

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***Abstract*—This paper present indentification disturbance that occurs in a transformer. The identification of disturbance using wavelet transformation. The proposed method can precisely identify fault caused by phase to neutral, two-phase, and three-phase short circuit. In this study makes a prototype transformer to create such faults and analyzed using wavelet transform. The results of this research on fault of the phase - neutral voltage decrease of 0.59pu and 0.14436s duration, Disruption of two-phase voltage decreased by 0.63pu and 0.12760s duration , Two phase-neutral voltage decrease of 0.68pu and 0.17698s duration, and the Fault three phase voltage decrease of 0.59pu and 0.21138s duration. According to IEC 61000-4-30 all the fault included in the classification of types of fault voltage sag.**

Keywords- Transformer; Disturbance of Voltage; Wavelet Transform

I. INTRODUCTION

Transformers are electrical equipment that hold an important role in the distribution of electrical energy due to the transformer directly related to the distribution of electrical power to the load. One of the things that affect the reliability of the transformer is a disturbance and will damage the transformer.

Electrical disturbance problem often occurs on the distribution system. Electrical disturbances associated with power quality, which include blackouts, power factor, harmonics, sags, swells, and unbalanced conditions [1][2][3][4].

Short circuit that occurs in a transformer can result in damage to the isolation transformer so that potential damage to the transformer. This is because the current flowing in the transformer during a short circuit is very large, it is necessary to know the difference between the state of the transformer under normal circumstances and the circumstances of the transformer short-circuit current. Identification of fault on the transformer is needed to determine the steps to handle, because each type of fault require its own treatment so the need for further analysis of the faults that occurred.

This research will be done is to create a transformer prototype which aims to create a disturbance like one phase to neutral, two-phase, and three-phase.

From some of these disturbance may result in breakdown voltage on the transformer. Disturbance voltage on the transformer can be imbalances, under voltage, over voltage. The under voltage like voltage sag, interruption, while the over voltage can be swell voltage depent on disturbance duration occur.

Wavelet transform is used to analyze the fault created by the prototype, because the wavelet transform is a tool that can be used to analyze the signals are non-stationary, such fault would be made on a prototype designed transformer. Wavelet transform can also detect when the disruption and how long the interruption occurred.

Voltage sags are reduction the rms value of voltage with short duration, it can be characterized by residual voltage and duration[4][5]. IEEE Standard 1159 defines voltage sag as reduction in the rms voltage between 0.1 and 0.9 pu. of the nominal voltage, for duration of 0.5cycle to 1 min.[6]. Power quality problems cause equipment damage, under and over voltage. The under voltage and over voltage occurs in long duration voltage variation or in short-duration voltage variation. Researchers have published topics in improvement of power quality in weak grid system and weak grid characteristics[7]. This paper discusses a method to identify disturbance on transformer. It analyses the power quality characteristics using wavelet transformation. The WT approach prepares a window that simultaneously gives proper resolutions in both the time and the frequency domain [8]. The wavelet transforms disturbance signals into approximate signal and detail signal [9]. The wavelet method is suitable for transforming event which occurs in a short duration.

II. IDENTIFICATION METHOD

The identification disturbance on transformer is identified applying 4 steps: design prototype experiment, testing of prototype experiment, measuring data and wavelet transformation. The flowchart is illustrated in Figure 1.

A. Design of Prototype Experiment

This stage is to design a prototype experiment consists of a single transformer, in design there is a switch connected to the transformer, which is used to create a short circuit fault and an electric motor as a load.

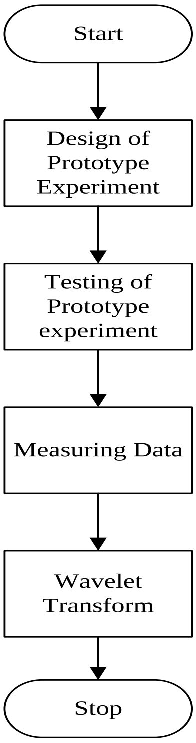

Fig.1. Flowchart System

B. Testing of Prototype Experiment

The second stage is testing, disturbance of one-phase to neutral, two-phase, and three phase. The testing was conducted to determine the form of the signal from the disturbances and will be used as measurement data.

