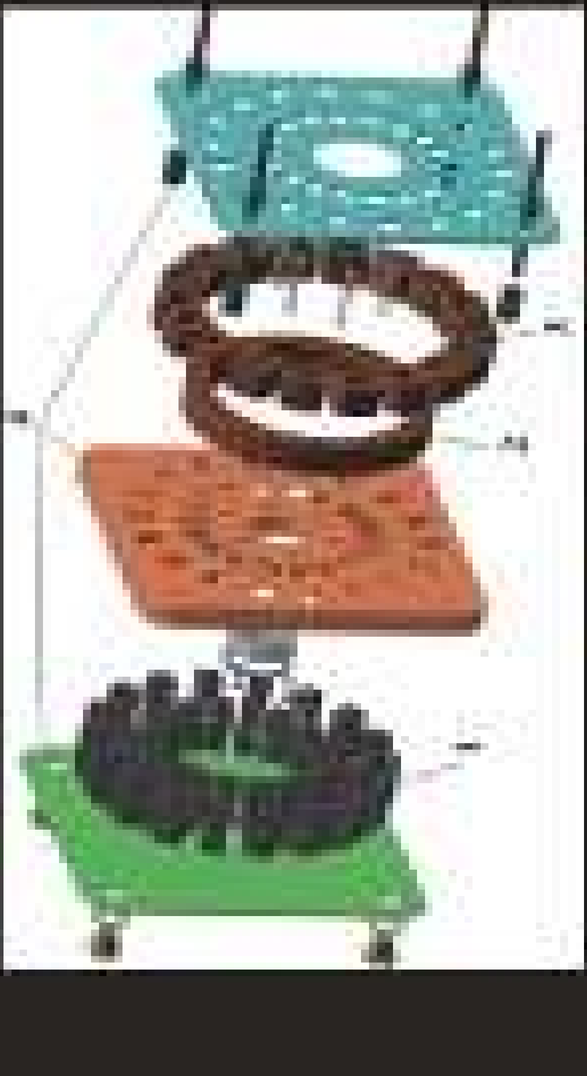
PL ISSN 0033-2097

11'2014

PRZEGLĄD ELEKTROTECHNICZNY

ROK 90



tttt/div>

Oldest magazine of Polish electrician. It appears since 1919.

🇵🇱 🇬🇧

MENU

Price list of subscription

Program Advice

- Prof. Roman Barlik, Warsaw University of Technology
- Pavol Bauer, Delft Univeristy of Technology, Netherland
- Prof. Jan T. Białasiewicz, Univ. of Colorado at Denver, USA
- Prof. Janusz Białek, Univ. of Edinburgh, UK
- Prof Mihai Cernat, Univwersity ofTransilvania Brashov Romania
- Prof. Andrzej Cichocki, Riken, Brain Science Inst., Japan
- Prof. Leszek Czarnecki, Louisiana State Univ., USA
- Prof Viliam FedakTechnical University of Kosice, Slovakia
- Prof. Zdobysław FlisowskiWarsaw University of Technology
- Prof. Yoshiyuki Ishihara, Doshisha University, Japan
- Prof. czł. PAN Tadeusz Kaczorek, Warsaw University of Technology
- Prof. Marian Kaźmierkowski, Warsaw University of Technology
- Prof. Krzysztof Kluszczyński , Silesian Technical IUniversity
- Prof. czł. PAN Józef Korbicz , Zielona Gora Technical University
- Prof Peter Korondi, Budapest University of Technology, Hungary
- Prof. Andrzej Krawczyk, Czestochowa Technical University
- Prof. Jan Machowski, Warsaw University of Technology
- Prof. czł. PAN Jacek Marecki , Gdansk Technical University
- Dr Maria Evelina Mognashi, Pavia University , Italy
- Prof. Teresa Orłowska-Kowalska, Wroclaw Technical University
- Prof. Stanisław Osowski, Warsaw University of Technology
- Prof. Marian Pasko, Silesian Technical University
- Prof. Maciej Pawlik , Lodz Technical University
- Prof. Lidija Petkovska, Ss. Cyril & Methodius Univ., Macedonia
- Prof. Stanisław Piróg, Minng Academy, Cracow
- Prof. Andrzej Piłatowicz, Institute of Power Energetics

Portal informacji technicznej | Wykonanie i obsługa strony

SJR Scimago Journal & Country Rank Enter Journal Title, ISSN or Publisher Name

Home Journal Rankings Country Rankings Viz Tools Help About Us

Przeglad Elektrotechniczny

Country Poland

Subject Area and Category Engineering
Electrical and Electronic Engineering

Publisher Wydawnictwo SIGMA

Publication type Journals

ISSN 00332097

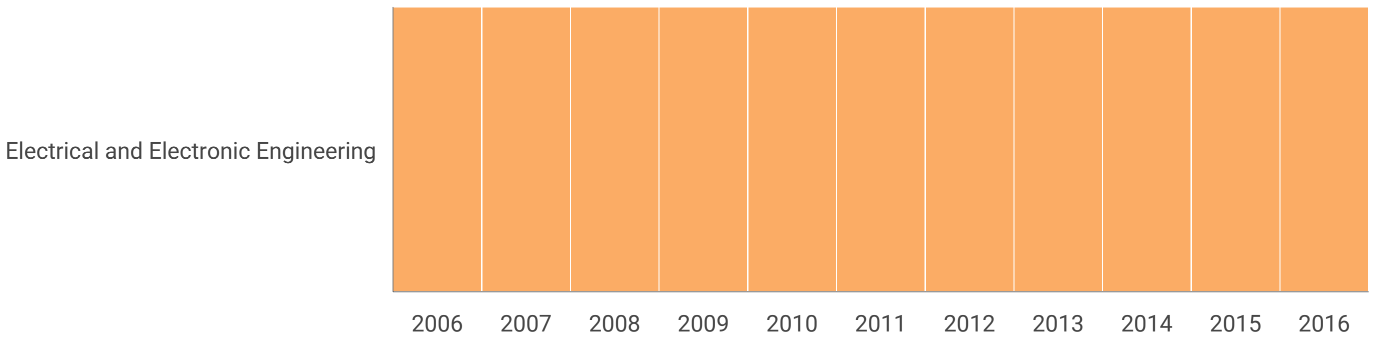
Coverage 1969-1984, 2005-ongoing

Scope "Przegląd Elektrotechniczny" (Electrical Review) exists since 1919 and it is one of the oldest Polish scientific journals. It is dedicated to electrical engineering and it is edited by SEP (Society of Polish Electrical and Electronics Engineers). Przeglad Elektrotechniczny is published monthly in average 80 pages per issue. We publish the papers in Polish or English. The Scientific Level of our Journal is controlled by 30-person Program Editorial Board. (source)

