CHAPTER 1

INTRODUCTION TO PROTECTIVE RELAYS

## 1.1 Protective Relays

Modern electrical power systems are remarkably dependable, standing ready night and day to deliver their energy without interruption. Protective relays have an important part in assuring this continuous service. Always on guard, they react instantly to protect the system from damage and to minimize any service interruption. The function of protective relays is to cause the prompt removal from service of any element of a power system when it suffers a short circuit, or when it starts to operate in an abnormal manner that might cause damage or otherwise interfere with the rest of the system. The relaying equipment is aided in this task by circuit breakers that are capable of disconnecting the faulty element when they are called upon to do so by the relaying equipment. To define a protective relay, we say that it is a device which, when energized by suitable currents, voltages or both, responds to the magnitudes and the relationships of those currents and voltages to indicate or isolate an abnormal operating condition. Basically, the protective relay consists of an operating element and a set of contacts. The operating element takes the information from the instrument transformer in the form of currents and voltages, performs a measuring operation, translates the result into the motion of the contacts. When they close, the contacts either actuate a warning signal or complete the trip circuit of a circuit breaker, which in turn completes the isolation of the faulty element by interrupting the flow of current into that element.

## 1.2 Relay System Requirements

There are three characteristics required by any protective relay to perform its function properly. These are sensitivity, selectivity, and speed. The relay must be sensitive enough so that it will operate under the minimum conditions expected. In any power system at various times of the day and during various seasons of the year, the load supplied varies over rather wide limits. To meet this changing requirements, various combinations of generating sources are switched in and out of the system to provide the most efficient mode of operation. The condition which provides the minimum of the genaration is often the criterion in deciding how sensitive the relay must be. Under this condition, a short circuit fault would draw the minimum current through the relay for which it must be sensitive enough to operate to effect removal of the fault.

The selectivity of a protective relay is its ability to recognize a fault and trip a minimum number of circuit breakers to clear the fault. The relay must select between the fault in their own protected equipment for which they should trip, the faults in adjoining equipment for which they should not trip. Some relaying schemes are inherently selective; that is they are unaffected by faults outside of their own protected apparatus. An example of an inherently selective scheme is differential relaying.[1] Other types of relaying, which operate with time delay for faults outside of the protected apparatus, are said to be relatively selective. Their selectivity is obtained by adjustment of operating times and characteristics relative to the relays with which they are intended to be selective. If the relays are of different types of characteristics, it is especially important that selectivity be established over the full range of short circuit current magnitude.

The relay must also operate with the proper speed. Of course, speed is essential in clearing a damaged element of a power system since it has a direct bearing on the damage done by a short circuit and, consequently, the cost and the delays in making repairs. The speed of operation also has a direct effect on the general stability of the power system. During a short circuit fault, the rest of the power system can transmit less power because the various sources of generation tend to go out of synchronism. The less time that the fault is allowed to persist, the smaller the effect on the synchronism or stability of the system.[2]

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[1] Mason, C. Russel. 1962. The Art and Science of Protective Relaying. New York: John Wiley and Sons, Inc. Page 63.

[2] General Electric Company. The Art of Protective Ralaying. Page 6.

For a relay system to perform properly it must have reliability. This is a measure of the degree of certainty that the relay system will perform correctly. It must have the dependability to operate cårrectly under these conditions when it should operate, and it must have security which is free from incorrect operations due to extraneous causes. The reliability of a relay system depends on the inherent reliability of the relays themselves and on their application, insallation, and maintenance as a part of the system.

1.3 Static or Solid-State Relays

The continued growth and developement of electric power systems have increased the demands made on the ingenuity of the protective-gear designer and the integrity of the user; in particular relays with greater speed, greater reliability, and greater degree of response and sensitivity are required. One possible approach which meets, to some extent, all these requirements, is to use circuit techniques and static components to replace some or all of the relays necessary in a scheme; such arrangement is now becoming known as " Static Relay". Static relay is defined as a relay ( or relay unit) in which there is no armature or other moving elements, the designed response being developed by electronic, solid-state, magnetic or other components without mechanical motion.[1] Note that a relay which is composed of the static

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[1] Sutton, H.J. Resumé of North American Protective Relaying Practices and Trends. Conférence Internationale des Grands Réseaux Electriques à Haute Tension. 112, Boulevard Haussmann, Paris. Session 1964 - 1er - 10 Juin. Page 15.

and elctromechanical units in which the designed response is accomplished by static units may be referred to as a static relay.

Considerable research and developement over the past five to ten years has shown that the established protection functions and operating characteristics are reproducible,[1] and that new and potentially ones are also possible. Developement has now reached a stage where a number of practical static relays are available in manufactured form, and many others have been shown to be feasible.

Many countries which deal with static relay applications have reported the advantages and disadvantages of static relays, based on laboratory experience and field experience.[2] They are as follows :-

Advantages :

1. Low burdens which may eventually reduce the cost of current and potential transformers and the size of testing equipment.

2. Smaller size, which can reduce panel cost.

3. Improved performance, which will improve discrimination in difficult applications and facilitate the use of reclosing; viz

a) fast reset;

b) low overtravel;

c) more consistent pick-up and timing.

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[1] Application of Transistor Techniques to Relays and Protection for the Power System. Proc. IEE, Vol.114, No 2, February 1967. Page 4.

[2] Warrington, A.R. Van C. and Dienne, G. Recent Developements in the Transistorisation of Protective Relays and the Problems Posed by their Use in H.V. System. 337. Report on the Work of Study Committee No. 4. Protection and Relays.(TNDC 9963 Bangkok) Page 16.

4. Resistance to vibration and to industrial corrosion.

5. Lower maintenance cost due to absence of moving parts.

6. Possibility of wider range of setting and characteristics in one relay, this facilitating stocking.

7. Possibility of choice of time-current characteristics in the same relay. Considered only theoretical advantage.

Disadvantage :

1. More expensive, though this may be offset by savings in cost of panels, cubicles, etc., due to small size.

2. Some types require a separate d.c. supply.

3. Test engineers will have to learn the new electronic techniques.

4. More complex circuitry; ten times as many/connections.

5. More difficult to trace faults if the relay becomes defective.

Practically all forms of protection operate on one of three basic principles, namely :-

1. Quantity magnitude measurement.

2. Quantity comparison.

3. Quantity ratio measurement.

These principles were introduced in the early days of electrical power system and, although they have been modified and refined, no new basic principles have been found to be commercially practicable. Electromechanical relays which operate on the quantity magnitude measurement principle are, for examples, overcurrent, overvoltage, undervoltage, overfrequency and under frequency relays. Some that operate on the quantity comparison principle are differential relays, directional relays and power relays. Those which operate on the quantity ratio measurement are impedance, reactance, mho relays, etc.

Basic static units generally use electronic components such as rectifier diodes, reference diodes, transistors and silicon control switches. Rectifier diodes are used for converting an a.c. voltage or current into a d.c. voltage or current. Reference diodes provide reference voltage levels, therefore they are analogous to control springs in electromechanical relays. Amplifications and logic operations are accomplished with the aids of transistors. Silicon control switches may be used for the final output stage of static relays. Another static unit which is found extensively used in differential relaying is the transductor which operates on the same basis as the magnetic amplifier.