TRANSMISSION LOSS ANALYSIS AND ECONOMIC LOADING WITH PARTICULAR REFERENCE TO THE A.R.E POWER SYSTEM

A THESIS

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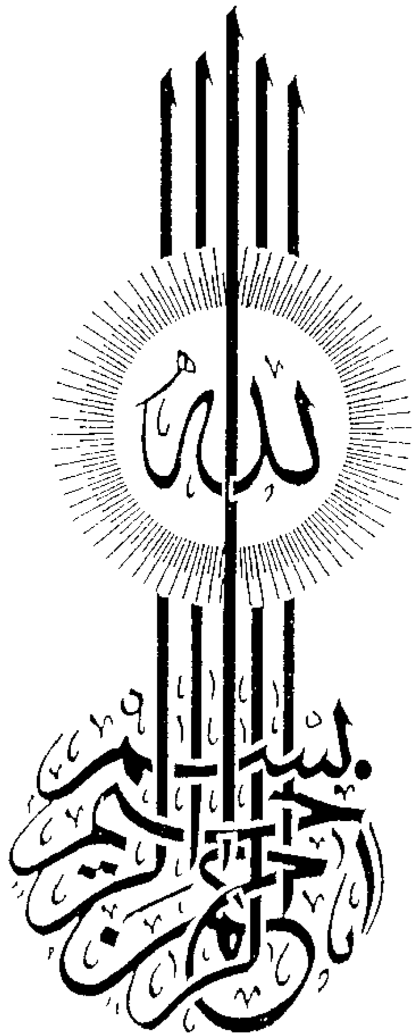
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SUMMARY

This thesis investigates the analytical methods and the methods of the mathematical simulation on the Direct Current Network Analyser used for the study of the transmission loss and the economic loading.

A particular reference is made to the Arab Republic of Egypt power system and other systems for the sake of the generalization of results of the study.

The thesis consists of six chapters, introduction, conclusion and five appendices.

The First chapter contains a complete description for the D.C. network analyzer used in the study and available in the Electrical Engineering Dept. of the Faculty of Engineering, Ain-Shams University. The low percentage error incurred in the network simulation on the analyzer allowed to use it for the compartively acurate analysis of the power system. This is obvious, especially in developing countires where the overall capacity of the network is low, since the additional cost of operation due to error incurred in the simulation results may be less than the additional cost necessary for the replacement of these simplified analyzers by high speed digital computers.

The parameters and the configurations of the investigated systems are given in the Second chapter. Also the relations between the active and the reactive generation are given for the different power stations in the Cairo area. These relations were obtained on both the D.C. network analyzer and the I.B.M 1130 digital computer. Both results almost coincided.

In chapter Three a correlation was proposed between the measurements based on nodal voltage and loop current methods. This allowed to obtain the open circuit impedances for the investigated power systems by using the D.C. network analyzer. The results obtained from the designed programme on the 1130 digital computer were very close to those obtained on the D.C. network analyzer.

The details of the convergence of the load flow on the D.C. network analyzer are given in the Fourth chapter. Also the flow chart of a programme based on the Gauss-Seidel method with an accelerating factor is given for the analysis of the load flows in the considered power systems. Comparison of results indicated the better convergence of the load flow as obtained on the D.C. network analyzer.

In chapter Five formulae for the B_{mn} loss coefficients are derived. Also the power loss was estimated for five different operating conditions using the loss formulae and the $\sum I^2R$ from the load flow studies obtained both on digital computer and network analyzer Results of D.C. network analyzer and of the digital computer were very close.

A programme is given in the Sixth chapter for economic loading of the Cairo area of the unified power system comprising both coordination equation and the incremental loss. The actual input-output relations of the different thermal units are used in this programme. Comparison of results with the published data of other authors indicated the validity of the proposed approach.

The thesis also contained the conclusion and the recommendations, which may be suggested for the economic operation of the UPS of the Arab Republic of Egypt.