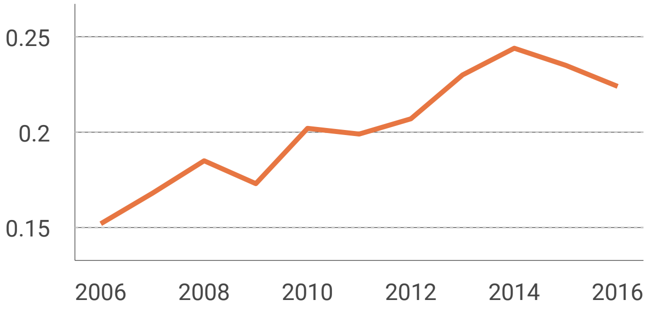
18

H Index

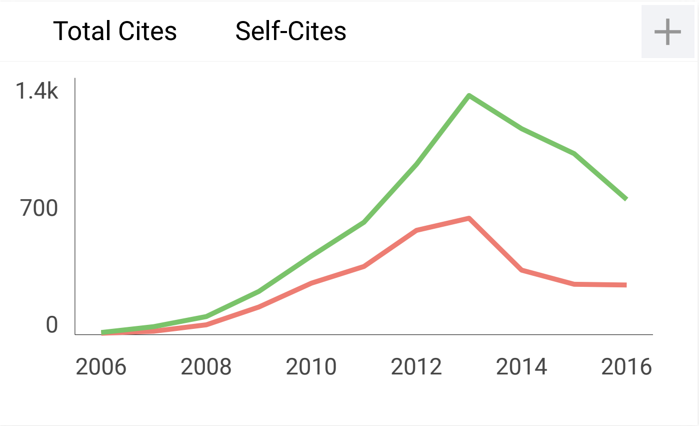
Quartiles

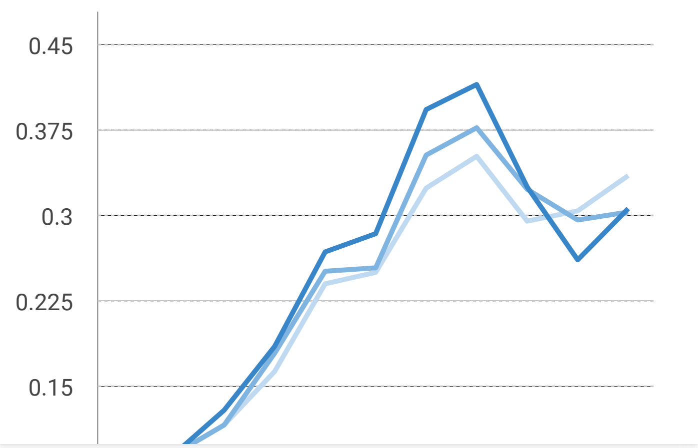


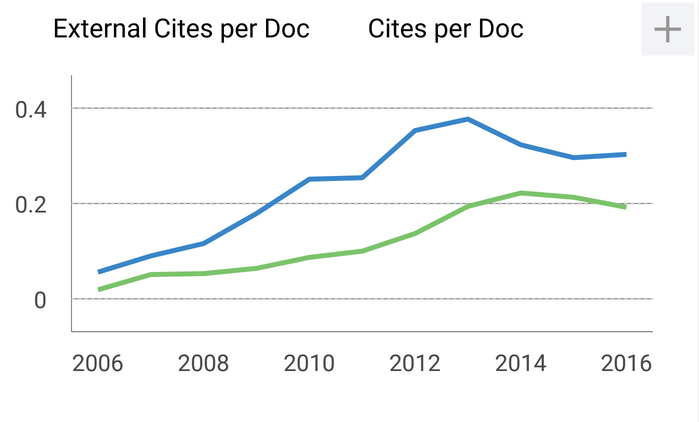
SJR

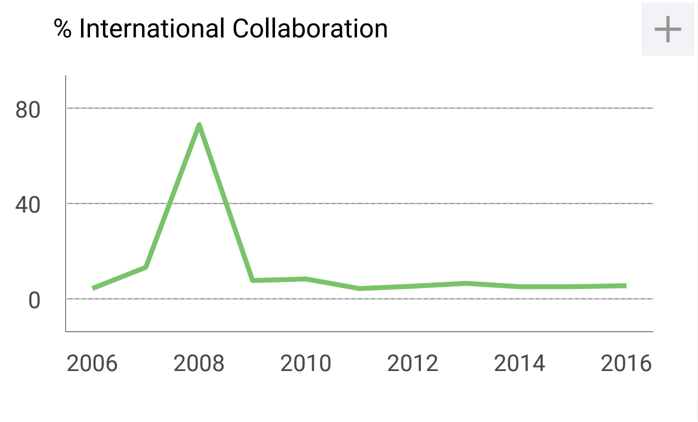


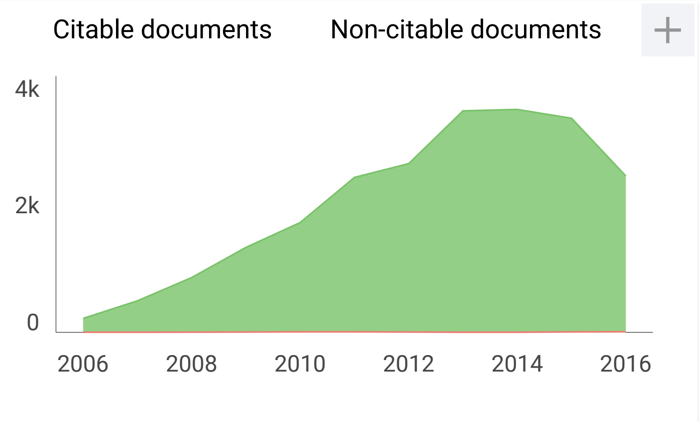
Citations per document

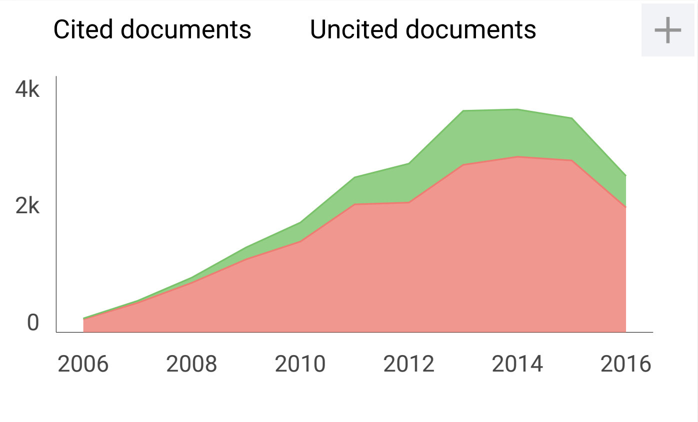


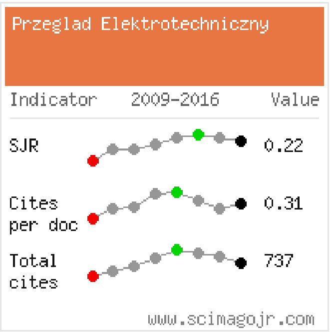












Przeglad Elektrotechniczny

Indicator	2009-2016	Value
SJR		0.22
Cites per doc		0.31
Total cites		737

www.scimagojr.com

← Show this widget in your own website

Just copy the code below and paste within your html code:

`<a href="http://www.scimag`

Developed by:

Powered by:

Follow us on Twitter

EST MODUS IN REBUS
Horatio (Satire 1,1,106)

slawomir tumanski@tumanski.pl

Mail

Move to Inbox

M

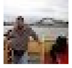
COMPOSE

Inbox
Starred
Important
Sent Mail

Categories

Follow up
Misc
Priority
More

(no subject)

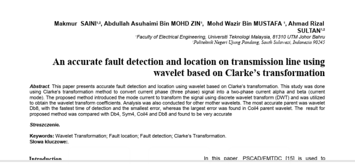


Makmur Saini <makmur.saini@fkegraduate.utm.my>
to ST, ST-PW

Dear Prof,
Thank you for your correction. The final paper (4360) is enclosed.
The data for invoice : Name : Makmur Saini
Address : Faculty Of Electrical Engineering Universiti Teknologi Malaysia
Skudai - Johor Bahru Johor - Malaysia 81310

Best Regards

3 Attachments



Makmur SAINI[1,2], Abdullah Asuhaimi Bin MOHD ZIN[1], Mohd Wazir Bin MUSTAFA [1], Ahmad Rizal SULTAN[1,2]
[1]Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru
[2]Politeknik Negeri Ujung Pandang, South Sulawesi, Indonesia 90245

An accurate fault detection and location on transmission line using wavelet based on Clarke's transformation

Abstract. This paper presents accurate fault detection and location using wavelet based on Clarke's transformation. This study was done using Clarke's transformation method to convert current phase (three phase) signal into a two-phase current alpha and beta (current mode). The proposed method introduced the mode current to transform the signal using discrete wavelet transform (DWT) and was utilized to obtain the wavelet transform coefficients. Analysis was also conducted for other mother wavelets. The most accurate parent was wavelet Db8, with the fastest time of detection and the smallest error, whereas the largest error was found in Coil4 parent wavelet. The result for proposed method was compared with Db4, Sym4, Coil4 and Db8 and found to be very accurate

Streszczenie.

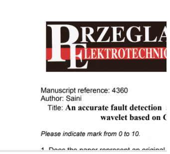
Keywords: Wavelet Transformation; Fault location; Fault detection; Clarke's Transformation.
Słowa kluczowe:.

Introduction In this paper PSCAD/EMTDC [15] is used to

W **(4360) An accurat.**

PDF **An accurate fault detection and location on transmission line**

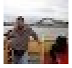
469 KB



Manuscript reference: 4360
Author: Saini
Title: **An accurate fault detection**
wavelet based on C

Please indicate mark from 0 to 10.

PDF **review 43**



Click here to Reply, Reply to all, or Forward

Makmur Saini <makmur.saini@fkegraduate.utm.my>

Re: Paper Submission

3 messages

ST <tumanski@tumanski.pl> Sun, Aug 10, 2014 at 7:46 PM
To: Makmur Saini <makmur.saini@fkegraduate.utm.my>

Review enclosed – we are awaiting for final version (written according the sample) and for data for invoice.

Best regards

Slawomir Tumanski
Professor

Warsaw University of Technology
IETiSIP
ul. Koszykowa 75
00-661 Warszawa

tel (mobile): 48 693 428 056
tel. (private): 48 22 711 0303
e-mail: tusla@iem.pw.edu.pl
e-mail (private): tumanski@tumanski.pl

Przeglad Elektrotechniczny (Electrical Review)
Editor in Chief
ul. Ratuszowa 11
00-950 Warszawa
e-mail: red.pe@sigma-not.pl
www.red.pe.org.pl

From: Makmur Saini
Sent: Wednesday, May 21, 2014 6:57 AM
To: red.pe@iem.pw.edu.pl
Cc: tusla@iem.pw.edu.pl
Subject: Paper Submission

Dear,
I have send paper in attached file with title
"An accurate fault detection and location on transmission line using wavelet based on Clarke's transformation"
for Przeglad Elektrotechiczny review.
Thanks for cooperation

best regard

Makmur Saini
Faculty of Electrical Engineering
Universiti Teknologi Malaysia
Skudai - Johor
Malaysia 81300

PRZEGLĄD ELEKTROTECHNICZNY

REFEREE REPORT

Manuscript reference: 4360
Author: Saini
Title: **An accurate fault detection and location on transmission line using wavelet based on Clarke's transformation.**

Please indicate mark from 0 to 10.

1. Does the paper represent an original contribution to the field of interest of electrical engineering: 8

2. Is the paper of good scientific quality and free from obvious errors: 8

3. Is the paper clear, concise and well organized: 8

4. Do the authors place the paper in proper context by citing previous relevant papers: 8

5. Does the abstract adequately summarize the work and the main conclusions: 6

6. Are figures and tables clear and relevant and captions adequate: 8

7. Is the paper written in correct English: 8

8. Are the conclusions supported by experimental evidence, computed results or prior publications: yes

9. To what extent is the material in the paper likely to be of interest by other researcher in the field: b
   - a. Very Much:
   - **b. Much:**
   - c. Average:
   - d. Little:
   - e. Never:

10. Recommendation
a. Accept as it is
~~b. Accept with minor changes~~
~~c. Accept subject to required revision~~
~~d. Do not publish~~

Please put additional remarks on the next page. Comments are strongly encouraged.

I think it will be interesting in case authors provide tests results presenting evaluated distance to fault in case fault appeared on different angle of voltage signal (e.g. in case voltage in faulted phase is equal 0, 10, 20, 30 deg etc.)