C. Measurement Data

The data which use in this study obtains from prototype experiment like seen at figure 2.


Fig. 2. Prototype Expeiment

D. Wavelet Transformation

Wavelet transformation has the objective to detect any disturbance. This paper used discrete wavelet transform (DWT) with wavelet Daubechies as mother wavelet. Transformed signal is voltage V (single phase). Original signal is decomposed into approximation and detail signals [7][9]. Wavelet orthogonal consist scaling function (($\emptyset(x)$) and wavelet function ((ψ (x)) in equation (1)

$$\phi(x) = \sum_{t=0}^{J-1} a_k \phi(2x-t)$$
$$\psi(x) = \sum_{t=0}^{J-1} b_k \phi(2x-t) \quad (1)$$

($a_0 - a_{J-1}$) is scaling sequence and ($b_0 - b_{J1}$) is wavelet sequence. Scaling function is assosiated with low-pass filterswith coefisient $\{h(n), n \in z\}$, and wavelet function is asssosiated with *high-pass filter* with coeficient $\{g(n), n \in z\}$,(Figure 4)

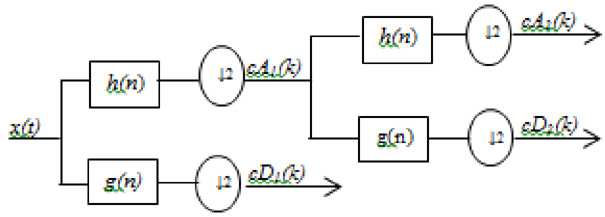

Fig.3. Wavelet Decomposition 2 Levels [10]

Some important traits for low pass filter and high pass filter are:

1. $\sum_n h(n)^2 = 1$ and $\sum_n g(n)^2 = 1$ (2)
2. $\sum_n h(n) = \sqrt{2}$ and $\sum_n g(n) = 0$ (3)
3. Filter *g(n)*is alternative from filter *h(n)*, which is an odd integer N so:

$$g(n) = (-1)^n h(N-n) \quad (4)$$

Based on implementation from figure 4, correlation of approximation coefficient with detail coefficient defined as:

$$cA_j(k) = \sum_n h(2k-n) cA_{j-1}(n) \quad (5)$$
$$cD_j(k) = \sum_n g(2k-n) cA_{j-1}(n) \quad (6)$$

cA_j and cD_j represent approximation coefficient and detail coefficient from signal to the level-j.

In the simulation results show the measurement data and the wavelet scale, so it must use equation (7) in order to obtain the time value of disturbance is detected by the wavelets. Here are the equations used to obtain the time:

$$t = \frac{0{,}5 \times \text{data sample at the time of disturbance}}{\text{the large number of data sample}} \quad (7)$$

With the amount of data that is obtained along the 11250 data and sampling time is 0.5.

III. Result and Discussion

Data obtained from the voltage measurement, the results of the normal condition of transformer that has been transformed wavelet, and the results are shown in figure 3.

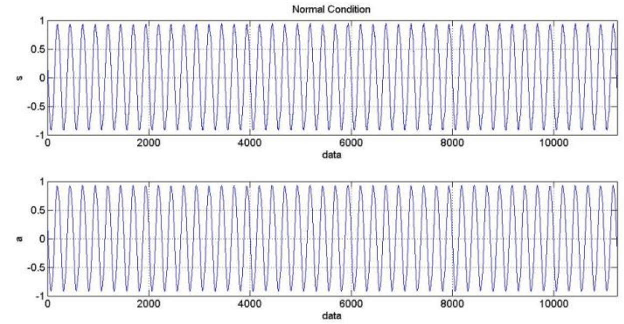

Fig.3. Results of Wavelet Transformation Normal Condition.

Figure 3 is the result of the wavelet transform that consists of *s* and *a*, where *s* is the original signal and *a* is an approximation. Approximation is a high-scale components of low frequency, because of the high-scale approximation take the form of the signal resembles the original signal, and the results of the wavelet transformation also generates detailed signal, shown in the following figure 4.