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INTRODUCTION

The continually increasing demand for electric power has led to the development of natural resources at locations that are often far removed from load centers. Utilization of these resources is coordinated with economic and reliability considerations. The prime function of a modern power system is to satisfy the system load demand at the lowest practical cost. An important consideration in the economic appraisal of bulk power transmission is the attendent power transmission losses. The system planners view transmission losses as an integral part of the economic evaluation of alternate transmission proposals. These responsiblities for the operation of the power system are faced with the problem of minimizing the overall costs of operating the system concieved by the planner.

This thesis is to study the analytical and mathematical simulation techniques by which transmission losses can be incorporated in the optimum operation of the system.

In the continuous scheduling of the system generation, optimum operation is obtained when the incremental cost of the received power at the system load is the same from each source in the system. This condition requires the coordination of the incremental power production costs and the incremental transmission losses and it is therefore convenient to represent the system transmission losses as a function of the generator power out-puts. A practical mathematical approach of the form shown in equation (1) was first represented by E.E. Georg[1] in 1943.

P_L = Total transmission losses

$$= B_{11}P_1^2 + B_{22}P_2^2 + B_{33}P_3^2 + \ldots\ldots\ldots\ldots + B_{nn}P_n^2$$

$$+ 2B_{12}P_1 P_2 + 2 B_{13} P_1 P_3 + \ldots\ldots\ldots$$

$$+ 2B_{23} P_2 P_3 + 2B_{24} P_2 P_4 + \ldots\ldots + 2B_{mn} P_m P_n \quad (1)$$

or in summation form:

$$P_L = \sum_m \sum_n P_m B_{mn} P_n \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where

P_m, P_n = Generator power outputs.

B_{mn} = Transmission-loss-formula coefficients.

B_{nj} = Mutual loss formula coefficients between constant load and generator components.

Transmission losses calculated using this type of formula can be readily used to determine optimum plant loading schedules by coordinating the incremental fuel costs and the incremental transmission losses or by modification of the incremental fuel costs by the use of plant penalty factors.

The basic system data required in the analysis of the economic scheduling of system generation is:

1- Electrical-System Data

a- Impedance diagram of transmission and subtransmission facilities whose losses are dependent upon the manner in which generation is scheduled.

b- Daily load cycles for typical week's operation.

c- Load duration curve for period of operation to be considered. This curve is required in the determination of the annual differences in production costs resulting from different scheduling methods.

d- Selection of base-case loading period and tabulation of loads, voltages, and probable generation schedules and interconnections flows for base-case.

2- Plant Data

a- Thermal characteristics of units and in particular the incremental fuel rate data on all units.

b- Costs of fuel at various plants in millims per million Btu.

c- Determination of straight-line equations of incremental production costs of various units.

An improved method for calculation of economic load scheduling for multiplant power system was represented by M.Y. Akhter[6], 1967. The method proposed uses exact penalty factors and loss formula coefficients, and takes the total generation or load requirements directly as input in the designed digital computer program. Other algorithms are proposed (PSCC, 1972) and realized on digital computer.

However, some companies have built boards with fixed resistors permenantly connected to represent their own systems and interconnections with neighbouring systems. The particular advantage of the calculating board over the digital computer is that the board closely simulates the physical network, the loads and the sources, and so aids the engineer in preceiving the actual system. The reading obtained from the instruments of the board and recorded manually on the system diagram are in a form more descriptive to most engineers than are the tabulated data printed by the machine.

At the same time digital computer furnishes a flexible and accurate method of taking into account the various and rapidly changing system conditions in the plant and on the transmission system. This results in putting the computers(on line) to issue instructions to the various plants to adjust their outputs at regular intervals to secure economical operation in accordance with the system requirements.

However, in power systems for which interconnection transaction are not frequent and for which the fuel costs across the system vary together precalculated schedules are applicable. These schedules are also used in system not equipped with (on line) computers. The classical methods of network analysis on digital computer, particularly where meshed networks are concerned, are very time consuming and need a developed program library. On the other hand; network analyzer measurements supply the correct answers in a minimum of time and; by suitably manipulating the disposable parameters; these can be optimized for a given problem. The network