PRZEGLĄD ELEKTROTECHNICZNY Vol 2014, No 11

Contents

PRZEGLĄD ELEKTROTECHNICZNY Vol 2014, No 11

Contents

Makmur SAINI[1,2], **Abdullah Asuhaimi Bin MOHD ZIN**[1], **Mohd Wazir Bin MUSTAFA** [1], **Ahmad Rizal SULTAN**[1,2]

[1]Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru
[2]Politeknik Negeri Ujung Pandang, South Sulawesi, Indonesia 90245

An accurate fault detection and location on transmission line using wavelet based on Clarke's transformation

***Abstract**. This paper presents accurate fault detection and location using wavelet based on Clarke's transformation. This study was done using Clarke's transformation method to convert current phase (three phase) signal into a two-phase current alpha and beta (current mode). The proposed method introduced the mode current to transform the signal using discrete wavelet transform (DWT) and was utilized to obtain the wavelet transform coefficients. Analysis was also conducted for other mother wavelets. The most accurate parent was wavelet Db8, with the fastest time of detection and the smallest error, whereas the largest error was found in Coil4 parent wavelet. The result for proposed method was compared with Db4, Sym4, Coil4 and Db8 and found to be very accurate*

Streszczenie.** W artykule opisano dokładną metodę wykrywania awarii w sieciach przesyłowych bazująca na falkowej transformacie Clarka. Sygnał trójfazowy jest przekształcany do postaci dwufazowej Za najbardziej się do tego celu nadająca uznano falkę Db8 z najszybszym czasem wykrywania i najlepszą dokładnością. Wyniki porównano z innymi typami falek.* ***Dokładna metoda lokalizacji awarii w sieciach przesyłowych bazująca na wykorzystaniu transformaty falkowej Clarka

Keywords: Wavelet Transformation; Fault location; Fault detection; Clarke's Transformation.
Słowa kluczowe: wykrywanie i lokalizacja awarii, transformata falkowa, transformata Clarka.

doi:10.12915/pe.2014.11.42

Introduction

Fault detection and determination of the location of short circuit transmission lines have become a growing concern. There are two commonly used methods to determine the location of the fault in accordance with standard IEEE Std C37.114. 2004 [1]. The first method is based on a frequency component, and the second is based on signal interference at high frequencies where the wave theory is ignored and a shorter sampling window is used [2]. The determination of wave theory for intrusion detection was introduced by Dommel and Michess [3], where transient voltage waveform and current waveform were used to describe the graph pattern and detect fault location respectively.

C.Y.Evrenosoglu and A.Abur [4] developed a circuit defining the technical relationship between the arrival of peak measurement of, the forward and backward traveling waves which were used to predict the travel time of a transient signal transmitter (source signal) to the point affected by the fault. Wave theory is categorized under graphic patterns [5]-[7]. These are described based on the voltage and current waveform, in the form of a brief relationship between the arrival of the peak value at the measurement point of forward and backward waves.

A new approach to detect and determine fault location is introduced in this paper. It is based on Clarke's transformation which basically transforms a three-phase system into a two-phase system [8,9]. The results of this transformation are then transformed into wavelet transformation.

Wavelet transformation is a technique used to solve signal problem, based on the development of Fourier's transformation. [10].The basic functions used in wavelet transform have band pass characteristics that make mapping similar to the mapping in the form function of time and frequency [11]. The wavelet transformation analyzes not only the frequency as in Fourier's traditional method, but also include sudden disturbances such as a transient disturbance. The wavelets generate waves and disrupt the signal frequency [12].

There are many advantages of applying a wavelet in an electric power system as mentioned in many references [13,14]. These papers present an overview comparison of Fourier; short-time Fourier and wavelet transformation, which are examples of the application of wavelet transformation to analyze the transient power system.

In this paper, PSCAD/EMTDC [15] is used to obtain the transient signal interference from transmission lines using MATLAB, which is used to perform Clarke's transformation.

Overview of Clarke's and wavelet transformation.

A. Clarke's Transformation.

Clarke's transformation, also referred to as *(αβ)* transformation, is a mathematical transformation to simplify the analysis of a series of three phases (a, b, c). It is a two-phase circuit *(αβ0)* stationery and conceptually very similar to the *(dqo)* transformation. The wave signal analyzer is a very useful application for the transformation.

Clarke's transformation is one of the transformation matrices, which correspond to three-phase transmission lines. A three-phase current that has a digital representation is assumed to have the form [16]

(1)

$$\begin{aligned} i_a(n) &= I_a \cos(n\omega T + \varphi a) \\ i_b(n) &= I_b \cos(n\omega T + \varphi b) \\ i_c(n) &= I_c \cos(n\omega T + \varphi c) \end{aligned}$$

where T is the sampling period.

Equation (1) can be re-formed into the following matrix form

(2)

$$\begin{bmatrix} i_\alpha(n) \\ i_\beta\ (n) \\ i_0(n) \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \frac{1}{2} & \cos(\frac{2\pi}{3}) & \cos\left(-\frac{2\pi}{3}\right) \\ 0 & \sin(\frac{2\pi}{3}) & \sin(-\frac{2\pi}{3}) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} (\mathrm{x}) \begin{bmatrix} i_a(n) \\ i_b\ (n) \\ i_c\ (n) \end{bmatrix}$$

(3)

$$\begin{bmatrix} i_\alpha(n) \\ i_\beta\ (n) \\ i_0(n) \end{bmatrix} = \frac{2}{3} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} (\mathrm{x}) \begin{bmatrix} i_a(n) \\ i_b\ (n) \\ i_c\ (n) \end{bmatrix}$$

Therefore, the above components can be formed into matrix form [17, 18]

(4)

$$= \mathrm{i}_{\alpha\beta 0} = \mathrm{C} i_{abc} = \frac{2}{3} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} (\mathrm{x}) \begin{bmatrix} i_a(n) \\ i_b\ (n) \\ i_c\ (n) \end{bmatrix}$$

where C is the famous transformation introduced by Edith Clarke [19].

Wavelet Transformation

Wavelet transformation is a refinement of the Fourier transformation, where the wavelet transform allows placement time as a frequency component within the given different signal. Sort Time Fourier Transforms is another improvement of the Fourier transform [20, 21], which uses a fixed amount of the modulation window. This is because a narrow window gives bad time resolution. Therefore, the Fourier transform is only suitable for the information signal frequency as it does not change according to time.

Continuous Wavelet Transformation.

Continuous Wavelet Transformation (CWT) is used to calculate the convolution of a signal from a modulation signal, with a window at any time to any desired scale. By giving a wave function f (t), the CWT can be calculated as follows [22, 23].

(5)

$$\mathrm{CWT}(f,a,b)=\frac{1}{\sqrt{\mathrm{a}}}\int_{-s}^{s}\mathrm{f(t)}\varphi^{*}\left(\frac{\mathrm{t-b}}{\mathrm{a}}\right)dt$$

where *a* and *b* are the constants and constant scale transnational, CWT (f, a, b) is the continuous wavelet transform of a coefficient, and *φ* is wavelet functions which value are not real but just for simplification purposes only. The selection of the parent wavelet will be adapted to the needs of the wavelet coefficients.

