Combine Study of Transmission Line Fault Detection Techniques

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Abstract— **Most methods of fault detection and location depend on measurements of electrical quantities provided by current and voltage transformers. These transformers require physical contact with the monitored high-voltage equipment. Likewise, during fault transients, the secondary current is not a true reproduction of the primary current. This paper explores the opportunity of replacing current transformers with magnetic field sensing coils. These coils are located at the sending and receiving ends of the power lines, in the nearness of the conductors. Rather than monitoring the current in each individual phase conductor, magnetic field sensors allow transmission line monitoring by means of a single collective measurement. This study explores the use of the magnetic field sensors as alternative measurement devices for fault detection and location**

***Index*—transformers, transmission line, phase conductor, magnetic field sensors**

I. INTRODUCTION

Fault detection and location has been an objective of power system engineers since the establishment of distribution and transmission systems. Quick fault detection can help to protect equipment by allowing the disconnection of faulted lines before any major damage is done. Accurate fault location can help utility personnel remove persistent faults and locate areas where faults regularly occur. Various fault detection and location schemes have been developed in the past, a variety of algorithms continue to be developed to perform this task more accurately and more effectively. Most analysis methods depends on the values of either current or voltage phasor measured by means of current or voltage transformers at substations or switching stations. To collect this information, at least three transformers are typically required at each end of the sub transmission or transmission line [1]. These transformers are expensive, especially when the system involves high voltage lines. Some algorithms mainly fault impedance-based algorithms require both current and voltage information [2].

A major drawback of current transformers is attached to their performance during fault transients, namely the possibility of magnetic core saturation [3]. During saturation the flux remains nearly constant for a time when no voltage is induced in the secondary coil, and the secondary current would be nearly zero. The duration of saturation times depends on the current transformer burden and its power factor, as well as the magnitude of the fault current and the primary circuit ratio X/R .

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During the saturation times, the secondary current is chopped and the measured values of the instantaneous, peak, and rms currents are compromised.

However, it is possible to monitor a transmission system without using current or voltage transformers through the analysis of the magnetic field near the conductors. Since each conductor in a transmission line creates a magnetic field due to the current through it, there is the possibility of analyzing the transmission line system based on the resultant magnetic field produced by its conductors. The magnetic detection is performed using two sensing coils at each end of the transmission line. One detects the vertical magnetic field intensity and the other detects the horizontal magnetic field intensity [4]. The two-dimensional magnetic field intensity can then be resolved from this information. Just as with many other fault detection methods, faults are detected when unexpected changes occur within the monitored data. The only difference is that this analysis attempts to detect changes in the vertical and horizontal magnetic field intensities rather than individual changes in the monitored voltages or conductor currents [5].

The fault detection and location method discussed is based on analysis of the expected behavior of the magnetic field near a transmission line and algorithms for detecting unexpected variations. Two-terminal methods require communication between the locators at both ends of the transmission line to transfer information about the currents, voltages, and source impedances.

II. METHODOLOGIES FOR FAULT DETECTION

Sr. No	Methods	Type	Function Requirement
1.	Impedance Base	One Terminal	Impedance of transmission is used in this method
		Two Terminal	
2.	Traveling-Wave	One Terminal	One-terminal depends upon timing between reflection of voltage/current while Two terminal depends upon time delay at the end of transmission line
		Two Terminal	
3.	Magnetic Field		In this two sensing coils at each end of the transmission line. One detect the vertical magnetic field intensity and the other detects horizontal field intensity

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A. *Impedance-Based Methods*

This technique can be classified in two categories.

1. Single-ended method and makes use of fundamental frequency phasor data measured at one terminal of a transmission line.

2. Multi terminal method and it utilizes data from more than one end of a transmission line.

Impedance-based fault location methods use the voltages and currents at one or both ends of a transmission line to determine where a fault has occurred or not. The impedance of the transmission line per unit length is usually required in these calculations. Single-ended, impedance based fault location methodology is attractive because it is simple, fast, and does not require communications. Applications with strong zero-sequence mutual coupling, higher fault resistance, tapped loads, and nonhomogeneous power systems challenge the accuracy of single-ended fault location methods [1].

