

เอกสารอ้างอิง

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ภาคผนวก ก.

ผลงานที่ได้รับจากโครงการวิจัยที่ได้รับทุนจาก สจล.

1. ผลงานวิจัย/ผลผลิตที่ได้จากการทำวิจัย และมี Impact ต่อสังคม, ประเทศชาติ

1. โครงการวิจัยนี้เป็นการรวมกันของวิทยาการด้านต่างๆ คือ กระบวนการประมวลสัญญาณ ทฤษฎีระบบป้องกัน และ วิศวกรรมไฟฟ้ากำลัง เข้าด้วยกัน ซึ่งจะก่อให้เกิดประโยชน์ร่วมกันของนักวิจัยในสาขาดังกล่าว ทั้งในด้านการแลกเปลี่ยนความรู้ ความคิดเห็น นับเป็นการพัฒนาระดับงานวิจัยของประเทศ
2. การศึกษาวิเคราะห์ฟอลต์ที่เกิดขึ้นในสายส่งที่นำเสนอในโครงการวิจัยนี้ สามารถนำรูปแบบการวิเคราะห์ไปประยุกต์ใช้กับหลักการของระบบป้องกันแบบต่างๆ นับได้ว่าเป็นประโยชน์สำหรับวิศวกร นักวิจัย นักศึกษา ตลอดจนผู้สนใจอื่นๆ เพื่อใช้ในการศึกษาวิจัยและพัฒนาต่อไป
3. ได้องค์ความรู้ของเทคโนโลยีที่เป็นของประเทศไทยเอง โดยไม่ต้องพึ่งเทคโนโลยีจากต่างประเทศ

2. การนำผลงานวิจัยไปประยุกต์ใช้

1. วิเคราะห์ฟอลต์ที่เกิดขึ้นบนระบบส่งจ่ายกำลังไฟฟ้าแนวใหม่โดยใช้ข้อมูลองค์ประกอบความถี่สูงที่ได้จากสัญญาณฟอลต์แบบทรานเซียนต์ ซึ่งช่วยลดช่วงของสัญญาณที่ทำการวิเคราะห์ให้สั้นลง จะส่งผลให้ระบบการวิเคราะห์และตัดสินใจใช้เวลาลดลงตามไปด้วย
2. หาคำแนะนำและสาเหตุที่แท้จริงของฟอลต์ที่เกิดขึ้นในระบบส่งจ่ายกำลังไฟฟ้าได้อย่างถูกต้อง เพื่อนำมาวางแผนป้องกันระบบไฟฟ้ากำลังและซ่อมแซมบำรุงรักษาสายส่งต่อไป
3. สามารถนำรูปแบบการวิเคราะห์สัญญาณด้วยการแปลงเวฟเล็ตและการใช้ทฤษฎีการแปลงเวฟเล็ตไปประยุกต์ให้มีประสิทธิภาพเพิ่มมากขึ้นได้โดยการนำปัญญาประดิษฐ์เข้ามาใช้ร่วมด้วย

3. ผลงานตีพิมพ์ในวารสารวิชาการในประเทศ การเสนอผลงานในที่ประชุมวิชาการ หนังสือ การจดสิทธิบัตร หรือผลงานตามที่คาดไว้ในโครงการวิจัย

- 3.1 การนำเสนอในการประชุมวิชาการระดับนานาชาติ นำเสนอบทความในที่ประชุมวิชาการระดับนานาชาติ รวมทั้งสิ้น 1 บทความ (ภาคผนวก ข)

1. C. Pothisarn, C. Jettanasen, A. Ngaopitakkul, and C. Apisit, "Identification of Fault Location for Simultaneous Fault in Distribution System using Discrete Wavelet transform" An International Journal of Research and Surveys ICIC Express Letters, Vol. 5, Issue 4(B), pp.1423-1428, April 2011.



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ภาคผนวก ข.

ตัวอย่างบทความประชุมวิชาการระดับนานาชาติที่ได้นำเสนอในที่
ประชุมระดับนานาชาติ

1. C. Pothisarn, C. Jettanasen, A. Ngaopitakkul, and C. Apisit, "Identification of Fault Location for Simultaneous Fault in Distribution System using Discrete Wavelet transform" An International Journal of Research and Surveys ICIC Express Letters, Vol. 5, Issue 4(B), pp.1423-1428, April 2011.

