

## **Protection principles and components**

The essential and discriminative removal of an abnormality from a power system, thereby minimizing loss of supply and damage, involves two basic requirements:

- 1-The system must be provided with a sufficient number of circuit-breakers or other correctly-located disconnecting devices adequate for the duty which may be imposed upon them.
- 2-Each of these devices must have controlling means which being able to recognize, disconnect the devices to function, and thereby remove the abnormal conditions

## **Power system network**

Power system can be subdivided into three major parts:

- Power generation
- Power transmission
- Power distribution

## **Faults**

### **Short circuit**

A short circuit (sometimes abbreviated to short or s/c) in an electrical circuit is one that allows a current to travel along a different path from the one originally intended. The electrical opposite of a short circuit is an "open circuit", which is an infinite resistance between two nodes. It is common to misuse "short circuit" to describe any electrical malfunction, regardless of the actual problem.

### **Definition**

A short circuit is an abnormal low-resistance connection between two nodes of an electrical circuit that are meant to be at different voltages. This results in an excessive electric current (overcurrent) limited only by the Thevenin equivalent resistance of the rest of the network and potentially causes circuit damage, overheating, fire or explosion. Although usually the result of a fault, there are cases where short circuits are caused intentionally, for example, for the purpose of voltage-sensing crowbar circuit protectors.

In circuit analysis, the term short circuit is used by analogy to designate a zero-impedance connection between two nodes. This forces the two nodes to be at the same voltage. In an ideal short

circuit, this means there is no resistance and no voltage drop across the short. In simple circuit analysis, wires are considered to be shorts. In real circuits, the result is a connection of nearly zero impedance, and almost no resistance. In such a case, the current drawn is limited by the rest of the circuit.

## **Examples**

An easy way to create a short circuit is to connect the positive and negative terminals of a battery together with a low-resistance conductor, like a wire. With low resistance in the connection, a high current exists, causing the cell to deliver a large amount of energy in a short time.

A large current through a battery can cause the rapid buildup of heat, potentially resulting in an explosion or the release of hydrogen gas and electrolyte, which can burn tissue and may be either an acid or a base. Overloaded wires can also overheat, sometimes causing damage to the wire's insulation, or a fire. High current conditions may also occur with electric motor loads under stalled conditions, such as when the impeller of an electrically driven pump is jammed by debris; this is not a short, though it may have some similar effects.

In electrical devices, unintentional short circuits are usually caused when a wire's insulation breaks down, or when another conducting material is introduced, allowing charge to flow along a different path than the one intended.

In mains circuits, short circuits may occur between two phases, between a phase and neutral or between a phase and earth (ground). Such short circuits are likely to result in a very high current and therefore quickly trigger an overcurrent protection device. However, it is possible for short circuits to arise between neutral and earth conductors, and between two conductors of the same phase. Such short circuits can be dangerous, particularly as they may not immediately result in a large current and are therefore less likely to be detected. Possible effects include unexpected energisation of a circuit presumed to be isolated. To help reduce the negative effects of short circuits, power distribution transformers are deliberately designed to have a certain amount of leakage reactance. The leakage reactance (usually about 5 to 10% of the full load impedance) helps limit both the magnitude and rate of rise of the fault current.

A short circuit may lead to formation of an arc. The arc, a channel of hot ionized plasma, is highly conductive and can persist even after significant amount of original material of the conductors was

evaporated. Surface erosion is a typical sign of electric arc damage. Even short arcs can remove significant amount of materials from the electrodes.

### **Types of electrical faults:**

Symmetrical faults:   1- Three phase fault  
                                  2- Three phase to ground  
fault

Unsymmetrical faults: 1- Single-line to ground  
                                  faults  
                                  2- Line to line faults  
                                  3- Double line to ground  
                                  fault

### **Purpose of protection system:**

- Minimize damage
- Leave unaffected equipment in-service.
- Maintain equipment operating limits.
- Maintain electrical system stability.

