Chapter 1
Electrical Faults in Power Systems

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ABSTRACT
The identification and classification of electrical faults have a great importance in power system analysis. They help in the dimensioning and the adequate choice of electrical equipment, especially, for protective and interrupting devices. This chapter describes the various faults undergone by the power system and removes some ambiguities causing confusions and difficulties for the correct classification of faults. Once the faults terminologies are well understood and properly assessed; they can be used efficiently to develop enhanced algorithms dedicated to fault detection, classification, isolation and diagnostics.

1. INTRODUCTION
Power system analysis usually involves the calculation of the different electrical parameters (voltages, currents, power…) under specified conditions. When the computation concerns the normal operating mode; the calculated parameters are called the nominal (or rating) values of the system, whereas, if it considers the abnormal circumstances that can effect on the normal functioning of any electrical equipment, the calculation must be regarded as fault analysis (FA).

FA aims to identify and classify faults according to:

- **Nature:** Current, voltage, frequency…,
- **Magnitude:** Over or under the magnitude of the nominal value;
- **Synchronization:** Phase shift, time;
- **Duration:** Transient or steady state mode;
- **Progression in Time:** Oscillatory, impulsive, constant…;
- **Emplacement:** Internal or external;
- **Exposition Manner:** Direct, indirect, induced…;
- **Tolerance:** Tolerable fault, dangerous fault.

In this chapter, we try to give the most comprehensive approach allowing to distinguish efficiently among the different electrical faults and remove some ambiguities causing confusions and
difficulties for the accurate classification of faults, while indicating the definition limits of each fault.

Once the faults terminologies, presented here, are well understood and properly assessed; they can be used efficiently to develop competitive algorithms dedicated to fault detection, classification, isolation and diagnostics.

2. THE MAIN ELECTRICAL FAULTS

2.1. Definition

A fault can be defined as an accidental change affecting the normal operation of a process (Abdelmoumene, 2010). In other words, any phenomenon that causes a modification, more or less than the nominal values of electrical quantities within their maximal tolerances, is considered as fault.

In general, we can distinguish five main families of electrical faults:

- Overcurrent (OC) faults;
- Overvoltage (OV) faults;
- Voltage dip and cut-off;
- Harmonics;
- Unbalance

2.2. Overcurrents

All currents that exceed the nominal values of service are considered as overcurrents. Generally, the OCs are caused by overload and short circuit (Abdelmoumene & Bentarzi, 2012).

2.2.1. Overloads

The overload can be due to the increase in the number of loads fed simultaneously or to the increase in the power absorbed by one or more loads. It results in an over-current which causes a rise in temperature prejudicial to the characteristics of insulators and the longevity of the transformer (Abdelmoumene, Bentarzi & Ouahdi, 2012; Abdelmoumene, Ouahdi & Bentarzi, 2011).

From the viewpoint of the duration of appearance, overloads may be classed into two categories:

- Temporary Overloads: Last only some moments (from some seconds to few minutes). Except certain special application; this type of overcurrent is tolerable from protective relaying.
- Persistent Overloads: When the overload persists and risks causing damage in the system; the protective relay must isolate the source of fault.

2.2.2. Short Circuits

A short-circuit is an accidental connection between active conductors presenting a difference of potential with a null impedance (solid short circuit) or not (impedent short circuit). It can be internal the equipment or external (Abdelmoumene & Bentarzi, 2012; Abdelmoumene, 2010).

The classification of short circuits according to the nature of the connection is shown in Figure 1.

There are also other forms of overcurrents, but, generally they are known under specific names according to the phenomenon causes. Thus, the starting current of motors and the inruch current resulting when energizing a magnetic circuit are a particular kind of overcurrents (Figure 2).

2.2.3. Inruch Currents

Inruch Current is a form of over-current results from any abrupt changes of the magnetizing voltage that leads to the core saturations (see Figure 3). The inruch current is of transient nature and, in general, it is not really dangerous for the equipment rather than undesirable event that may cause mal tripping of protective relays. The problem of
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