IDENTIFICATION OF FAULT LOCATION FOR SIMULTANEOUS FAULT IN DISTRIBUTION SYSTEM USING DISCRETE WAVELET TRANSFORM

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ABSTRACT. *Currently, the most effective technique for identifying fault location, based on a travelling wave, has been proposed in several research papers. However, the effects of simultaneous faults have been neglected. In order to overcome this problem, a new algorithm will be developed in order to predict fault location precisely. This paper presents a technique to detect fault locations, during simultaneous fault, in an underground distribution system using discrete wavelet transform (DWT). The DWT is used to detect the high frequency components. The time that the fault signal uses to reach the ends of the distribution line is considered, then, applied so that the distance of fault can be calculated. The result is found that the proposed algorithm gives satisfactory both in case of single fault and simultaneous fault.*

Keywords: Distribution, Cable, Wavelet transform, Simultaneous fault, Fault location

1. Introduction. It is an important issue to seek out the fault location on the distribution lines as fast as possible in order to maintain the stability of the power system. The most effective technique to locate fault location has been proposed based on travelling wave [1,2]. Although, travelling wave technique can give precise results in fault location, however, high sampling rate is required and, in addition, problem concerning distinguishing between travelling waves reflected from the fault point and from the remote end of the line. In the literature for fault location, most researches have only considered the fault location for overhead transmission system and underground distribution system with several algorithms [3-9]. A technique selection is available for fault locating; it depends on several factors such as length of circuit (or cable), type of fault (sustained or temporary), etc. The location of fault using wavelet transform was initially proposed by F. H. Magnago et al. [3]. Although the underground cable distribution system provides higher reliability than the overhead line system, it is hard to seek out the fault location. Bridge technique [5], Murry loop pulse radar [5] are used for identifying fault location in underground distribution system. Travelling wave theory [6,7] has been also reported in the literature for identifying underground system.

However, in previous research works [10], the first peak time that can detect fault obtained from all buses are compared and the two fastest first peak times obtained from comparison are used as an input data for traveling wave theory. It was concluded that in case of single fault, the accuracy of fault locations from the prediction of the travelling wave theory is highly satisfactory. However, during simultaneous fault, the travelling wave theory is not efficient in predicting the fault location in an electrical power transmission system. When carefully investigated, it is found that in case of single fault, the time that the fault signal used to reach the ends of the transmission lines is considered as an input data for traveling wave equation. From Figure 1(a), during single fault, T_{F1S} and T_{F1R} are

