CHAPTER ONE

1.0 FAULT

1.01 INTRODUCTION

A fault is any abnormal condition in a power system. The steady state operating mode of a power system is balanced 3-phase a.c. .However, due to sudden external or internal changes in the system, this condition is disrupted.

When the insulation of the system fails at one or more points or a conducting object comes into contact with a live point, a short circuit or a fault occurs.

1.0.2 CAUSES OF POWER SYSTEM FAULTS

The causes of faults are numerous, e.g.

- Lightning
- Heavy winds
- Trees falling across lines
- Vehicles colliding with towers or poles
- Birds shorting lines
- Aircraft colliding with lines
- Vandalism
- Small animals entering switchgear
- Line breaks due to excessive loading

1.0.3 COMMON POWER SYSTEM FAULTS

Power system faults may be categorised as one of four types; in order of frequency of occurrence, they are:

- Single line to ground fault
- Line to line fault
- Double line to ground fault
- Balanced three phase fault

The first three types constitutes severe unbalanced operating conditions which involves only one or two phases hence referred to as unsymmetrical faults. In the fourth type, a fault involving all the three phases occurs therefore referred to as symmetrical (balanced) fault.

1.04 EFFECTS OF POWER SYSTEM FAULTS

Faults may lead to fire breakout that consequently results into loss of property, loss of life and destruction of a power system network. Faults also leads to cut of supply in areas beyond the fault point in a transmission and distribution network leading to power blackouts; this interferes with industrial and commercial activities that supports economic growth, stalls learning activities in institutions, work in offices, domestic applications and creates insecurity at night.

All the above results into retarded development due to low gross domestic product realised.

It is important therefore to determine the values of system voltages and currents during faulted conditions, so that protective devices may be set to detect and minimize the harmful effects of such contingencies

1.1 THEVENIN'S EQUIVALENT CIRCUIT

Theveninôs theorem states that any linear network containing any number of voltage sources and impedances can be replaced by a single emf and an impedance.

The emf is the open circuit voltage as seen from the terminals under consideration and the impedance is the network impedance as seen from these terminals.

This circuit consisting of a single emf and impedance is known as Theveninôs equivalent circuit.

The calculation of fault current can then be very easily done by applying this theorem after obtaining the open circuit emf and network impedance as seen from the fault point.

1.2 SYMMETRICAL COMPONENTS

The majority of faults in power systems are asymmetrical. To analyse an asymmetrical fault, an unbalanced 3- phase circuit has to be solved. Since the direct solution of such a circuit is very difficult, the solution can be more easily obtained by using symmetrical components since this yields three (fictitious) single phase networks, only one of which contains a driving emf.

Since the system reactances are balanced the thee fictitious networks have no mutual coupling between them, a fact that is making this method of analysis quite simple.

1.21 General principles

Any set of unbalanced 3-phase voltages (or current) can be transformed into 3 balanced sets. These are:

1. A positive sequence set of three symmetrical voltages (i.e. all numerically equal and all displaced from each other by $120^{0)}$ having the same phase sequence *abc* as the original set and denoted by $V_{a1,}V_{b1,}V_{c1}$ as shown in the fig(1a)

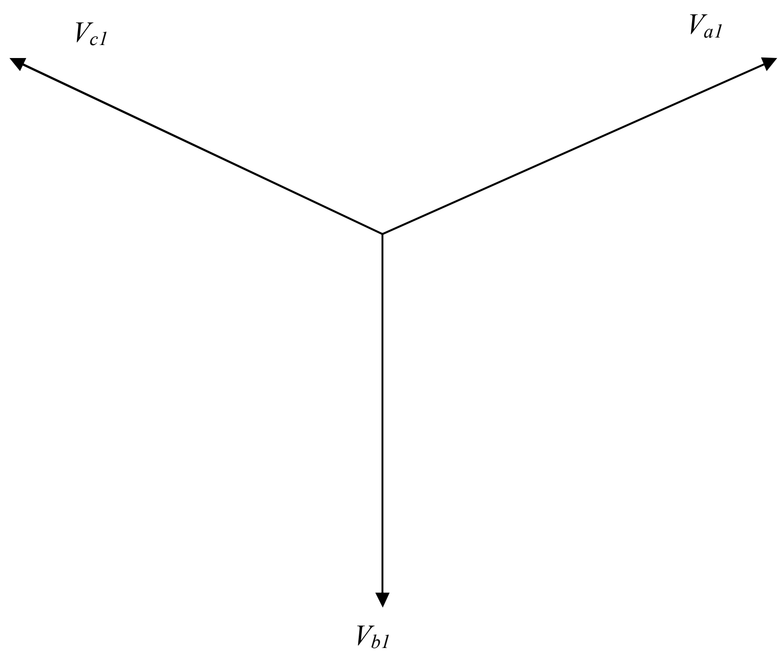

Fig. (a)

