HIGH TRANSIENT BASED TRANSMISSION LINE PROTECTION TECHNIQUES

Badal N. Mondal[1], Miss. Preeti [2]

[1] PG Scholar, Electrical Engineering Department, Shri Sai College of Engg & Tech, Bhadravati, Maharashtra, India

[2] Assistant Professor, Electrical Engineering Department, Shri Sai College of Engg & Tech, Bhadravati, Maharashtra, India

ABSTRACT

This paper presents the application of 'Transient Based Protection' techniques in power transmission lines. A brief introduction to the history of development of relaying principles for transmission line protection, which outlining the background of the development, is given first. The advantages of transient based protection schemes over the existing techniques are illustrated by the introduction of a number of novel techniques for transmission line protection. These are transient identification; transient based protection and adaptive transient enclosure techniques. The protection schemes provide a fast response, high accuracy, and are not affected by power frequency phenomena, such as fault path impedance, power swing and CT saturation.

Keyword: - *High transient based protection, DWT.*

---

1. INTRODUCTION

The majority of the protection principles were developed within the first 3 decades. All these relay principles are based on the measurement of power frequency signal for fault detection. With the continuous development of modern technology and industry, the protection devices based on the above mentioned principles have advanced through the development stages of electro mechanical, semiconductor, integrated circuit and microprocessor. Although decades of research have been put into the continued development and perfection of the relay technology, the basic relay principles have not been changed, they are still playing the dominant role in the area of power system protection today.

It was not until the later *70's,* with the continuous expansion of the power network, the demand for the fast fault clearance to improve system stabilities has resulted in the searching for methods to increase the speed of relay response. This leads to the development of the so called 'ultra-high speed protection' based on the travelling wave and superimposed components[1-3], which was the beginning of utilizing the fault generated transient for the purpose of transmission line protection. The protection relays developed have the advantage of fast response; directionality; not affected by power swing and CT saturation. However, one of the main reasons that these relays were unable to reach ideal accuracy and reliability is the limitation imposed by the bandwidth of transducers.

As a result of the development, the performance of the protection relays. However, the development has been concentrated to the improvement of conventional protection principles, the basic principles of the various relays have not been changed by the application of the adaptive and AI techniques.

In recent years, the newly developed 'fault generated noise based protection for transmission line' marks the start of protection using fault generated high frequency transients. The main advantage of this technique is the saving in cost of the communication link. More importantly, the fault high frequency transient voltage signal is first used for fault detection. Following the development, extensive research work has been conducted to develop new relaying principles and techniques based on the detection of fault generated transients. Thus far, the new schemes proposed have already covered many aspects of power system protection. This development has led to a new concept in power system protection - the 'Transient Based Protection' (TBP). This paper presents the development of the TBP in the area of transmission line protection by introducing a number of novel protection techniques, such as transient identification, transient based protection techniques and transient adaptive enclosure.

2. DIFFERENT METHODS FOR TRANSIENT BASED PROTECTION

One of the author presents a novel ultra-high-speed directional protection [1] scheme developed using mathematical morphology (MM). The MM technique proposed is used to extract transient features from fault-generated voltage and current wave signals propagating along transmission lines during a post-fault period. Fault direction is determined by two composite relaying signals which are composed of the extracted transient features. A variety of fault scenarios has been simulated to evaluate the validity of the proposed scheme.
Author presents a novel single-ended transient positional protection (SETPP) scheme developed using the combined scheme with multi-filter units of mathematical morphology (MFUMM) and multi-resolution morphological gradient (MMG) [2]. Multi-filter units can effectively and gradually suppress a variety of random and pulsed noises existing in fault generated transient signals which can be detected by using multi-resolution morphological gradient. The fault can be located accurately according to relative traveling times and polarities of transient signals. A typical 500-kV extremely high voltage (EHV) transmission system has been simulated by PSCAD/EMTDC to evaluate the scheme. The simulation results show that this scheme is capable of locating accurately under various types of faults occurring at different positions on power lines. Meanwhile, it should be indicated that this algorithm has less computational complexity than multi-resolution wavelet transform, which makes it possible to put into practice.