Discrete Wavelet Transformation

Discrete Wavelet Transformation (DWT) is considered relatively easy to implement compared to CWT. The coefficient of the discrete wavelet transformation of a wave can be obtained by applying the DWT as given by equation (6) [24, 25].

$$\mathrm{DWT(f.m.k)}=\frac{1}{\sqrt{a_0^m}}\sum_k f(k)\varphi^{*}\left[\frac{n-ka_o^m}{a_0^m}\right] \qquad (6)$$

where the parameters a and b in equation (6) are replaced as $a_o m$, ka_o^m and where k and m are positive integer variables. From just a few samples of WTC taken, the implementation of DWT decomposition is essentially based on a Mallat algorithm [26,27].

(i)

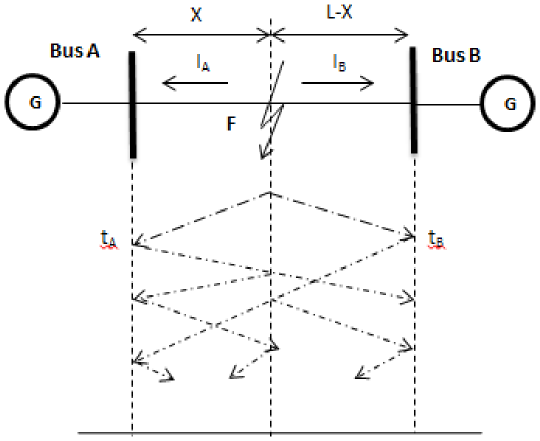


Fig..1. Bewley Lattice diagram of the transmission line

The proposed Algorithm

The simulations were performed using PSCAD, and the simulation results were obtained from the fault current signal.

The steps performed in this study were:

(ii) Finding the input to the Clarke transformation, wavelet transformation, and the signal flow of PSCAD converted into m.files (*. M) and then converting this into mat. Files (*mat).with a sampling rate of (10^5) and a frequency dependence of 0.5 Hz – 1 MHz.

(iii) Determining the data stream interference, where the signal was transformed by using the Clarke transformation to convert the transient signals into basic current signal (Mode).

(iv) Transforming mode current signals again by using DWT and WTC, which was the generated coefficient and then squared to be $(WTC)^2$ in order to obtain the maximum signal amplitude to determine the timing of the interruption.

Processing the ground mode and aerial mode *(WTC)*^{2} using the Bewley Lattice diagram [28] of the initial wave to determine the fault location as shown in Fig. 1.

If

(7) $$t_A = \frac{x}{v}$$

and

(8) $$t_B = \frac{L-x}{V}$$

Then

(9) $$x = \frac{L-\Delta t\,(x)v}{2} \text{ km}$$

where t_A - Time fault from bus A, t_B - Time fault from bus B; x - Calculated distance of fault location; L - Distance transmission line; V - Propagation velocity ;d - Estimation of the distance of fault location.

To determine the distance from the fault location from Bus A $\Delta t = t_B - t_A$

To determine the distance from the fault location from Bus B $\Delta t = t_A - t_B$

Error

(10) $$= |(x - d)/L| \text{ (x) } 100\%$$

The flowchart of the algorithm used in this study is. shown in Fig. 2

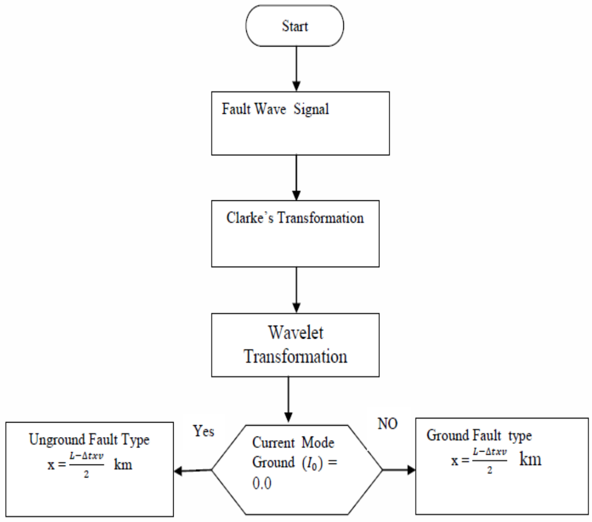


Fig. 2. Flowchart of fault detection and fault location

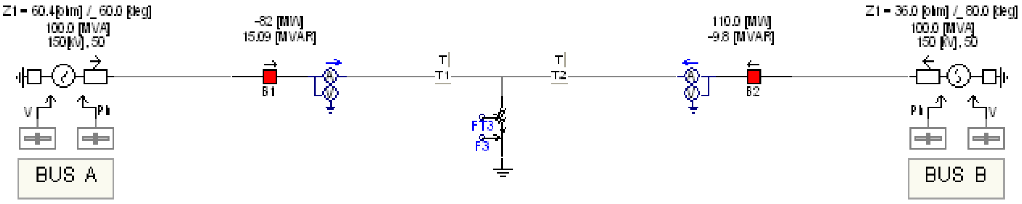


Fig. 3. Single line of the system under study using PSCAD/EMTDC

Simulation model.

The system under study is shown in Fig. 3. It consists of 150 kV transmission line 100 km in length. Two sources are connected at both sides of the transmission line edges. The system was performed using PSCAD/EMTDC software.

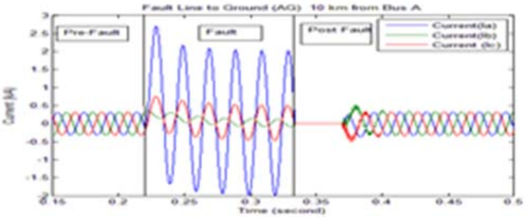
Transmission data:

Sequence Impedance ohm/km
Positive and negative = 0.03574 + j 0.5776
Zero = 0.36315 +j 1.32.647
Source Bus A Z1 = Z2 = Z0 = 30.20 + j 52.32 Ohm
Source Bus B Z1 = Z2 = Z0 = 6.25 + j 35.45 Ohm
Fault Starting = 0.22 seconds
Duration in fault = 0.15 Seconds
Fault resistance (R_F) = 2 ohm
Type Conductor = Chukar , diameter = 1.602 inch [29]

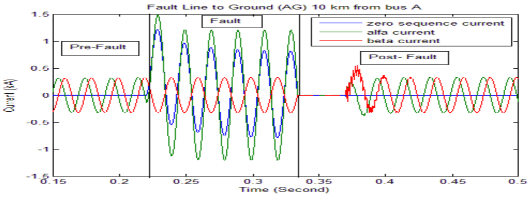
The position of the tower and the distance between the conductors were taken into account to achieve system accuracy. The conductor types used for this simulation were obtained using propagation velocity = $\frac{1}{\sqrt{LC}}$ = 299939.4321 km/seconds.

