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A Comprehensive Review on Transmission Line Fault Detection and Location using Synchrophasors

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ABSTRACT

The most commonly used protection scheme for transmission line protection is the distance protection also known as impedance protection. The impedance seen by relay is sensitive to fault resistance, arc resistance, also the atmospheric effects, which results in overreach or under reach. So the distance protection is unable to meet the desired reliability because of mal-operations. As we know the current differential protection has the highest reliability among all types of protection scheme, but it is not being used for transmission line protection because of certain problems such as CT ratio mismatch, pilot wire length, tap changing transformer etc. It is known as the unit protection used to protect generator, transformers, sometimes current differential protection is used for feeder protection but again the time reference used there is the local one which has the synchronization accuracy of 1-10ms which is the main factor that it is not being used for transmission line protection.This technique uses samples of voltage and currents from both the end of transmission line. The complete fault location analysis has been presented in this, it is observed that the fault is located accurately and it is independent of fault resistance.

KEYWORDS: Syncrophasors, WAP, GPS, Phase Measurement unit, Current Compensation, Fault Localization, Synchrophasor Application

INTRODUCTION

The power demand and generation has increased drastically in our country. The generation will double within 2015. Presently in India almost all regional grids are interconnected with the national grid, which makes the system more complex as far as the protection is concern. For getting good quality of supply from such a complex grid the major factor is that the reliability of the system should be very high, which is very challenging job for the engineers. So, there is a need of protection system which will have all the essential qualities such as high reliability, selectivity, sensitivity, stability etc.

Following are the basic protection schemes which are generally used in electrical power system, each one has its advantages and disadvantages.

1) Differential Protection Scheme
2) Distance Protection Scheme

STRUCTURE OF PAPER

The paper is organized as follows: In Section 1, the introduction of the paper is provided along with the structure, important terms, objectives and overall description. In Section 2 we discuss about detail of synchrophasor detection and location. In Section 3 we have the complete information about Synchrophasors. Section 4 shares information about the Synchrophasor detection. Section 5 tells us about the Synchrophasor location . Section 6 tells us about the future scope and concludes the paper with acknowledgement and references.

OBJECTIVES

The predominant invoice processing systems are either entirely studyofsynchrophasor detection and location. How to find fault in transmission lines and the location of fault is studied in detail.This project aims to address some of the problems in transmission line system by greatly minimizing the fault location.

RELATED WORK

There are numerous works that have been done related to Synchrophasors

Their where many techmiques of fault detection in transmission lines as
Following are the basic protection schemes which are generally used in electrical power system, each one has its advantages and disadvantages.

1) Differential Protection Scheme
2) Distance Protection Scheme

1) Differential protection is generally a unit protection. Its main application is to give protection to generator, generator-transformer unit, large induction motor etc. Sometimes Differential protection is used for feeder protection. Most of the Differential protections are current differential protection in which the difference of current entering the winding or unit to be protected and the current leaving the same is used for relay operation.

2)Distance Protection The most viable alternative protection scheme for Distance protection scheme is the Differential protection (current differential). Current differential protection based on Kirchhoff's first law is a simple and reliable protective principle for any kinds of transmission lines. However, when applied in practice, some problems will arise due to the distance between the line terminals. Traditional analogue design using metallic pilot wires as communication channel is susceptible to electrical interference and hence becomes less applied. Power line carrier channel tends to be used in phase comparison principle because of its limited bandwidth. Now, the microcomputer based digital current differential protection can overcome most of these problems by using digital communication link. Differing from analogue design, digital differential protection uses current samples data, not the current waveforms varying with time, to make differential comparison. Thus, some form of synchronization must be provided in order to meet the requirement of the current differential principle. The synchronization ensures that the samples derived from all terminals of the protected line can be time aligned; this is the key technique for implementing this kind of protection. To solve this sampling time alignment problem, most existing digital differential protections adopt techniques that measure the delay of communication channel and compensate for this delay. These techniques have some disadvantages. In fact, the most desirable way is to precisely synchronize the samplings at all terminals with the help of external common timing reference. Today the Global Positioning System provides us a very good chance to reach the goal.

New technology known as Synchrophasor technology and GPS (Global Positioning System) are given. By using which current differential protection can be used for protection oftransmission line having ideally no limit on its length

SYNCHRO PHASORS TECHNOLOGY

SYNCHROPHASORS

The advents of satellite-based time-keeping systems and advances in computer technology have made possible protective relay sampling synchronization within 1 μs. These relays can now provide synchronized phasor measurements that eliminate the need to have different devices for protection, control, and electric power system analysis for system-wide applications and traditional protection applications.