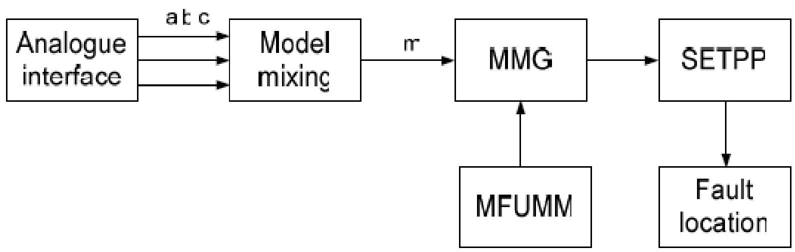

Fig.1:- Scheme block diagram for mathematical morphology (MFUMM) and multi-resolution morphological gradient (MMG) approach [2].

The potential of using discrete wavelet transform in protective relay is examined and model of relay using transient phenomena [3] to fault line selection in distribution system is proposed and next integrated into ATP simulation program. Detailed model of distribution system was made in ATP draw with connected relay through CT model for consideration of possible saturation effect. Simulations were performed for algorithm evaluation with included detailed model of arc fault or high impedance ground fault and results show excellent discrimination function under various operating conditions.
Author proposes [4] a powerful high-speed traveling- wave-based technique for the protection of power transmission lines. The proposed technique uses principal component analysis to identify the dominant pattern of the signals preprocessed by wavelet transform. The proposed protection algorithm presents a discriminating method based on the polarity, magnitude, and time interval between the detected traveling waves at the relay location. A supplemental algorithm consisting of a high-set overcurrent relay as well as an impedance-based relay is also proposed. This is done to overcome the well-known shortcomings of traveling-wave-based protection techniques for the detection of very close-in faults and single-phase-to-ground faults occurring at small voltage magnitudes. The proposed technique is evaluated for the protection of a two-terminal transmission line.

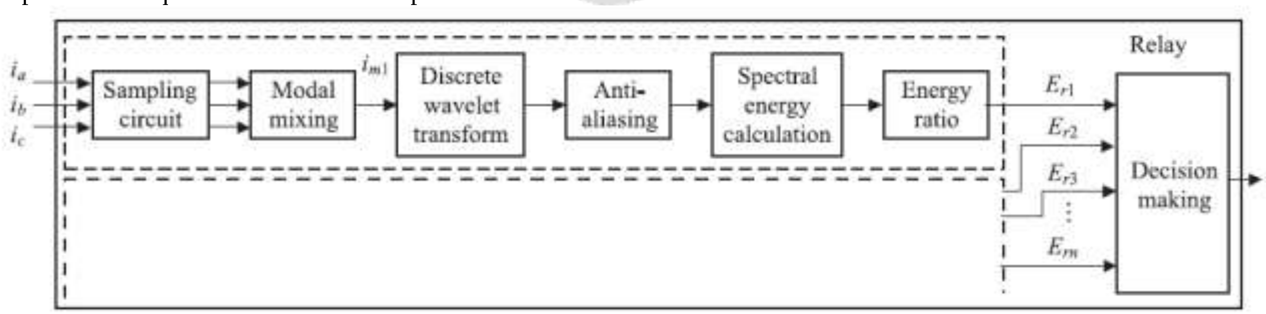

Fig.2:- Block diagram of the proposed relay unit [3].

Extensive simulation studies using PSCAD/EMTDC software indicate that the proposed approach is reliable for rapid and correct identification of various fault cases. It identifies most of the internal faults very rapidly in less than 2 ms. In addition, the proposed technique presents high noise immunity.

The real-time detection of the fault-induced transients on both transmission line terminals can allow the directional protection system to detect and locate faults in agreement with a high-speed fault clearance. Author [5] presents a wavelet based method for real-time detection of the fault-induced transients. The method can detect whether the fault is within the protected line and estimate the fault location through a communication link at both line terminals. The wavelet coefficients were computed with both the Discrete Wavelet Transform (DWT) and the Maximal Overlap Discrete Wavelet Transform (MODWT). However, the MODWT provided faster fault detection and better fault location. The method was implemented and evaluated by means of the Real Time Digital Simulator (RTDS).