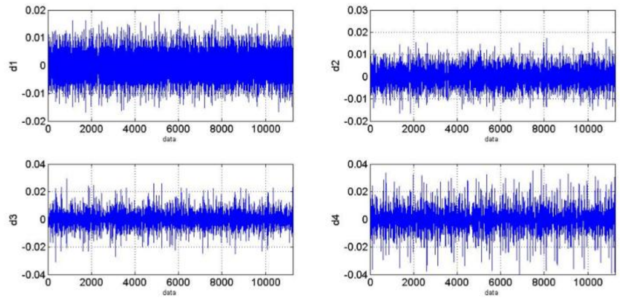

Fig.4. Signal Detail of Wavelet Transformation 4-level

Details are components of the low scale, high frequency detail of figure 4, 4-level of transformation in normal condition.

A. *Disturbance One Phase to Neutral*

The next from experiment data of short circuit phase to neutral condition of trasformer

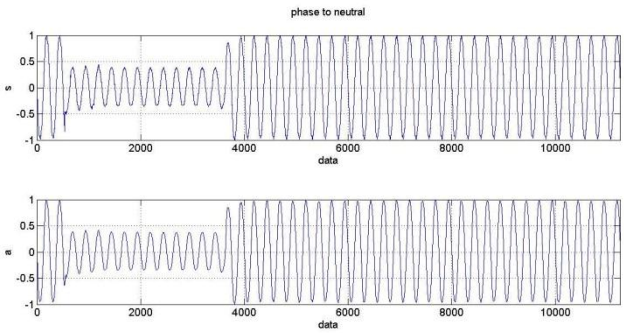

Fig.5. Wavelet Transform of original signal and approximation signal

Figure 5 and Figure 6 are the result of wavelet transform signal one phase to neutral. This results in voltage decline by 59% this disturbance. Wavelet transforms divided the original signal into two parts, namely the approximation and detail signal. Approximation signal has signal the same shape with the original signal, while the signal detail is formed when a disturbance occurs. In this experience the difference in outcome and duration of interruption time. And the results of its wavelet details are as follows:

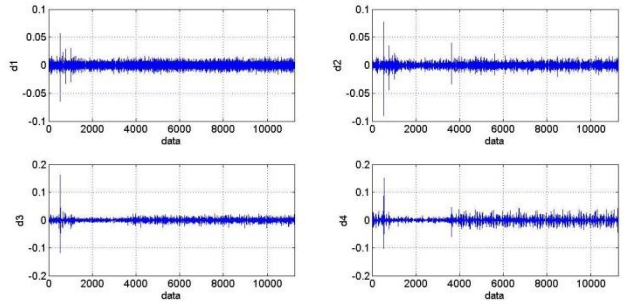

Fig.6. Signal Detail of Wavelet Transformation 4-level

From Figure 6 can explained that disturbance occure at the time of the data from 505 to 3753. So, time when disturbance occur can determine using equation (7).

$$tA = \frac{0{,}5 \times 505}{11250} = 0{,}02244s$$

$$tB = \frac{0{,}5 \times 3753}{11250} = 0{,}1668s$$

B. *Disturbance Two-Phase*

The data of short circuit two phase obtained from prototype experiment, this data then transformed using wavelet transform.

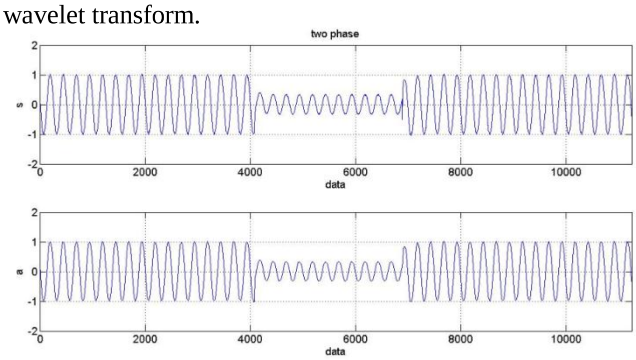

Fig.7. Wavelet Transform of original signal and approximation signal

Figure7 and Figure 8 are results of wavelet transform signal disturbance two phase on transformer. This result in voltage decline by 63% this disturbance. In this research, the wavelet transform up to 4 levels, the result can be seen in Figure 8.