Case 1: Single line to ground fault (AG), 10 km from bus A and 90 km from bus B

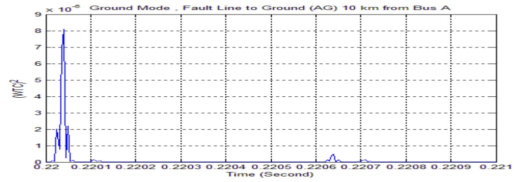
In the transient signals in Fig. 4(a). the interference was measured from Bus A. The fault current was obtained from a bus as far as 10 km, with disorder type.I_a= 2.699 kA, I_b = 0.53388 kA and I_c= 0.7556 kA. Fig. 4(b). shows a mode signal graph with the application of a current signal that was obtained using Clarke's transformation, with I_α= 1.484 kA, I_β = 0.5518 kA and I_0= 1.216 kA from bus A to the point of interruption of 10 km. Fig. 4(b). shows that, there was a signal waveform Io, which was assumed to occur due to ground fault. Fig. 4(c). shows the graph *(WTC)*^{2} in the ground mode. The results of the wavelet transformation value did not indicate zero, meaning that the ground fault occurred in the first peak which is 0.22004 seconds. Fig. 4 (d). shows *(WTC)*^{2} in which the peak occurred in aerial mode *(WTC)*^{2} at t_A equal to 0.22004 seconds .



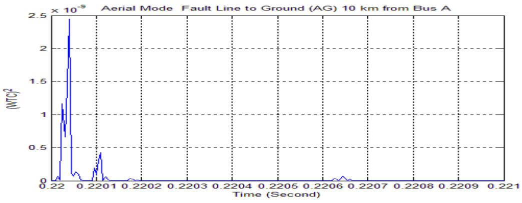
(a) Current waveform signal original



(b). Current mode waveform from Clarke's transformation



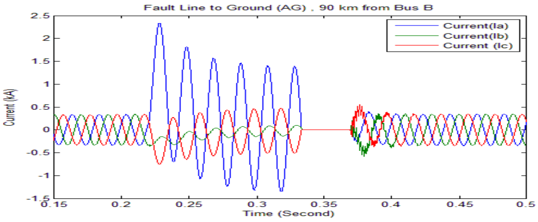
(c). Ground mode for wavelet mother Sym4



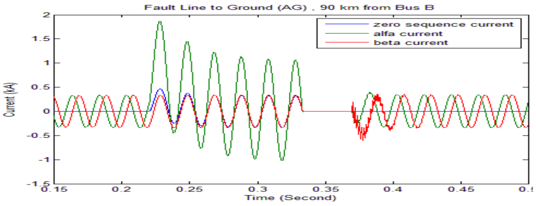
(d). Aerial mode for wavelet mother Sym4

Fig. 4. Single line to ground fault (AG) 10 km from bus A for case 1

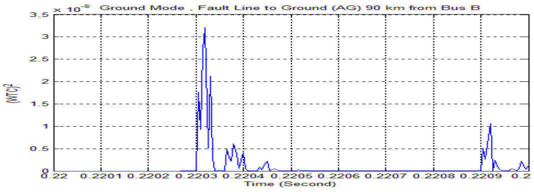
Fig. 5(a). presents the transient interference signals, measured from Bus B, obtained from the bus fault current interruption that was located 90 km from bus B, with I_a= 2.340 kA, I_b= 0.352 kA and I_c= 0.5579 kA. Fig.. (5b). shows a graph of the signal mode Clarke transformation , with signal I_α= 0.930 kA, I_β= 0.358 from bus B to the point of interruption which occurred at 90 km at I_0= 0.4712 kA is obtained. It was assumed that there was interference on the ground fault type. Fig.. 5(c) shows the graph *(WTC)*^{2} in the ground mode, where in the results of the wavelet transformation mode at ground zero, the value did not indicate zero, meaning the ground fault occurred in the first peak at 0.22032 seconds. In Fig.. 5(d). the graphs show the *(WTC)*^{2} in Aerial mode, in which the peak occurred in *(WTC)*^{2} which is t_B= 0.22031 seconds



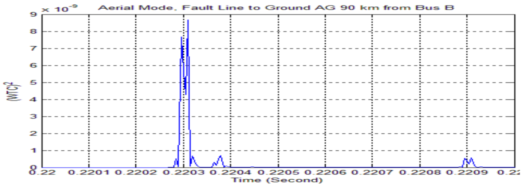
(a). Original signal of current waveform



(b). Current mode waveform from Clarke's transformation



(c). Ground mode for wavelet mother Sym4

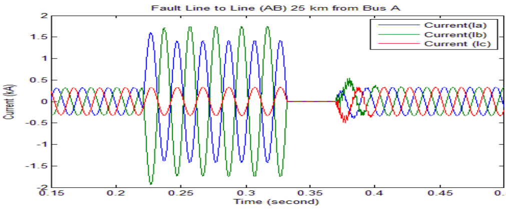


(d). Aerial mode for wavelet mother Sym4

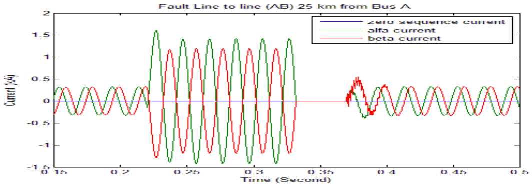
Fig.. 5. Single line to ground fault (AG)   90 km from bus B for case 1

Case 2 : Line to line fault (AB), 25 km from bus A and 75 km from Bus B

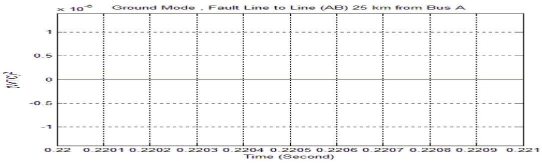
In Fig. 6(a). the graph shows the transient interference signals measured from bus A, where the fault current was obtained from bus A to a point where the fault was located 25 km from bus A with .I_a= 1.608 kA, I_b ==1.73533 kA and I_c= 0.3542 kA. Fig. 6(b) shows a graph of the obtained mode signal current with I_α= 1.607 kA, I_β= 1.193 kA and I_0= 0 kA to the disturbance point of the bus located 25 km away. Fig. 6(b) shows that the current Io produced no signal. Therefore, it can be concluded that the above disorder was a type of ungrounded fault. Fig. 6(c)   shows the graph *(WTC)*^{2} on ground mode. The results of the wavelet transformation mode showed the ground zero value, meaning that this type of fault was ungrounded. Fig. 6(d) shows *(WTC)*^{2} in Aerial mode where the peak occurred in *(WTC)*^{2} at t_A= 0.22009 seconds.