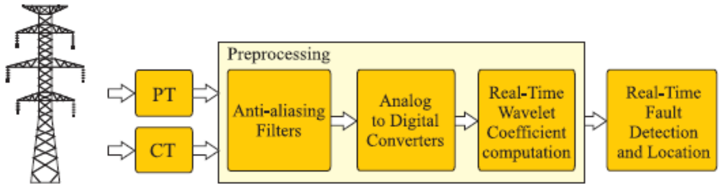

Fig.3:- Flowcharting of the preprocessing module [5].

A novel technique [6] is applied to detect fault in the transmission line using wavelet transform. Three phase currents are monitored at both ends of the transmission line using global positioning system synchronizing clock. Wavelet transform, which is very fast and sensitive to noise, is used to extract transients in the line currents for fault detection. Fault index is calculated based on the sum of local and remote end detail coefficients and compared with threshold value to detect the fault. Proposed technique is tested for various faults and fault inception angles. Simulation results are presented showing the selection of proper threshold value for fault detection.

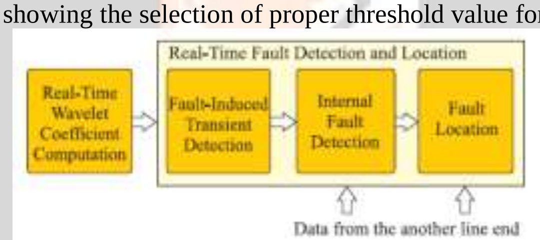

Fig.4:- Flowchart of the real-time fault detection and location [5].

The protection of multi-terminal transmission lines is a challenging task due to possible infeed or outfeed currents contributed from the taped lines. As a result, the first zone reach of a non-communication-based scheme (e.g., impedance-based distance relays) usually cannot be extended more than a small portion beyond the tap point. Author paper presents a protection technique based on the high-frequency transients generated by the fault [7] to cover almost the total length of multi-terminal transmission lines. For this purpose, appropriately designed line traps are installed at terminals of the protected transmission line, and the support vector machine is used to classify the internal and external faults based on the frequency spectrum of the current signals decomposed by the wavelet transform. Extensive simulation studies indicate that the proposed approach is well capable of discriminating between the internal and external faults and provides a very fast, secure, and reliable protection technique.

A new protection scheme for transmission lines is presented. The method has some advantages in comparison with conventional line protection schemes. Faster fault detection and instantaneous coverage of almost 100% of the line are the main advantages of the new method. A full-cycle averaging window is used for fault [8] detection. While the power system is in normal operation conditions, this average is approximately equal to zero. As soon as the faulty signals enter the window, the average is changed to a nonzero value. It is shown that the product of this average value for voltage and current of the faulty phase, in a specific time interval after fault inception, is negative for the forward faults and positive for the reverse faults. The fault is detected by communication between the local and the remote relays. Simulation and experimental results show the efficiency of the proposed method in fast detection of line faults in less than a half cycle.

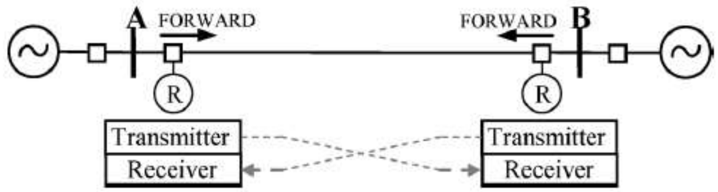

Fig.5:- Directional comparison relaying by the proposed method.

In the few years, wavelet-based methodologies have been proposed as a good alternative for real-time fault detection. However, these methodologies usually fail to detect faults with over-damped transients and they are highly influenced by the choice of the mother wavelet, presenting time delay in the real-time analysis. By using the discrete wavelet transform (DWT) or the maximal overlap discrete wavelet transform (MODWT), the wavelet coefficient energy has been also used for fault analysis and presents the same drawbacks of the wavelet coefficient analysis.

