Chapter 2 Power System Protection

Power systems protection involves the isolation of sections of a power system that have failed in real time with a minimum disruption to the remainder of the system. Short circuits, known as faults, and power imbalances are the two most common types of disturbances in power systems. Protective equipment must sense and isolate faults and imbalances in the shortest possible time to prevent further damage and system disruption. Lines, motors, generators, and transformers all require different types of fault sensing schemes to give adequate protection. This chapter provides the general methods used for fault calculations and discusses protection coordination of motors and generators. The sections in this chapter are:

Faults produce excessive currents that damage buses, lines and apparatus. In three-phase systems, faults may involve all three phases, two phases, a single phase and ground, or two phases and ground. Phase-to-phase faults and phase-to-ground faults produce imbalances in the system and require analysis by the method of symmetrical components. Sections 2.1 and 2.2 give a method for computing the magnitude and phase angle of fault currents in a power system. The documents include methods for three-phase, phase-to-phase, phase-to-ground, and phase-to-phase-to-ground fault types.

These sections also show a method for finding the fault currents and post-fault voltages for any fault located between the system buses. These calculations are valuable in protective relay coordination. The methods in these sections can be extended to systems of any size. However, in large system fault studies, the effects of a fault are localized and, therefore, a small equivalent system representation suffices.

Overcurrent and impedance relays are the two major protective relays used in power systems protection. Overcurrent relays respond to the magnitude of fault current seen at the point where the protective equipment is located. Impedance relays respond to the ratio of post-fault voltage and fault current seen at a point in the system. These devices are the basis for more specialized protective relays that sense only particular types of faults and imbalances on power systems. Relays provide the fault detecting intelligence to trip power circuit breakers. All apparati connected to a power system require protection from abnormal conditions.

Loss-of-synchronization is a problem that occurs between generators in a single utility system, between a utility system and a large industrial customer that cogenerates electricity, and between power systems and synchronous motors used in industrial plants. Section 2.3 provides a method that solves the transient stability of a small system and gives information for the computation of the correct values necessary in setting protective relays.

The majority of the electric energy produced is converted into mechanical energy by ac and dc motors. These motors represent a considerable investment in industrial and commercial operations. The protection of motors must be reliable and effective yet allow for the normal inrush currents associated with motor start-up. Sections 2.4 and 2.5 include methods for determining the transient response of three-phase induction and dc motors.