There are two single-ended fault location algorithms:

• Simple Reactance

• Takagi-based

The simple reactance method works reasonably well for homogeneous systems when the fault does not involve major fault resistance and load current. Large errors are introduced to the fault location estimate by remote end current feed, load impedance, power transmission angle, and differing angles of line and power system source impedances. One of the major problems with basic one-terminal impedance based fault location methods is that only use measurements from one end of the transmission. This problem has been mitigated in several different ways. One of the best-known of these ways is the Takagi method. This change the calculation to include the difference between the current measured before the fault and the current measured after the fault. This eliminates the fault impedance from the analysis, thus removing this significant source of error.

Two-ended impedance based fault locating methods can improve the accuracy of single ended methods. It required knowledge of pre-fault load flow information for phase form the fault location. The use of both sides of the transmission line in calculation removes most of the problems associated with one-terminal impedance-based fault location methods [4]. However, that short-duration fault are difficult to accurately detect with any impedance-based fault location methods since less data is available about the voltages and currents and the data that is available is not necessarily in steady-state.

B. *Traveling Wave-Based Methods*

This technique can be classified in two categories.

1. *One-terminal Method*

One-terminal methods are work based on the timing between reflections of voltage or current at impedance discontinuities. This can be further divided into below,

Type A: - This is a one terminal method which calculates the fault location based on the time between the first detection of a fault and the detections of reflections of the transient generated by the fault.

Type C: - is a one terminal method it uses a generated pulse and its reflections to locate the fault rather than using the fault transient and its reflections.

Type E: - is a one-terminal method which uses the transients produced when the circuit breaker re-energizes the line in order to locate persistent faults.

2. *Two-terminal methods*

Two-terminal methods work based on the time delay between arrivals of information at the ends of the transmission line.

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Type B: - is a two-terminal method in which as the locator at each end of the transmission line detects a fault, it sends a signal to the other end of the transmission line. The time of the signal's arrival is used in the fault location timing.

Type D: - is a two-terminal method which uses the detection times of the transients at opposite ends of the transmission line to determine the fault location, the locators at both ends of the transmission line must be synchronized properly for this Type to work. Types A, D, and sometimes E are the Types which are used most frequently in modern traveling wave-based fault locators GPS has made Type D locators especially attractive since it provides a method for synchronization of the fault locators at the two ends of the transmission line Such a system is depicted in Fig. This enables an accurate measurement of the difference between two fault detection times and thus a more accurate location of the fault.

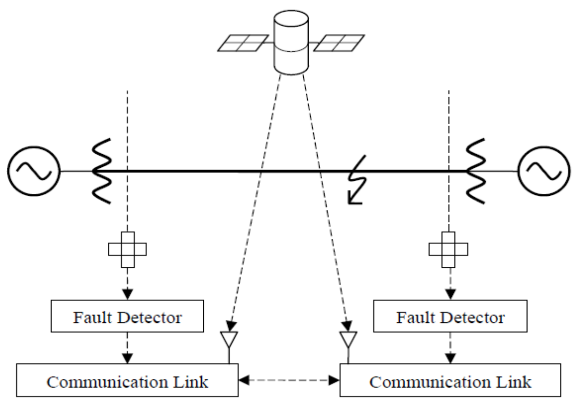

Fig 1 GPS satellite used to synchronize fault detection timing

Traveling wave-based locators can be very accurate, provided the time of fault arrival can be detected accurately. Problems can arise, with faults that occur at the zero-crossing of the transmission line voltage or current since the resulting change in the waveform is not particularly definite. This is a more significant problem for high fault impedances than low fault impedances, a well designed traveling wave-based fault location algorithm will still be able to locate all faults with a great deal of accuracy.

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3. Detection and Location Using Magnetic Field Sensors

For every conductor, which has some current passing through it, has also a magnetic field around it. As The magnetic field lines are located perpendicular to the conductor, the maximum flux linkage can be achieve when sensing coil is also perpendicular to the conductor. This is followed by a small step, in order to measure current in a conductor the magnetic sensor should be placed in the vicinity of the conductor to be measured.

Following figure shows the application of magnetic loop for measurement of current along a conductor. B is magnetic flux density created by the current passing through the conductor.

