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THE METHODOLOGIES FOR POWER PLANNING AND OPERATION OF DISTRIBUTION SYSTEM

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ABSTRACT

The problem of losses in the distribution system assumes greater importance with the price of fuels no longer a relatively minor factor in the supply of electric energy. It is difficult to measure the actual energy losses in such a system, as many other factors are included in the different between the energy consumed by each of the consumers connected to it and the energy sent out by the power plant. In general the loss varies with the square of the current flowing; reducing the value of such current will reduce losses. The present paper is focused on methodologies for power planning and operation of distribution system sothe power plan just run smoothly and reduces the loss. This paper concentrates around the development of knowledge based methodology for some of DA functions. The major areas of the research are: Planning of distribution system, Sequence switching and service restoration of distribution system and optimal reactive power control in distribution system.

INTRODUCTION

In the early days of the electric power industry, the distribution systems were often mere appendages to the power generating plants. The areas served and the number of consumers was relatively small; individual usages were not very large, generally limited to few applications. Quality, interims of voltage regulation and service reliability, was almost nonexistent. With little study, their installation and operation were considered more of an art than a science. The increasing demand for electrical energy and growing cost of investment required for destruction of energy has made the system more complex and posed an technological challenge to utilities in developing countries. The system not only had to serve greater number of consumers, but had to supply their greater individual loads that requires closer supervision of voltage variations at the consumer terminals with only fewer interruptions of shorter duration. At this point the design, construction, maintenance and operation of distribution systems became a science involving technical and economic aspects. The normal sequence in the installation or expansion of distribution system begins with the planning and design of facilities, then proceeds to their construction and finally includes their maintenance and operation. The inter relationship of these factors, their effects one upon the other, is of the almost importance in achieving an eminently satisfactory, if not optimum operation.

Earlier distribution systems supplied direct current at the low distribution voltages. But the advent of transformer has replaced the direct current distribution by alternating current almost universally. The earlier simple redial feeders were provided with sectionalizing points which enabled a faulted section of the circuit to the disconnected and the remainder of the circuit beyond the faulted section can be

reenergized by connecting it to other adjacent circuits. These emergency life points specifically provided for this purpose also enabled loads to be transferred conveniently from one circuits to another. Other designs were the circuit formed into loops, operating open at some point or as a closed loop. The circuits are interconnected into a mesh or a network in the important and greater load density areas.

The problem of losses in the distribution system assumes greater importance with the price of fuels no longer a relatively minor factor in the supply of electric energy. It is difficult to measure the actual energy losses in such a system, as many other factors are included in the different between the energy consumed by each of the consumers connected to it and the energy sent out by the power plant. In general the loss varies with the square of the current flowing; reducing the value of such current will reduce losses. Many means have been employed to achieve this, the principal one being that of raising the voltages of circuits. Increasing conductor sizes and shortening circuit lengths have also been employed. In a.c. system, the installation of capacitors at strategic locations will improve the power factor and thereby reducing the current flow for given loads. Further, distribution system designs are often affected by extraneous factors. For example, sometimes improvement or modernization of a circuit cannot be justified technically or economically. Often however advantages are taken of other considerations, such as road widening or other constructions, to rebuild or replace lines, the opportunity being afforded to make desirable changes that otherwise would not be considered for some time.

Many of the features described for improving the quality of electric service as well as for reducing losses lens themselves to automatic operation of distribution system. The advent of micro electronics and communication technology for power distribution system promised a new era in the automated control and operation of distribution systems. Automation in the electrical distribution system can be achieved from the basic level to a sophisticated level of using knowledge based system (KBS). Reduction of the system losses and optimization of the investments are two main important concerns for developing countries to favour distribution automation (DA). Most of the distribution substations in developing countries are still manually controlled and hence the distribution automation should aim at integrated approach for all devices in the distribution network including distribution substation (DSS) control. Most of the developed countries have introduced supervisory control of distribution substation and some forms of load management through one way communication system like cyclic control. Hence the DA is considered as control and operation of devices provided in the primary and secondary distribution network after the DSS. The above definition of DA AMY not is appropriate for utilities in the developing countries, considering the present status of the automation of the network. The three important facts which are to be considered in developing countries context are

1. DSS are of small capacity, large in number and are controlled manually.
2. Load management is yet to be introduced even though it is identified as key area to improve the operational efficiency and optimize investment.
3. The major loads have to be monitored because of the continuous power shortages.