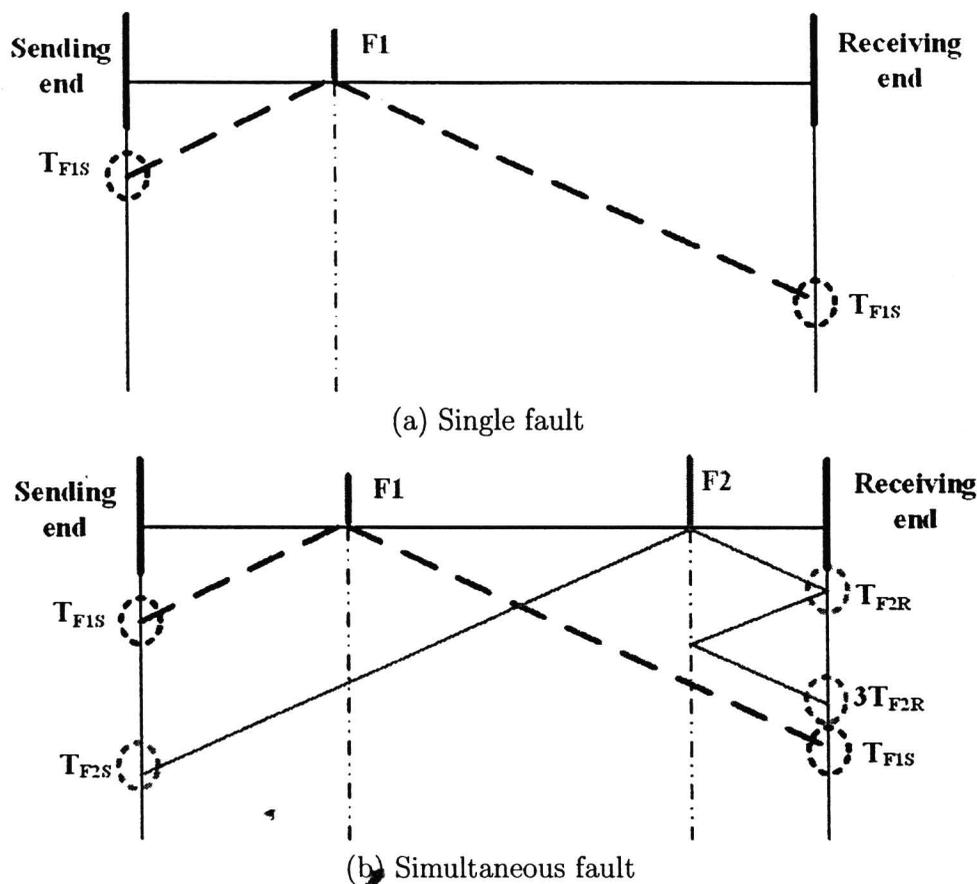


FIGURE 1. The arrival peak time on each end of line

the first peak time at both end of distribution line as an input data. On the other hand, during single fault, T_{F1S} and T_{F1R} are the first peak time at both end of distribution line as an input data as shown in Figure 1(b). It is noted that the simultaneous faults are detected faster than the single fault due to the fact that the time which the first fault (F1) at both end of transmission line should be calculated, however, in this case, there is an effect of second fault (F2). Consequently, travelling wave theory could give an error in predicting the fault location in case of simultaneous fault. In order to overcome this problem, a new algorithm should be developed in order to predict fault location precisely.

Therefore, this paper aims to present a development of a new decision algorithm used in the protective relays in order to detect fault locations, during simultaneous fault, in an underground distribution system using discrete wavelet transform (DWT). The simulations, analysis and diagnosis are performed using ATP/EMTP and MATLAB. The current waveforms obtained from ATP/EMTP are extracted to several scales with the wavelet transform, and the coefficients of the first scale from the wavelet transform that can detect fault are investigated.

2. Simulations. The ATP/EMTP is employed to simulate fault signals, at a sampling rate of 200 kHz. The system employed in case studies is chosen based on the underground distribution system as illustrated in Figure 2. In addition, a cross-sectional view of a cable is shown in Figure 3. To avoid complexity, the fault resistance is assumed to be 10 Ω . Fault patterns in the simulations are performed with various changes of system parameters as follows:

- Fault types are single line to ground, double lines to ground, line to line and three-phase fault.

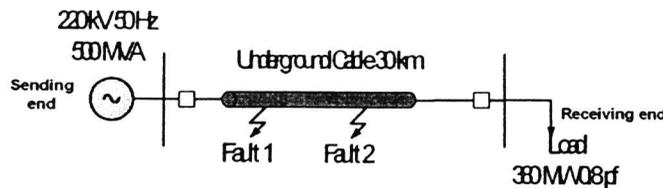


FIGURE 2. The system used in simulation studies [10]

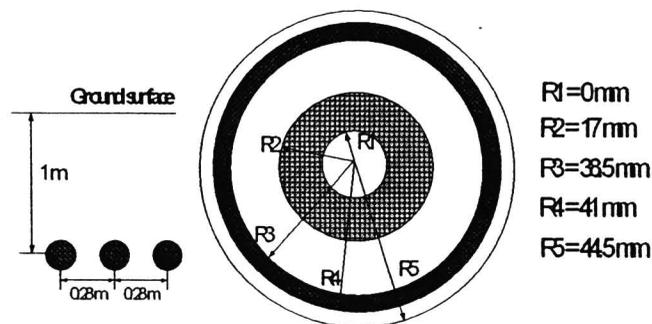


FIGURE 3. The configuration of cable in simulation studies

- For the single fault, fault locations are the distance of 4.5, 6, 9, 12 km measured from the sending end.
- For the simultaneous faults, the location of F1 on the underground distribution system is designated at the distance of 4.5, 6, 9, 12 km from the sending end.
- For the simultaneous faults, the location of F2 on the underground distribution system is designated at the distance of 15, 21, 24, 27 km from the sending end.
- Fault inception angles on the phase A voltage waveform were varied from 0° to 150° with a step of 30° .

3. Decision Algorithm. The fault detection decision [10] is processed using the positive sequence current signals. Fault signals generated by ATP/EMTP are used to calculate the positive sequence as well as the zero sequence of currents using the Clark's transformation matrix. The resulted current signals are extracted using the wavelet transform. The mother wavelet daubechies4 (db4) [10,11] is employed to decompose high frequency components from signals. The coefficients of the signals obtained from the wavelet transform are squared for a more explicit comparison. The fault detection decision algorithm is assumed that if coefficients of any scales are changed around five times before an occurrence of the faults, there are faults occurring on underground distribution line.

After the fault detection process, the time which the fault at both end of distribution line are detected fault, then, applied so that the distance of fault can be calculated with proposed algorithm as follows:

$$d = LT \times \frac{t_{diff-FS}}{t_{diff-FS} + t_{diff-FR}} \quad (1)$$

where,

d = the fault location measured from the sending end.

LT = the length of the cable in which the fault is detected.

