MICROCOMPUTER BASED METHODOLOGY FOR DISTANCE PROTECTION ON LONG UHV TRANSMISSION LINES USING SYMMETRICAL COMPONENTS

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Abstract

This research work proposes a methodology for the long UHV transmission lines distance protection using microprocessor for fault detection, isolation and auto reclosing processes. For the protection of transmission lines distance relays are used, which depend on a function of impedance between relay location and fault point. In the present era, the development of microprocessors, their extra efficient controlling and computing abilities can be utilized in distance relaying for efficient computing of fault distance on transmission line and the type of fault occurred. The approach that is adopted here is to use sequence components to calculate the distance of fault point. In a normal distance relaying system that uses phasor values of voltage and current as input, six impedance calculating units are required for all ten types of fault that may occur in transmission line. With the advent of symmetrical component analysis tool these six impedance calculating units can be replaced by a single unit which will overall result in a considerable optimized and efficient protection system. Using Symmetrical component theory a single performance equation is developed that will encounter all type of faults on transmission

lines. Microprocessor will serve the purpose of computing sequence components, distance of the fault from the relay point and the type of fault. The phasor values of voltage and current is given as an input to the microcomputer that will calculate symmetrical components and resulting sequence impedances. It eventually finds the distance of the fault using performance equation, ratios of voltages in that particular equation and their resulting phase difference. These calculations will lead us to the judgment of the phases involved in fault. ETAP is used for simulation to obtain desired results. Although the formulation described here is independent of hardware yet it provides a complete analytical base for distance protection and is analyzed for different types of fault conditions using simulation tools.

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Dedicated to the service of mankind and the noble cause of energy crisis eradication

Table of Contents

List of Figures

List of Tables

Chapter 1
Introduction

1.1 Motivation and Objectives

Modern civilization uses bulk amount of energy and power for the production and utilization of goods. From the huge generation units to the commercial applications, all of them need energy for the development of a sophisticated society. The purpose of energy and power systems is to ensure continuous supply of energy and electricity for human use in an efficient and cost effective way. The core parts of electric power systems comprises of the components that generate, transmit and distribute electricity. Electric power systems are among the most important and complicated inventions that human ever made. Faults and failures are inevitable on any power system. Due to the great amounts of energy involved, faults represent a threat to the operation and security of power systems if the faults are not promptly corrected. Power systems need an auxiliary system that must take corrective actions on the occurrence of a fault. This auxiliary system is known as protection system.

Protection systems are sets of equipments, schemes and policies dedicated to detect faults in the protected elements of the power systems, to disconnect the faulted element and to reestablish the service, if it was the case. Because power systems operate in different operating states, different fault scenarios may occur. Protection systems must provide different schemes and equipments to detect and to react to each and every one of these fault scenarios, from the most simple of them to the most complex and compelling.

In any electric power system, a protective relaying scheme is considered as the key element to ensure the reliability and continuous flow of power from the generating end to the consumer end. A protection scheme must protect electrical transmission lines and power generating equipments against the faults and consequent short circuits which may ultimately collapse the whole power system. Protective relays perform the function of monitoring of AC voltages and currents, locate

and classify the faults and initiate the isolation by generating the tripping signal of circuit breakers. Distance relaying process is employed for applying the electrical protection on transmission lines with the protective impedance relays installed on either side of the transmission lines in stepped zones of protection to make sure the reliability, observability and controllability.

In the development of any relaying system the relaying algorithm is the major factor that affects the sensitivity selectivity and overall efficiency of the protection scheme. A fast, reliable and fool proof algorithm ultimately leads to an optimized and efficient protection scheme.

1.2 Problem Statement

With the advent of microprocessor technology, its efficient control and computational capabilities can be utilized to implement distance relaying function with the intelligent fault diagnostic, sophisticated control and effective fault clearing features at a reasonable cost. Thus a protection scheme must apply a very pragmatic and pessimistic approach for clearing system faults and must be equipped with the extra intelligent features of sensitivity and selectivity. This thesis proposes a digital scheme for long UHV transmission lines distance protection for fault detection isolation and auto reclosing processes. It provides for the old conventional analogue protection schemes by employing microprocessor technology.