Hence the suggested definition of DA in developing countries context like India is automated control and operation of distribution substations and all devices provided in the primary and secondary

distribution networks including function of load managements, remote meter reading, switching of control devices etc.

Considering all the above factors and as the automation of distribution system can be achieved through knowledge based system as attempt is made in this thesis to study the following aspects of distribution system and to develop knowledge based methodology namely planning of distribution system, sequence switching and service restoration of distribution system and volt/var control of distribution system. As the distribution automation is tremendously potential area, the research work is confined only too few DA functions along with planning strategies using knowledge based algorithms.

The electrical distribution engineer faces problems that are seldom exactly, or even approximately the same. And the solution proposed is often not perfect but the best available, solutions. Often improvisations and compromise must be used, so that any work on this subject cannot be exact nor provide all the answers to all the questions that may arise. All that this work can do is to lend some direction and to point the way towards meeting the technological challenges in the developing countries.

AI APPLICATION IN DISTRIBUTION SYSTEM

Recent development in AI can be explored for power engineering areas. Implementation of AI approached could be cost intensive and usually cannot guarantee optimal results, but only good enough results. Consequently, it makes sense to use AI technique for problems not solvable by conventional methods. The practical benefits of the AI approaches, especially from power engineering prospective are the AI will make computer more effective even to the point of actually realizing the automation of power system spanning and operation processes. In the context of operations, operational planning and planning, various application areas are identified as shown in table 1.1

AI application areas for distribution system problems

Operation	Operational planning	Planning
1. System monitoring and diagnosis	2. Intelligent operational planning aids	1.Distribution system planning
1. Load shedding		2. Switching action
2. Volt/var control		3. Maintenance scheduling
3. System restoration		4. Safety regulation
4. System configuration for loss minimization		5. Remedial action
5. Load Management control		6. pricing
		7.Demand side management

SCOPE FOR PRESENT WORK

This thesis concentrates around the development of knowledge based methodology for some of DA functions.

The major areas of the thesis are:

a. Planning of distribution system
b. Sequence switching and service restoration of distribution system
c. Optimal reactive power control in distribution system

PLANNING OF DISTRIBUTION SYSTEM

The distribution system is very important to an electrical utility for two reasons:

i. It is in close proximity to the ultimate customer and
ii. Its high investment cost

The failure of distribution system affects the customer service more directly than the failure on transmission and generating systems. Hence, a distribution system must be maintained in good service condition which requires good planning and time to time expansion. But these two require the prediction of future loads. Hence, planning load forecasting and expansion planning are the most important fields of interest in distribution systems. System planning is essential to assure that the growing demand for electricity can be satisfied by distribution system additions which are both technically adequate and reasonably economical. The objective of distribution system planning is to assure that the growing demand for electricity can be satisfied in an optimum way by additional distribution system. The constraints to be satisfied are permissible voltage values, voltage dips, ecological and social considerations, availability or equipments etc.

A distribution planner must determine the load magnitude and its geographic location. Then the distribution substation must be placed and sized in such a way as to serve the load at maximum cost effectiveness by minimizing feeder losses and construction costs while considering the service reliability. The demand type, load factor and other customer load characteristics dictate the type of distribution system required. Other factors influencing a good long range distribution planning are:

1. Transformer impedance, insulation levels availability of spare transformer and their ratings.
2. Dispatch of generation
3. Rates that are charged to customers
4. Timing and location of energy demand
5. Duration and frequency of outages
6. Cost of equipment, labour etc.
7. Increasing or decreasing prices of alternative energy sources
8. Changing socio-economic conditions and trends such as population growth, technological changes, environmental concerns, regulation of government etc.