T_{F1S} = the first peak time which can detect fault at sending end.

$3T_{F1S}$ = the second peak time which can detect fault at sending end.

T_{F1R} = the first peak time which can detect fault at receiving end.

$3T_{F1R}$ = the second peak time which can detect fault at receiving end.

t_{diff_FS} = the different time by comparing the arrival peak time to reach the sending end as calculated in Equation (2).

$$t_{diff_FS} = \left| \frac{T_{F1S} - 3T_{F1S}}{2} \right| \quad (2)$$

t_{diff_FR} = the different time by comparing the arrival peak time to reach the receiving end as calculated in Equation (3).

$$t_{diff_FR} = \left| \frac{T_{F1R} - 3T_{F1R}}{2} \right| \quad (3)$$

The results obtained from the proposed algorithm in this paper are shown in Figure 4. Figure 4 illustrates examples of simultaneous fault when the first fault (F1) happening at 9 km from sending end while the second fault (F2) is at 24 km from sending end, and two types of faults occurring at the same time. Meanwhile, examples of single fault when the fault (F1) occurs at 9 km from sending end. The results obtained from the proposed algorithm are shown in Tables 1 – 3. It can be seen that in case of simultaneous fault, the proposed algorithm gives satisfactory results in locating faults as shown in Tables 1 and 2. Further, fault location for single fault is also calculated in order to shown the

TABLE 1. The results obtained from proposed algorithm for fault F1 of simultaneous fault

Real locate from sending end (km)		Fault location measured from the sending end (m)							
Fault F ₁	Fault F ₂	T_{F1S}	$3T_{F1S}$	t_{diff_FS}	T_{F1R}	$3T_{F1R}$	t_{diff_FR}	Calculation	Error
4.5	25.5	40.024	40.070	0.023	40.132	40.396	0.132	4451.61	48.39
5.0	15.0	40.026	40.078	0.026	40.130	40.388	0.129	5032.26	32.26
6.0	21.0	40.032	40.094	0.031	40.124	40.372	0.124	6000.00	0.00
9.0	24.0	40.046	40.140	0.047	40.108	40.326	0.109	9038.46	38.46
12.0	27.0	40.062	40.186	0.062	40.092	40.280	0.094	11923.08	76.92
14.0	16.0	40.072	40.218	0.073	40.082	40.248	0.083	14038.46	38.46

TABLE 2. The results obtained from proposed algorithm for fault F2 of simultaneous fault

Real locate from sending end (km)		Fault location measured from the sending end (m)							
Fault F ₁	Fault F ₂	T_{F2S}	$3T_{F2S}$	t_{diff_FS}	T_{F2R}	$3T_{F2R}$	t_{diff_FR}	Calculation	Error
4.5	25.5	40.132	40.396	0.132	40.024	40.070	0.023	25548.39	48.39
5.0	15.0	40.078	40.232	0.077	40.078	40.232	0.077	15000.00	0.00
6.0	21.0	40.112	40.330	0.109	40.046	40.140	0.047	20961.54	38.46
9.0	24.0	40.124	40.372	0.124	40.032	40.094	0.031	24000.00	0.00
12.0	27.0	40.140	40.420	0.140	40.016	40.046	0.015	27096.77	96.77
14.0	16.0	40.082	40.248	0.083	40.072	40.218	0.073	15961.54	38.46

TABLE 3. The results obtained from proposed algorithm for single fault

Real locate from sending end (km)		Fault location measured from the sending end (m)							
Fault F ₁	Fault F ₂	T_{F2S}	$3T_{F2S}$	t_{diff_FS}	T_{F2R}	$3T_{F2R}$	t_{diff_FR}	Calculation	Error
4.5	–	40.024	40.070	0.023	40.132	40.396	0.132	4451.61	48.39
5.0	–	40.026	40.078	0.026	40.130	40.388	0.129	5032.26	32.26
6.0	–	40.032	40.094	0.031	40.124	40.372	0.124	6000.00	0.00
9.0	–	40.046	40.140	0.047	40.108	40.326	0.109	9038.46	38.46
12.0	–	40.062	40.186	0.062	40.092	40.280	0.094	11923.08	76.92
14.0	–	40.072	40.218	0.073	40.082	40.248	0.083	14038.46	38.46