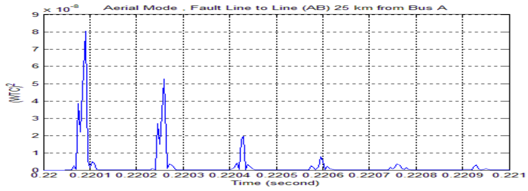
(a). Original signal of current waveform



(b). Current mode waveform from Clarke's transformation



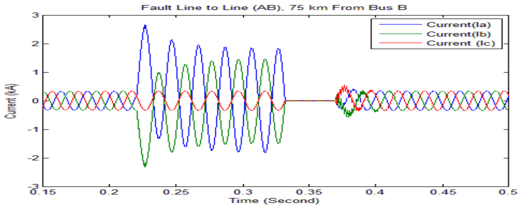
(c). Ground mode for wavelet mother Db8



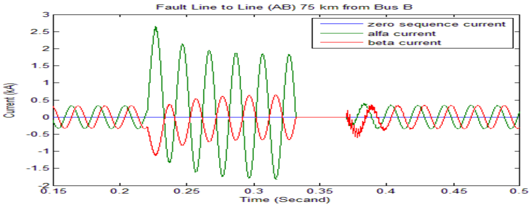
(d). Aerial mode for wavelet mother Db8

Fig 6. Line to line fault (AB) 25 km from bus A for case 2

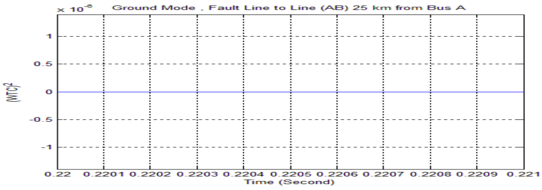
Fig. 7(a) signifies the transient signal interference graph measured from bus B, obtained from the bus fault current interruption to point B for 75 km with I_a = 2.654 kA, I_b ==1.4733 kA and I_c= 0.5468 kA. Fig.7(b) shows a graph of the signal mode with a current of I_α= 0.2654 kA, I_β= 0.6473 kA and I_0= 0 on bus B to the point of disorder at 75 km. Fig. 7(b). shows that the current I_0= 0, thus suggesting that the disorder was a disturbance at the ungrounded fault. Fig. 7(c). shows the graph *(WTC)*^{2} in ground mode. The results of wavelet transformation mode showed ground zero value, which means that this was an ungrounded fault. Fig. 7(d)..shows *(WTC)*^{2} in aerial mode in which the peak occurred at *(WTC)*^{2} at t_B= 0.22026 seconds.



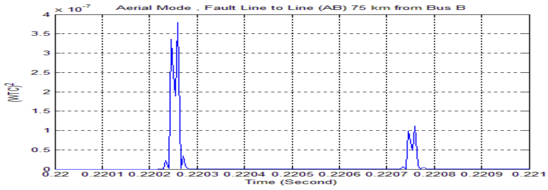
(a). original signal of Current waveform



(b). Current mode waveform from Clarke's transformation



(c). Ground mode for wavelet mother Db8



(d). Aerial mode for wavelet mother Db8

Fig. **7.** Line to line fault AB locatedat 75 km from bus B for case 2

Discussion and Result

Fig. 8 shows that the fault detection column Db4 had a long-time duration of 0.00018 seconds for time fault detection, while Sym4 and Coif4 have similar time for fault detection of about 0.000165 seconds. Db8 had a better time for fault detection compared to others at about 0.00016 seconds. The percentage of error in fault location for different type of mother wavelet is shown in Table 1. shows more detailed results, including the error calculation of the single line to ground fault. This shows that Db4, Sym4 and Db8 had the same percentage error for the distance of 10 km and 90 km of the transmission line, whereas at 25 km, Db8 had a better performance than the rest. In contrast, for 75 km transmission line, Db4 and Sym4 had less percentage error than Db8. The percentage calculation of the error fault line to line to the ground fault shows that at 10 km and 90 km, long transmission lines Db4, Sym4 and Db8 had the same percentage of error. Conversely, at 25 km and 75 km, the percentage error of Sym4 and Db8 were less compared with Db4 and Coif4 since Coif4 had a major percentage of error in all cases. This indicates that the proposed algorithm for fault classification is accurate and precise.

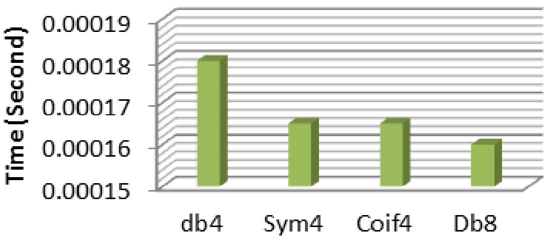


Fig..8. Fault time detection (second

.

Table 1. Percentage error in Fault Location for different type of Mother Wavelet, R_f= 2 Ohm and fault inception angle = 0 (degree)

Type Of Fault	Actual Point of Fault (km)	Db4		Coif4		Syms4		Db8	
		Calculated point of Fault (km)	Error =(x-d)/L *100%	Calculated point of Fault (km)	Error = (x-d)/L *100%	Calculated point of Fault (km)	Error = (x-d)/L *100%	Calculated point of Fault (km)	Error = (x-d)/L *100%
LG (AG)	10	9.51	0.419	12.52	2.051	9.51	0.419	9.51	0.419
	25	24.51	0.495	26.01	1.001	24.51	0.495	24.51	0.495
	75	74.45	0.258	73.99	1.005	74.45	0.258	75.49	0.495
	90	90.49	0.492	88.99	1.080	90.49	0.492	90.49	0.492
LL (AB)	10	9.51	0.419	11.01	1.001	9.51	0.419	9.51	0.419
	25	24.51	0.495	26.01	1.001	24.51	0.495	24.51	0.495
	75	75.49	0.495	73.99	1.001	75.49	0.495	75.49	0.495
	90	90.45	0.492	86.69	1.307	90.49	0.492	90.49	0.492
LLG (BCG)	10	9.51	0.419	10.86	0.857	9.51	0.419	9.51	0.419
	25	26.01	1.001	26.01	1.005	24.51	0.495	24.51	0.495
	75	73.99	1.001	73.85	1.155	75.49	0.495	75.49	0.495
	90	90.49	0.492	88.99	1.007	90.49	0.492	90.49	0.492
LLL (ABC)	10	9.51	0.419	11.01	1.008	8.76	1.242	9.51	0.419
	25	26.01	1.001	26.01	1.001	24.51	0.495	24.51	0.495
	75	73.99	1.001	73.99	1.001	75.49	0.495	74.49	0.495
	90	89.74	0.258	88.88	1.007	90.49	0.492	90.49	0.492

Conclusion

When transformed into a wavelet, the determination of fault location using the Clarke transformation was very accurate, with an error of less than 2%. This was true even at a distance of 50 km, with an average error of 0.258% which was achieved for the time of bus A to the point of disturbance for the time achieved by bus B. From the above results, Db8 was found to be the best compared with other mother wavelets, with the fastest detection time at 0.00016 seconds and produced the smallest error in all types of interference. Meanwhile, the largest percentage error was produced by the mother wavelet Coif4.