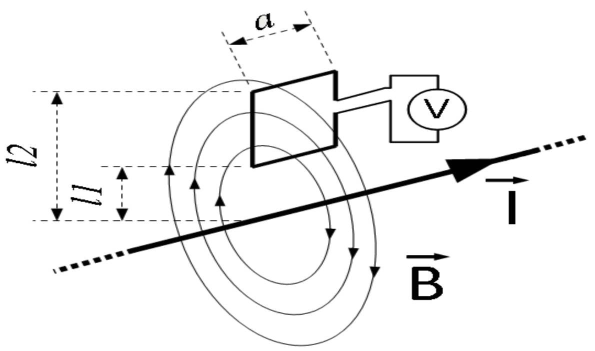

Fig. 2. Magnetic loop for measurement of current along a conductor.

Due to the simple relationship between current and magnetic field intensity, it is explicable that magnetic field sensors have earlier been used in fault detection and location schemes. These schemes often use magnetic field sensors in place of current transformers as magnetic field sensors can be installed independently from a substation or switching station with a minimum amount of additional equipment. Using this relationship replace each current transformer with a Hall Effect transducer. This transducer would usually need to be within the electrical arcing distance of the conductors to produce adequate voltage for analysis and thus require insulation. To eliminate this need for insulation, the transducer can be located between two tapered pieces of ferromagnetic material in order to concentrate the magnetic field into the transducer; therefore, the transducer does not need to be located within the arcing distance of the conductors. The measured magnetic field result can then be used similarly to a current measurement for fault detection and location. Due to the reduced amount of equipment needed for analysis when compared with current transformers, it is possible to use several sets of magnetic field intensity sensors on a single transmission line. For example, one patent suggests the installation of magnetic field intensity sensors on every pole of a transmission or distribution line as a distributed fault detection and location system. Phase to ground faults are detected using magnetic sensors around the ground conductors; phase to phase faults are detected with a sensor which detects orthogonal fields due to arcing. If a fault occurs, it is most likely between the first two poles at which it is detected, and thus any further searching for the fault only needs to be within that area. This requires only a least synchronization between the multiple sensors, since the fault location is not based upon exact time of the fault incidence but simply the first locations at which the fault was detected. Since a magnetic field sensor does not need to make contact with the conductors and can be installed remotely from substations, the effectiveness of the magnetic field sensor in fault detection and location algorithms is obviously worth examining.

III. SUMMARY

A variety of methods of finding and locating faults on power transmission lines exist. Most of these methods use the measurements from voltage and current transformers at substations or switching stations to perform their analyses. A major drawback of current transformers is attached to their performance during fault transients, namely the possibility of magnetic core saturation. During saturation the flux remains nearly constant for a time when no voltage is induced in the secondary coil, and the secondary current would be nearly zero. The duration of saturation times depends on the current transformer burden and its power factor, as well as the magnitude of the fault current and the primary circuit ratio X/R.

This paper suggests the effectiveness of using magnetic field sensing coils as alternative measurement devices for the purpose of fault detection and location. A review of common methods of fault location is described. This review is focused on impedance-based and traveling wave-based fault location as they are the most common traditional methods. The concept of detecting the state of electrical equipment operation by means of information extracted from magnetic field patterns produced by the respective equipment is not new. However, such applications to overhead lines and underground cables need more work. The proposed technique can achieve an excellent performance for detecting and locating the fault of transmission line. Since a magnetic field sensor does not need to make contact with the conductors and can be installed remotely from substations, the effectiveness of the magnetic field sensor in fault detection and location is obviously worth examining.

IV.CONCLUSION

This paper reviews the theory and methods of traveling wave and impedance base method. A new concept of fault detection and location using magnetic field sensing coils. The magnetic classification scheme using the wavelet transform could be modified to make use of the magnetic field. This will most likely improve the accuracy of fault location and increase the maximum detectable fault impedances. A new technique for the protection of a transmission line is presented in the paper. Unlike traditional protection schemes, this technique offers a new concept in transmission line protection. And the placement of the sensors does not need to be accurate with respect to the line conductors. This paper left out new techniques that deserve further research in the following areas.

- **Study of different algorithms with depend on magnetic field behavior**
- **Examine each the algorithms for fault location and detection.**

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- **Compare algorithms to detect which gives accurate result**
- **Study the mathematic used in determining magnetic field near conductor.**
- **There are potential problem caused by transformer inrush current, large motor startup and capacitor bank switching, operation of circuit breakers and switches**.

V. REFERENCE

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