In this technology, we have suggested a protection scheme which uses the concept of current differential protection using synchrophasors. Current phasors at both ends of a transmission line are measured by Phasor Measurement Units (PMU) and are sent to a central location using communication link and are synchronously compared to determine the state of the system at that particular instant.

WIDE AREA PROTECTION AND MONITORING SYSTEM.

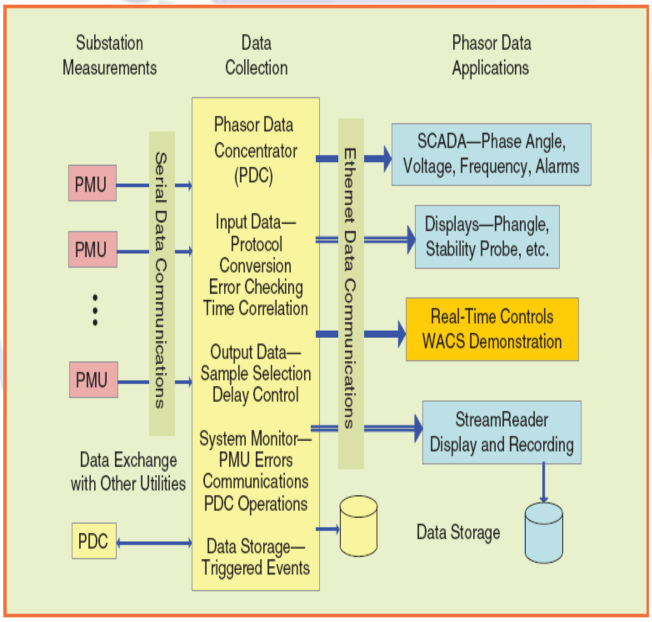
WAP and M system is a combination of relays, measuring instruments, control equipment, automation equipment, monitoring equipment, and communication techniques. Communication is made easy by the increase in world-wide application of digital devices and high-speed wideband communication and global positioning systems (GPS s).A general WAP and M system thus comprises of blocks such as distance relay, CT, PT, PMU, Transmitter, Receiver and Central data storage and processing unit.

THE GPS SYSTEM-AN OVERVIEW

The Global Positioning System (GPS) is a new generation of satellite based navigation, positioning and timing system of U.S.A. It provides in real time accurate three-dimensional position, three dimensional velocity and one -dimensional time information to users anywhere in the world. The time transferred by GPS is synchronized to the Universal Co-ordinated Time (UCT) and can be easily received all over the world by using GPS receiver. Up to now, it has been the most precise and most extensive time synchronization source around the world.

PHASOR MEASUREMENT UNIT –PMU

It is a device that samples analog voltage and current data in synchronism with a GPS-clock. Phasors are computed based on an absolute time reference, derived from a built in GPS receiver or time reference signals from an external GPS receiver. The samples are used to compute the corresponding phasors.



BENEFITS OF PMUS

1) It provides precise measurement of the power system state. It can be obtained at frequent intervals, enabling dynamic phenomena to be observed from a central location, and appropriate control actions can be taken.
2) Post-disturbance analysis is much improvedbecause precise snapshots of the system states are obtained through GPS synchronization.
3) Advanced protection based upon synchronized phasor measurements is possible.

TRANSMISSIOM FAULT DETECTION

NEW THEORY OF CURRENT DIFFERENTIAL PROTECTION

Severalnew theories with strong immunity to capacitive current have been proposed [16]. As a major protection of UHV transmission line system, current differential protection must be able to cope with the capacitive current. However, in electric power systems, as the requirements for the reliability of relay protection is stringent, these new theories have a long way to go to prototype test and practical applications. Therefore a capacitive current compensation algorithm, which can effectively compensate both transient and steady capacitive current without increase in the sampling rate, computation consumption and the telecommunication traffic, is a simple but feasible solution to improve current differential protection. Recently an algorithm [, known as time-domain compensation, is performed based on the differential equation of π equivalent circuit of the transmission line. The algorithm is believed to be a prospective solution for the capacitive current problem mentioned above for its capability of effective compensation for both the transient and steady distributed capacitive currents.