## **Requirements of a protection system:**

- Speed

The protection system should disconnect the faulty section as fast as possible for the following reasons:

- a) Electrical apparatuses may be damaged if they are made to carry the fault currents for a long time
- b) A failure on the system leads to a great reduction in the system voltage. If the faulty section is not disconnected quickly, then the low voltage which created by the fault may shut down the consumers motors and generators on the system may become unstable.
- c) The high speed relay system decreases the possibility of development of one type of fault into the other more several types.

- **Reliability**  
It is the ability of the protection system to operate under the per-determined conditions. Without reliability, the protection would be rendered largely ineffective and could even become a liability.
- **Security**
- **Sensitivity**  
It is the ability of the protection system to operate with low value of actuating quantity.
- **Economy:**  
The most important factor in the choice of a particular scheme is the economic aspect. Sometimes economically unjustified to use an ideal scheme of protection and a compromise method has to be adopted. As a rule the protective gear should not cost more than 5% of the total cost. However, when the apparatus to be protected is of utmost importance (e.g. generator, main transmission line, etc) economic considerations are often subordinated to reliability.

## **Relays**

Relays are electrical switches that open or close another circuit under certain conditions. The relay detects the fault and initiates the operation of the circuit breaker to isolate the defective element from the rest of the system. The relay detects the abnormal conditions in the electrical circuits by constantly measuring the electrical quantities which are different under normal and fault conditions. The electrical quantities which may change under fault conditions are voltage, current, frequency and phase angle. Through the changes in one or more of these quantities, the faults signal their presence type and location to the protective relays. Having detected the fault, the relay operates to close the trip circuit of the breaker. This results in the opening of the breaker and disconnection of the faulty circuit. Relays are used throughout the automobile. Relay which come in assorted sizes, ratings and applications are used as remote control switched. A typical vehicle can have 20 relays or more.

A typical relay circuit is shown in figure (1). This diagram shows one-phase of 3-phase system for simplicity.

The relay circuit connections can be divided into three parts:

- i) First part is the primary winding of current transformer (CT) which is connected in series with the line to be protected.
- ii) Second part consists of secondary winding of current transformer (CT) and the relay operating coil.
- iii) Third part is the tripping circuit which may be either A.C. or D.C. it consists of a source of supply the trip coil of the circuit breaker and the relay stationary contacts.

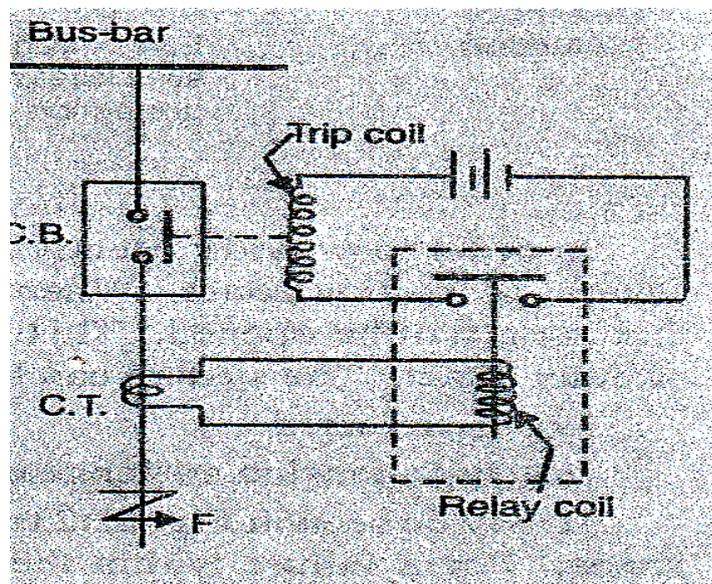


Figure (1).

When a short circuit occurs at point F on the transmission line, the current flowing in the line increased to an enormous value.

This results in heavy current flow through the relay coil causing the relay to be operated by closing its contacts. This in turn closes the trip circuit of the breaker making the circuit breaker open and isolate the faulty section from the rest of the system. In this way the relay ensures the safety of the circuit equipment from the damage and normal working of the healthy portions of the system.