2. A negative sequence set of three symmetrical voltages having the phase sequence opposite to that of the original set and denoted by V_{a2}, V_{b2}, V_{c2} as shown in fig(1b)

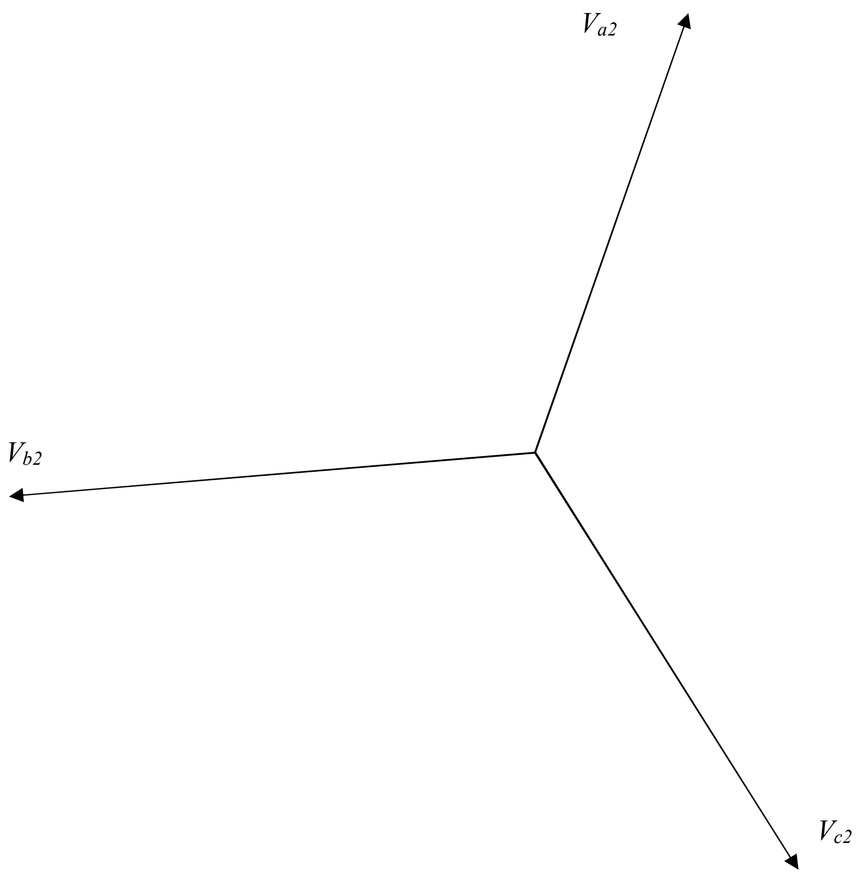

Fig. 1 (b)

3. A zero sequence set of three voltages, all equal in magnitude and in phase with each other and denoted by V_{a0}, V_{b0}, V_{c0} as shown in fig (1c) below:

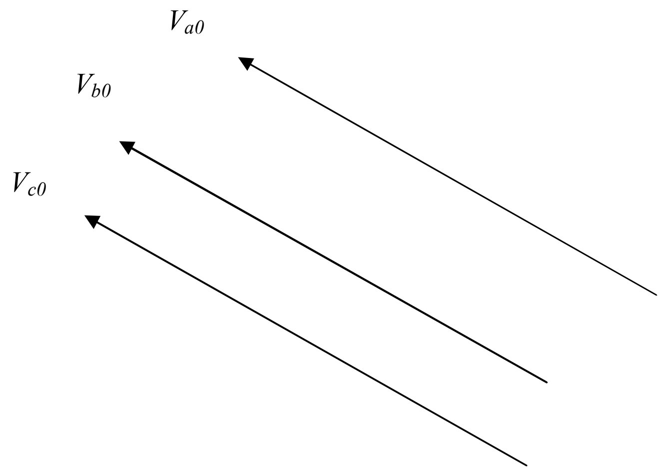

Fig. 1 (c)

The positive, negative and zero sequence sets above are known as symmetrical components.

Thus we have,

$V_a = V_{a1} + V_{a2} + V_{a0}$

$V_b = V_{b1} + V_{b2} + V_{b0}$

$V_c = V_{c1} + V_{c2} + V_{c0}$

The symmetrical components application to power system analysis is of fundamental importance since it can be used to transform arbitrarily unbalanced condition into symmetrical components, compute the system response by straightforward circuit analysis on simple circuit models and transform the results back to the original phase variables.

Generally the subscripts 1, 2 and 0 are used to indicate positive sequence, negative sequence and zero sequence respectively.

The symmetrical components do not have separate existence; they are just mathematical components of unbalanced currents (or voltages) which actually flow in the system.