CHAPTER 1

INTRODUCTION

1.1 Introduction

One of the most important parts of power system network is the protection system and relays act as the brain of this system. Protective relays are used to maintain the stability of power system network and also there are other reasons which make the protection systems important as follows:

- To isolate the faulty section of the system from the other sections.
- To limit the equipment damage
- Minimize the fire due to fault
- Personnel safety(IEEE, 2008a).

Transformer is one of the most important and expensive equipment in electrical power network. Hence, it needs to be protected. The main protection of power transformer is differential protection. In chapter two it is described that for earth fault on transformer winding the differential protection is not sensitive enough. Thus, for protecting the winding transformer, other protection function is needed (Hewitson, et al., 2005; Iran electric distribution co, 1995).

Figure 1.1 shows the simple connection of restricted earth fault in transformer. This figure illustrates that for using this protection scheme, star point grounded is required. Furthermore, this protection just protects one side winding of transformer with earth connection. An earthing transformer or reactor to provide earth connection in delta side of winding for transformer is also required.

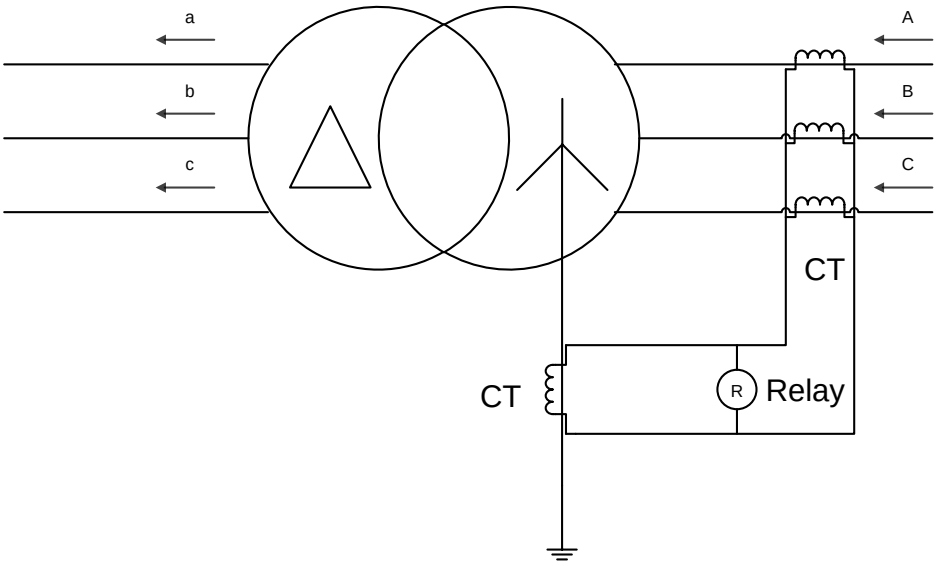

Figure 1.1: restricted earth fault protection

1.2 Restricted earth fault (REF) protection

There are two kinds of restricted earth fault protection: high impedance REF and low impedance REF. The high impedance restricted earth fault has a external resistor to limit the current which goes to the relay. High impedance REF has simple scheme but it needs a correct and accurate external resistance calculation(Bertrand, Gotzig, & Vollet, 2001). Moreover, the simple CT calculation is needed (Bertrand, Gotzig, & Vollet, 2001).

Low impedance restricted earth fault for current limitation that goes to the relay needs the software calculation (Bertrand, Gotzig, & Vollet, 2001). There are two phenomena that are very important in low impedance REF: magnetizing inrush current and over excitation current which can cause mal-operation in relay. Thus the diagram should be able to restrain the current at these conditions. Furthermore, CT saturation is an important phenomenon for heavy external fault current. The algorithm should be stable at external fault condition. But for internal earth fault this relay must operate quickly.

Numerical relays produce restraint current against differential current (by bias current). The restraint current is produced using a certain algorithm and each REF producer has a

unique algorithm to distinguish fault condition and stable condition (magnetizing inrush current or over excitation). Due to important of REF the main objective of this dissertation is to compare and discuss these five mentioned algorithms.

1.3 Problem statement

As the above mentioned, transformer is one of the expensive and important equipments in power systems. The main parts of power transformer are winding and insulator. If fault current flows in transformer windings, this current causes heat and stress on windings that in transformer windings and insulators damages is caused. Moreover, the transformer damages will be more when the fault happens close to transformer or at transformer windings.

Restricted earth fault is a protection function to protect power transformer when fault happens near to transformer or at transformer winding. There are three phenomena (these will be described in chapter 3) influence on operation of restricted earth fault. low impedance restricted earth fault uses software diagram to detect real fault and how the relay distinguished among fault and other phenomena are very important. Each company uses a unique REF diagram which it has some advantages and disadvantages.

1.4 Approach to the problem

If there are none of three phenomena that influence REF relay (over excitation, inrush current or CT saturation), all REF relays operate based on percentage differential current. It should be thus described how the restricted earth fault distinguishes between fault current and fake phenomena (over excitation, inrush current or CT saturation). This method of fault current calculation of REF is extremely important. In REF algorithm it should be kept speed, sensitivity and security of relay in high level. This dissertation compares five algorithms and indicates how each one keeps security, speed and sensitivity of relay at different conditions.

1.5 Thesis organization

Chapter 2 of this dissertation investigates faults that happen in power transformer. Also it explains the system grounding on star point connection and five sample algorithms.

Chapter 3 investigates magnetizing inrush current and over excitation, also the way in distinguishing between these phenomena and fault conditions is presented. Then, advantages and disadvantages of each algorithm are studied.

In chapter 4, simulation of two algorithms (Siemens and GE) by MATLAB Simulink in three conditions is presented. This chapter investigates fault occurring inside and outside of protection zone; also normal condition (without fault) is simulated.

In chapter 5, the best restricted earth fault algorithms are specified as conclusion. Two algorithms are presented as the best ones and in chapter 3, three other algorithms with their weakness points, will be mentioned.