Acknowledgment

The authors would like to express their gratitude to Universiti Teknologi Malaysia, The State Polytechnic of Ujung Pandang, PT. PLN (Persero) of South Sulawesi and the Government of South Sulawesi Indonesia for providing the financial and technical support for this research.

REFERENCES

[1] IEEE Guide for Determining Fault Location on AC Transmission and Distribution Lines, *IEEE Std C37.114*, (2004)

[2] Magnago F.H., Abur A, ,Fault location using wavelets, IEEE Transactions on Power Delivery. 13(1998), nr 4, 1475-1480

[3] Dommel H.W, Michels J.M. ,High speed relaying using traveling wave transient analysis. *IEEE Publications NO. 78CH1295-5 PWR. paper no. A78 214-9, IEEE PES Winter Power Meeting*, New York 1978, 1-7.

[4] Evrenosoglu C.Y, Abur., Fault location in Distribution System with Distribution Generation. *15th PSCC* 10,(2005), nr 5,1-5

[5] Paweł.D., Jan I., Przemysław B,. Fault location on double-circuit transmission line not requiring line

parameters, Przeglad Elektotechniczny, R. 89 NR .10(2013), 18-21

[6] Jafarian P,.Pasand M.S. ,A Traveling-Wave-Based Protection Technique Using Wavelet /PCA Analysis. *IEEE Transactions on Power Delivery* 25(2010), 588 – 599.

[7] Zhang Y, Tai N, Tang Y, Xu B., Travelling wave-based pilot direction comparison protection for HVDC line. Int. Trans. Electr. Energ. Syst. 23(2013), 1304–1316

[8] Polajzer B, Tumberger G.S, Seme S, Dolinar D., Detection of voltage sources based on instantaneous voltage and current vectors and orthogonal clarke's transformation. IET. Gener .Transm. Distrib 2(2008), nr 2, 219–226.

[9] Prado A.J, Filho J.P, Kurokawa, Bovolato L.F., Transmission line analyses with a single real transformation matrix - Non symmetrical and non-transposed cases, *The 6th Conference on Power System Transients (IPST'05) CD-ROM* Montreal. Canada, (2005).

[10] Chaari, Meunier M, Brouave F. Wavelet a new tool for the resonant grounded power distribution systems relaying. *IEEE Trans. on Power Delivery* 11 (1997), nr 3 ,1301-1308.

[11] Patthi S, Birendra P.S , Pulapa V.K.R., Neutral current wave shape analysis using wavelet for diagnosis of winding insulation of a transformer. *Turk J Elec Eng & Comp* Sci 20 (2012), 835 - 841..

[12] Samantaray S.R, Dash P.K.., Transmission line distance relaying using a variable window short-time Fourier transform. *Electric Power Systems Research 78*(200, 595–604

[13] Norman CFT, Long Z, Lai LL. Wavelet-based algorithm for power quality analysis. *Euro. Trans. Electr. Power* 20(2010), 952–964

[14] Kim C, Aggarwal R., Wavelet transform in power systems. *Power Eng. J* 15 2001, nr 4, 193–202

[15] PSCAD/EMTDC User's Manual. Manitoba HVDC *Research Center. Winnipeg MB. Canada* (2001)

[16] Noshad B, Razaz M, Seifossadat S.G. A new algorithm based on Clarke's Transform and Discrete Wavelet Transform for the differential protection of three-phase power transformers considering the ultra-saturation phenomenon, *Electric Power Systems Research* 110 (2014). 9-24.

[17] Brando F.J. Application of Clarke's transformation to the modal analysis of asymmetrical single-circuit three-phase line configurations, *Eur Trans on Electr Power* 10(2000), nr 4, 225–231

[18] Prado A.J, Filho J.P, Kurokawa S, Bovolato L.F., Non-transposed three-phase line analyses with a single real transformation matrix. *The 2005 IEEE/Power Engineering Society General Meeting, CD-ROM* 12-16 June (2005), San Francisco, USA .

[19] Alfredo O.F, Luis I.E, Carlos R.E., Three-phase adaptive frequency measurement based on Clarke's Transformation. IEEE Trans. on Power Delivery 21(2006), nr 3, 1101-1105

[20] Eldin E.S.T, Ibrahim D.K., Abdul Sahap EM, Saleh SM. High Impedance Fault Detection in EHV Transmission Line using Wavelet Transform, *Power Engineering Society General Meeting IEEE* (2007) , 1-7.

[21] Zhao W, Song Y,H, Min Y. Wavelet analysis based scheme for fault detection and classification in underground power cable systems. *Electr Power syst. Res* 53 (2000), 23-30

[22] Chanda D, Kishore N.K, Sinha A.K.. Application of wavelet multiresolution analysis for identification and classification of faults on transmission lines. *Electr Power Syst. Res.*73(2005, 323–333.

[23] Sadegh J, Navid G., A new method for arcing fault location using discrete wavelet transform and wavelet networks, *Euro. Trans. Electr. Power* 22(2012), 601–615

[24] Krzysztof G., . Désiré D. R ., Ryszard K.., Detection, classification and fault location in HV lines using travelling waves, Przeglad Elektotechniczny (Electrical Review) R.88 NR (**1a)** (2012) 269-275

[25] Eristi H, Demir Y., Determinant-based feature extraction for fault detection and classification for power transmission lines, *IET Gener. Transm.Distrib* 6(2012) , nr 10, 968–976

[26] Malla S.G. Theory for multiresolution signal decomposition the wavelet representation. *IEEE trans Pattern Anal Mach Intell* 11(1989) **,** nr 7, 94-798.

[27] Chandra D, Kishore N.K., Sinha A. A Wavelet multiresolution analysis for location of fault on transmission line, *Electrical Power and Energy System* 25(2003), 59-69

[28] Datta, Rajagopal A. Literature review on use bewley's lattice diagram, *Power and Energy in Nerist (ICPEN)*, India , (2012)

[29] Alcan. Aluminum Conduct or Steel Reinforced (ACSR) cable. ASTM specification B230 , B232 , B490 and B 500

Authors:

Makmur Saini, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 Johor Bharu, Johor, Malaysia. E-mail: makmur.saini@fkegraduate.utm.my.

Abdullah Asuhaimi Mohd Zin, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 Johor Bharu, Johor, Malaysia E-mail: abdullah@fke.utm.my..

Mohd Wazir Mustafa, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 Johor Bharu, Johor, Malaysia. E-mail: wazir.mustapa@fke.utm.my

Ahmad Rizal Sultan , Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 Johor Bharu, Johor, Malaysia. Rizal.sultan@fkegraduate.utm.my.