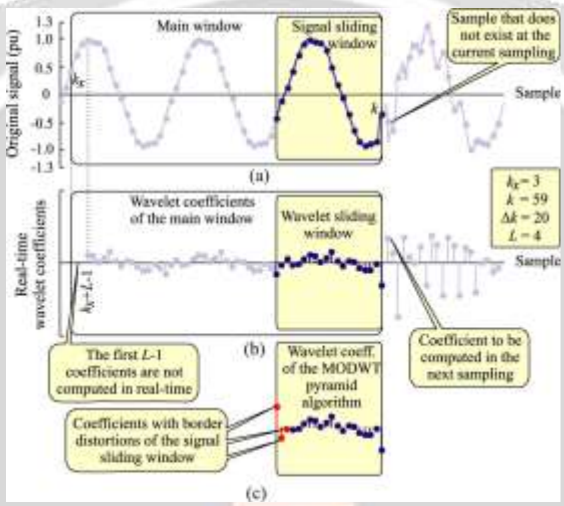

Fig.6:- Real-time computation of the wavelet coefficients: (a) original signal, (b) wavelet coefficients of the recursive MODWT, (c) wavelet coefficients of the MODWT pyramid algorithm related to the signal sliding window.

However, author presents a novel wavelet-based methodology for real-time detection of fault-induced transients in transmission lines [9], where the wavelet coefficient energy takes into account the border effects of the sliding windows. As a consequence, the performance of the proposed energy analysis is not affected by the choice of the mother wavelet, presenting no time delay in real-time fault detection, and the fault detection is scarcely influenced to the fault inception angle, fault resistance, and fault location, even if in critical situations where there are no fault-induced transients. The performance of the proposed methodology was assessed by using actual and simulated data. Some records were reproduced to be analyzed in real time with a digital signal processor.

4. CONCLUSION

The paper has given a comprehensive introduction to the transient based protection techniques for transmission lines. It has been shown that the proposed techniques offer many advantages both technically and economically over the conventional power frequency based protection technique. Although the new protection principles and schemes that have been introduced are at an early stage in development. There could still be many practical problems. However, it is not difficult to predict that the transient based protection will be an important new development.

5. REFERENCES

[1] Wu, Q. H., Zhang, J. F., & Zhang, D. J. (2003). Ultra-high-speed directional protection of transmission lines using mathematical morphology. IEEE transactions on power delivery, 18(4), 1127-1133.

[2] Jing, M., Zengping, W., Yan, X., & Lei, M. (2005, November). Single-ended transient positional protection of transmission lines using mathematical morphology. In Power Engineering Conference, 2005. IPEC 2005. The 7th International (pp. 1-603). IEEE.

[3] Janıcek, F., Mucha, M., & Ostrozlık, M. (2007). A new protection relay based on fault transient analysis using wavelet transform. Journal of Electrical Engineering, 58(5), 271-278.

[4] Jafarian, P., & Sanaye-Pasand, M. (2010). A traveling-wave-based protection technique using wavelet/PCA analysis. IEEE Transactions on Power Delivery, 25(2), 588-599.

[5] Costa, F. B., and B. Alencar Souza. "Fault-induced transient analysis for realtime fault detection and location in transmission lines." International Conference on Power Systems Transients. 2011.

[6] Rao, P. V., Gafoor, S. A., & Venkatesh, C. (2011). Detection of transmission line faults by wavelet based transient extraction. International Journal on Electrical & Power Engineering, 2, 42-46.

[7] Jafarian, P., & Sanaye-Pasand, M. (2013). High-frequency transients-based protection of multiterminal transmission lines using the SVM technique. IEEE Transactions on Power Delivery, 28(1), 188-196.

[8] Hashemi, S. M., Hagh, M. T., & Seyedi, H. (2013). Transmission-line protection: A directional comparison scheme using the average of superimposed components. IEEE Transactions on Power Delivery, 28(2), 955-964.

[9] Costa, F. B. (2014). Fault-induced transient detection based on real-time analysis of the wavelet coefficient energy. IEEE Transactions on Power Delivery, 29(1), 140-153.