Details are obseved signal, detail generate shape of the signal corresponding to mother wavelet when fault occurs.

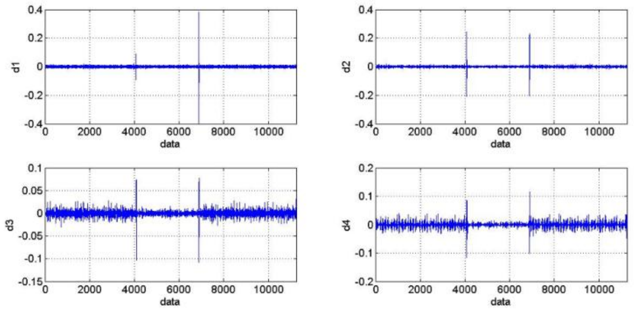

Fig.8. Signal Detail of Wavelet Transformation 4-level

The disturbance occurs when the data at 4122 to 6993, then to determine thedisturbance time using equation (7):

$$tA = \frac{0{,}5 \times 4122}{11250} = 0{,}1832s$$

$$tB = \frac{0{,}5 \times 6993}{11250} = 0{,}3108s$$

C. *Disturbnace Three-Phase*

The final experiment is disturbance three-phase at transformer, result of wavelet transform can see at Figure 9 and Figure 10.

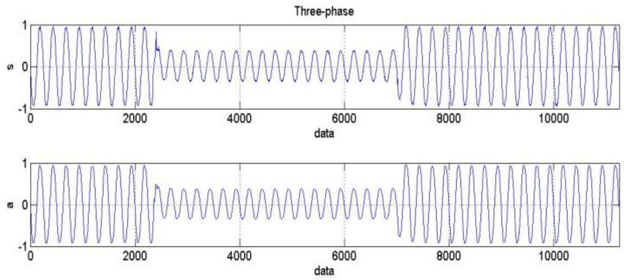

Fig.9. Wavelet Transform of Original Signal and Approximation Signal

Figure 9 and Figure 10 are results of wavelet transform signal disturbance two phase on transformer. This result in voltage decline by 59 % this disturbance. Details are obseved signal, detail generate shape of the signal corresponding to mother wavelet when fault occurs.

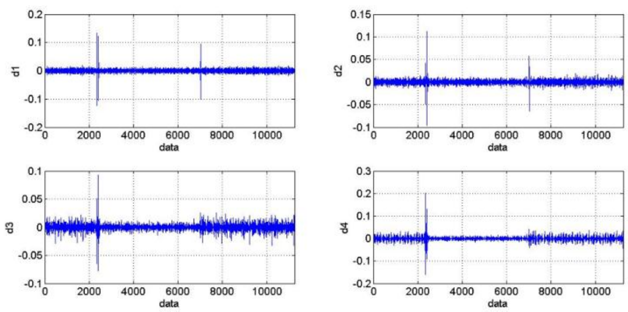

Fig.10. Signal Detail of Wavelet Transformation 4-level

The disturbance occurs when the data at 2364 to 7120, then to determine thedisturbance time using equation (7):

$$tA = \frac{0{,}5 \times 2364}{11250} = 0{,}10506s$$

$$tB = \frac{0{,}5 \times 7120}{11250} = 0{,}31644s$$

IV. CONCLUSION

Prototype experiment ssuccessfully simulating the disturbance on transformer. The method proposed to identification disturbance with wavelet transform has been developed and test. The test results are voltage decrease of 0.59pu and 0.14436s duration for one phase to neutral, voltage decreased by 0.63pu and 0.1276 s duration fortwo-phase, and voltage decrease of 0.59pu and 0.21138 s duration . Based on IEC 61000-4-30 all disturbance types included voltage sag.

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