CURRENT COMPENSATION

Distributed capacitances exist between phases as well, each phase to ground along transmission lines. The distributed capacitive current arises with the increase of the voltage level and the length of the power line, which may severely distort the current and voltage signal of UHV long-distance lines both in the steady state and the fault transient period. And the distortion situation is even worsened in the case of lower load current or lower fault current. Current differential protection, owing to its simple principle, higher sensitivity and inherent ability of phase selection, has been widely applied in various grid topologies and can still operate correctly even under complicated situations such as system oscillation and phase loss. In addition, the development of optical fiber communication technology has made it possible to solve the problems of digital communication channel for current differential protection. Accordingly several new principles of current differential protection have been devised and more and more devices have been put into practical operation. Till now the distributed capacitive current remains a major factor affecting the sensitivity and selectivity of current differential protection, and at present the methods proposed to reduce the adverse influences of distributed capacitive current can be classified into three categories as follows

SHUNT REACTOR

To limit line-frequency overvoltage and self-excitation on UHV long-distance transmission line, shunt reactors are often connected to the line, operating in under-compensation mode to offset the capacitive current. The reactor, however, can only partially compensate the power frequency steady-state capacitive current, and is invalid to the transient capacitive current. Even with shunt reactor, the current differential protection may misoperate in the event of faults beyond the protected zone.

CAPACITIVE CURRENT COMPENSATION

At present, Phasor basedcompensation algorithm is a major method inthe line-frequency capacitive current compensationadopted widely to eliminate the adverse influences ofthe distributed capacitive current. Unfortunately, onfault inception, especially when a single end fed line isswitched onto a fault or without load, the transientcapacitive current is much larger than the steadycapacitive current that the current differentialprotection schemes based on phasor compensationalgorithm cannot compensate transient capacitivecurrent and has to delay to avoid the influence of thetransient capacitive current and therefore cannot meetthe rapid requirement of relay protection in electricpower system.

FAULT LOCATIONTECHNIQUE

Reliable algorithms for the analysis of faults on overhead transmission lines have become an essential part of modern transmission line protection schemes. An integral part of such algorithms is the fault locator that determines the distance to the fault from the local line terminal. Numerous fault location algorithms (FLAs) have been developed in the past; some of which use data from one line terminal and some of which use data from two or more line terminals. FLAs using data from multiple line terminals are more complex than their single-terminal counterparts but have been found to be more accurate as they are less affected by factors such as fault resistance, untransposed lines and line loading. There are various methods of developing multi-terminal FLAs; some require the data sampling at the line terminals to be synchronised, whereas others are developed to be able to operate with asynchronous data sampling. Another method of fault location using artificial neural networks is given in . One common factor between all of the various methods is the requirement of the line parameters and the line length to determine the fault distance. However, the actual parameters of lines are not always available and they can vary with differing loading and weather conditions. Here the technique used for locating faults on transmission lines which does not require the parameters of the line. The aim of this technique is to develop a new numerical algorithm that can determine the distance to the fault on a transmission line without any knowledge of the line parameters. It was assumed that the unknown fault location would be determined from voltage and current phasors, synchronously measured at both line terminals.

In a number of approaches, the fault location is calculated by using information about the line parameters (resistance and inductance per unit length, which are known in advance) and the measured voltage and current phasors. Here the ‘fault location calculation’ is deterministic and based on a suitable formula for calculating the fault location. In reality, a number of stochastic factors generate a high level of uncertainty in determining the fault location. For example, the fault resistance, fault arc, other non-linear effects on instrument transformers, as well as the random errors introduced during A/D conversion, can adversely affect the accuracy of fault location. This makes the problem even more challenging and requires very careful algorithm design.

This technique discusses synchronised data sampling at each line terminal and gives a detailed algorithm derivation. Furthermore, it includes acomplete fault location analysis for different types of faults for the power system selected using the new setting free fault location algorithm through computer simulated tests.

FUTURE SCOPE AND CONCLUSION

The fault location technique for locating just asymmetrical faults. Similar technique can be used to locate the symmetrical fault. Also it is necessary to have a synchronized voltage and current samples to locate the fault, but the research is going on to locate the fault without synchronized samples of voltage and currents

Work done in this project report is totally depends on the synchrophasors which is explained earlier, but presently this technology is not being used in India for the power system protection. But by seeing the importance of the power system protection and security, also the electrical supply reliability, the Power Grid Corporation of India is taking some major steps regarding implementation of this technology for power system protection

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