In this thesis a fast and accurate algorithm based upon the symmetrical component theory is developed and implemented. The proposed algorithm is highly suitable for microcomputer applications due to simply executable techniques and less computational time. A microcomputer with this digital implementation will serve the purpose to protect the whole transmission line against fault, thus minimizing the outage of supply and restoration of the system capacity with minimum interruption and at a low manpower cost. Hence the methodology proposed here leads to the concept of unmanned and unattended protection scheme at a reasonable cost.

1.3 Proposed Strategy

A microprocessor monitors the phasor values of currents and voltages at input and output side, samples and quantizes the input waveform to attain the digital values of pre fault and post fault currents and voltages. These pre fault and post values of voltages and currents from both the input and output sides are used to calculate the symmetrical components which are further processed [2, 3, 4, 7]. Following steps are employed for the accomplishment of the desired task of microcomputer based distance protection of transmission lines using symmetrical components [19]

- Identifying of the protection problems with the existing transmission lines.
- Introducing the solution to these problems by proposing the algorithm.
- Forming the mathematical model in the form of equations for the proposed algorithm.
- Implementing the algorithm to identify, classify and locate the fault.
- Simulating algorithm to ensure the viability of suggested algorithm

1.4 Contribution to Field

In a normal relaying scheme six impedance calculating units are required to deal with all the ten types of shunt faults. On the occurrence of fault corresponding impedance unit operates to yield the fault distance but we have to keep energize all of these units for all the times. Moreover a combinational logical circuit is also required to select the appropriate impedance calculating unit to operate. With the use of symmetrical component theory a single performance equation is derived and implemented to encounter all types of shunt faults. So a single impedance calculating unit is used to calculate the location of the fault.

Further this implementation also processes the symmetrical components and resulting sequence circuits to find the type of fault. Faulty phase selection and identification has always been a problem of interest for power engineers as it results in a highly efficient single phase autoreclosure, thus minimizing the outage of supply and restoration of the system capacity with minimum interruption and at a low manpower cost. Using the proposed scheme faulty phase classification can also be made to distinguish faulty phases from healthy ones by employing the proposed algorithm. So overall this single performance equation based symmetrical component digital distance relay will ultimately lead to a greatly simplified, potentially faster and efficient

protection scheme and the methodology proposed here leads to the concept of unmanned and unattended protection scheme at a reasonable cost.

1.5 Thesis Overview

The Thesis Progressively discusses the approach employed to achieve the above targets. This chapter gives a general introduction to the thesis.

Chapter 2 discusses the fundamentals of protection systems and gives a detailed view of the background of protection systems related with the protection of transmission lines.
The chapter then reviews the types of distance relays and their regions of operation in terms of reactance diagrams. More emphasis is placed on digital distance relays and subsystems of digital relays system are discussed.

Method of symmetrical components transformation to get uncoupled sequence networks and its application on UHV transmission lines to investigate the faults is extensively described in chapter 3. Sequence circuit of transmission line is derived using symmetrical components transformation theory. Sequence circuits and their type of connections at the point of fault are studied which will serve as the basics of fault classification algorithm derived and discussed in chapter 4.

In chapter 4 a mathematical model is formulated for each type of fault, and a compact equation for fault distance is derived. Using this mathematical model an algorithm is designed to classify the type of fault and faulty phase classification.

In chapter 5 the simulation results are outlined. Electrical Transient Analyzer Program (ETAP) is used for simulations. A sample network is modeled and simulated under faulty conditions. Pre fault and post fault values of symmetrical voltages and currents are processed on the fault point and the applications of newly proposed algorithms are investigated.

Finally the conclusions are drawn and future research suggestions are discussed to enhance the relay speed and implementation of single pole switching and autoreclosure schemes to enhance the power system reliability and efficiency.