E-LECTURE NOTE

COURSE TITLE: POWER SYSTEM ENGINEERING I

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UNIT: 3

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LECTURE1

TRANSMISION LINES AND CABLES

1.1 Overhead lines

Overhead lines are suspended from insulators which are themselves supported by towers or poles. The span between two towers is dependants upon the sag in the line for steal tower with very high voltage lines, the span is always or normally 370-460m.

The presence of overhead lines constitutes environmental problems, these includes radio interference (RI), audible noise (AI), among others.

1.2 underground cables

Most of the problems associated with overheads cables lines can be overcome by the use of underground cables. These are not free from drawbacks. The limitation to cables transmitting current because of temperature rise consideration coupled with high manufacturing and installation result in the ratio of the cost of transmitting energy underground to that of overhead being between 10-20v, this increasing with operating voltage

1.3 Cables

Cables used in electrical circuit are of many types, but all consist of the following main part: conductors, insulators, mechanical protection.

1.4 Line parameters

The parameters of interest for circuit analysis are inductance, capacitances, resistance and leakage resistance. These four parameters affect the ability of the transmission line to fulfill its function as part of power system.

1.4.1 Inductance

The inductance a due to an internal flux (internal inductance) of a conductor is given by

1.4.2 Line Capacitance

Two overhead line conductor with air insulation between them constitute a capacitance which when connected to an alternating voltage supply will take a charging current which will flow even under no-load condition. The charge current will be greatest at sending end and will diminish to zero at the receiving end.

1.4.3 Line Reactance

Line reactance is given by:

$$X_L=2\pi fL- 1/2\ \pi fC$$

1.4.4 Line Resistance

Virtually all overhead power transmission line utilizes bare aluminum conductors because of their economy, good electrical conductor properties, and light weight.

1.5 Representation of power system elements

1. Generator
2. Synchronous motor
3. Transmission lines

1.6 Modeling of power elements

One line diagram or single line diagram is used for modeling of power element.

LECTURE11

LOAD FLOW STUDIES

2.1 Introduction

The electrical performance of a normal balanced 3face steady condition is of primary importance to the power system engineer. The determination of power flow in the network of power systems as well the voltage exit at various points witting the system is very essential for smooth operation of the power system. A load or power flow study achieve this result

Low flow studies are performed to investigate the follow ing:

1. Flow of MW and MVAR in branches of the N/W and sometimes this is in P.U values
2. Busbar voltages
3. Effects of rearranging circuit and incorporating new circuits on the systems loading.
4. Effects of temporary loss of generation and transmission circuit on the power system loading.
5. Effect of injecting in phase and quadrative boast voltages in system loading.
6. Optimum system running condition and of course load distribution.
7. Optimum system losses.

Therefore the principle involve in the power flow studies are straight forward and most important, but a study relating to dynamic real power system can be achieved by only the digital computer usually by the means of iteration procedures.

There are various method available for performing a load flow study, these include

1. Gauss – seidel (or Y-matrix or Y-bus) method

Usually the Y-matrix is very sparse i.e it contains some zero element in the matrix. This was the first method to be applied to study of load flow. It is very simple but convergeies slowly. Convergent is dependent upon systems conditions and parameters.

2. Newton – Raphson method

   The approach is considered to be the most reliable by the power industry. It is the preferred method of load flow analysis by utilities. It combines the quadratic characteristics with sponse matrix techniques to give very serious reliable result.

3. Fast – decoupled Newton Raphson load flow methods

   This is a derived version of Newton Raphson methods. It is faster than the Newton Raphson method and is well suited on on-line or real time application. The 2^{nd} order Newton Raphson method has been developed.

LECTUREIII

FAULT ANALYSIS IN POWER SYSTEMS

3.1 Introduction

Faults generally arise from lighting discharges, and others over-voltage or from mechanical forces such as trees touching over head lines or mechanical damage to cables. This requirement in the design of power network is the calculation of the current which flow in the component when faults of various types occur

For effect design of adequate protective relaying system and the rating of the circuit breaker, this information above is necessary. In the fault survey, faults are initiated at various points in the power system and the resulting fault-current in each line and the voltage at each mode are calculated by digital computer programming.

3.2 Types of Fault

1. One line to ground (L-G)
2. Two line shorted together (L-L)
3. Two line shorted together and connected to the ground (L-L-G)
4. All three lines shorted together (L-L-L)
5. All three lines shorted together and connected to ground (L-L-L-G)
6. L-G faults through an impedance, e.g a tree.

3.3 Symmetrical Short Circuit Fault.

The fault is symmetrical if the impedance seen at each phase at the fault points are identical.

3.4 Symmetrical Faults Analysis

In the design of power systems, it is necessary to calculate the current that flows in the component when various types of faults can occurs due to

1. Accidental insulation failures
2. Lighting flash-over
3. Accidental faulty operation

Because of damage the heavy current would cause on the component, it is necessary to determine the magnitude of the current. This will help us in the choice of circuit breakers or the setting for the protection.

Faults calculations can be broadly classified into two groups

1. 3-phase short circuit (symmetric faults)
2. Unsymmetrical faults (Unbalanced faults).

3.5 Current Limiting Reactors

To limit large short-circuit current, and reduce capacity of the circuit breaker, the reactance between the source and the faults can be increased using reactors. Large values of reactance and low ohmic resistance are introduced into the network in such a way that the system performance is not duly affected. The reactor may be connected.

1 in series with each generator

2. in series with each feeder

3. between busbar sections

3.6 Symmetrical Component

When a system voltage is unbalanced, the voltage and the current and the phase impedance are generally unequal. This type can be solved by means of the method of symmetric components. This method was proposed and called three component method

It is usually a method of per phase analysis of systems with an unbalance termination like circuit or faults.

3.6.1 Fortecue Theorem

An unbalance set of n-phasors may be resolved into (n-1) balance n-phase sequence and one, zero-phase sequence system.

3.6.2 Phase Sequence

The phase sequence of the phasor is the order in which they pass through a maximum sequence a,b,c is positive sequence a, b, c, in negative sequence.

3.7 Symmetric Component of an unbalance Three-Phase System

An unbalanced three-phase current may be represented by the sum of

1. A balance system of a three faced current having the same phase sequence as the original unbalance system called the positive-sequence systems
2. A balanced system of three face current having a phase sequence opposite to that of the original balance systems and called negative sequence system.
3. A system of three current equal in magnitude and in phase called zero sequence.

These three set of balance phasors are called the symmetrical component

of the original balance phasors.