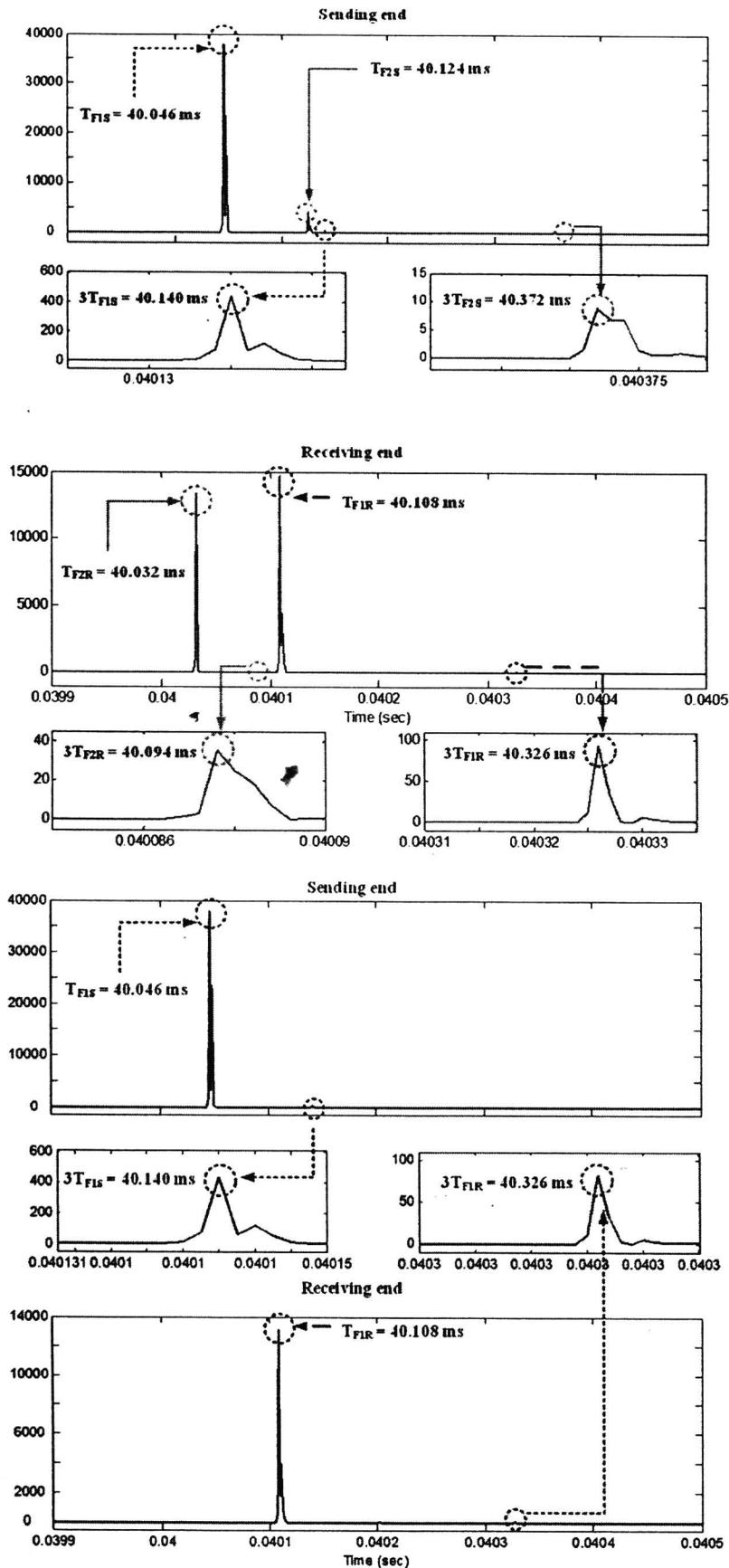


FIGURE 4. The time that can detect simultaneous fault in the scale 1 for the positive sequence of current signal

advantage of the proposed algorithm. It is found that the proposed algorithm still also gives satisfactory results in locating faults as shown in Table 3.

From Tables 1 – 3, the analysis of simultaneous faults and single faults is performed with this algorithm, and it can be seen that the accuracy of fault locations from the prediction of the proposed algorithm is highly satisfactory both single fault and simultaneous fault. As a result, this algorithm is an improvement of the fault location which is detected using the wavelet transform.

4. Conclusions. This paper proposes a technique using discrete wavelet transform in order to identify of fault locating, during simultaneous fault, in an underground distribution system. Daubechies4 (db4) is selected as a mother wavelet. Positive sequence current signals are used in fault detection. The time that the fault signal used to reach the ends of the distribution line is considered, then, applied so that the distance of fault can be calculated. It is shown that the proposed algorithm is a powerful tool because it gives satisfactory results both simultaneous fault and single fault as shown in Tables 1 – 3. It can be considered as first processing in fault location on transmission line. The further work will be the improvement of the algorithm so that locations of simultaneous fault along the loop structure of distribution network can be identified.

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