Hence the planning problem is an attempt to minimize the cost of sub-transmission, substations, feeders, laterals etc., as well as cost of losses. This collection of requirements and constraints has put

the problem of optimal distribution system planning beyond the resolving power of an unaided human mind.

REVIEW OF LITERATURE

In the part, several efforts have been made to plan the distribution system forecast the future load and to expand the given system. Some of them are mentioned below.

Ever since the development of expert system technology it has found enormous potential in power system application [56-56b]. In the literature, several mathematical programming techniques such as mixed integer linear programming, branch and bound model, fixed charge network formulation [1-28] have been applied for distribution system planning. In reference of power distribution system planning is given. References present the method for optimal conductor size for distribution system, optimization techniques were used to find the substation location and feeder configuration. In the other references mixed integer programming was used which was a promising and feasible approach. But the application was limited to small system. An algorithm for static investment planning of large distribution systems using linear programming technique is presented. Branch and bound search method is given for finding the optimal substation location. This utilizes the shortest path table to obtain the lower bound and transshipment model for upper bounds. Non linear mixed integer programming subject to nonlinear constraints is given. The objective function is the present value of system investment, maintenance and energy loss costs. A mixed integer programming technique with fixed charged network model to account for fixed charges of the substations and feeders is presented. Computer aided automation distribution system planning were presented. Comparison of several computerized distribution system planning methods is given. However all these methods fail to take the heuristic rules currently employed by system planners into account? This motivates the development of knowledge based expert system which are capable of combining heuristic rules with mathematical methods in it problem solving. The load pattern was treated as a time series signals and the future load was predicted using time series analyses techniques. Uses stochastic model which decomposes the load into three components: nominal, residual and type loads. The parameter of the model was adopted to load variation. The references shows Uses the general exponential smoothing method for the predication of future loads, uses recursive algorithm based on extrapolation and the load behavior is represented by Fourier series or trend curves. Weather information was added and the total load was decomposed into weather sensitive load and non weather sensitive load. The weather sensitive loads were predicted by correlation technique and non weather sensitive loads by the methods give in references. Each component is predicted separately and the sum gives the total load. Researchers have found alternative to the classical models using artificial intelligence make use of knowledge based expert system for short term load forecasting in which operators experience and heuristic rules were included. Recently, the national science foundation organized a workshop to address the importance of artificial neural network in power system engineering where is demonstrated that the artificial neural network can be successfully used in load forecasting with acceptable accuracy. These uses back propagation algorithm for training the network used the adaptive learning algorithm for training the network and uses strategy for selecting the suitable training cases which reduce the number of total training cases and there by the training time and computer memory. The dynamic programming technique which can treat the discreteness of variable

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and necessity for multi term planning is restricted to only small scale problems because of its complexity and memory requirement. Therefore approximate algorithms were developed. The most effective approximate solution algorithm is given. Hence the N-year expansion planning problems was decomposed into N number of one year problem and was solved by branch exchange method. The results of the sub problem were coordinated. In the whole problem was formulated by including predetermined fault cases. Then it was decomposed into sub problem and was solved by decomposition coordination method. In knowledge based expert is used for reallocation of loads during expansion planning.

The above literature survey carried out provides a clear idea about the present day research in planning, load forecasting and expansion planning of distribution system. The present practices of the engineers of our utilities for location of substation, feeder configuration and expansion planning are successfully utilized to develop a knowledge bases system for planning of distribution system.

OVERVIEW OF THE RESEARCH WORK

The research begins with the development of knowledge based system for planning of distribution system as it has assumed a lot of importance in the present literature. Current practices in distribution system planning have evolved such that many classical rule of thumb guide lines are increasingly being supplemented by more rigorous optimization procedures. Several method for planning of distribution system such as mixed integer, branch and bound etc. have failed to take the heuristic rules currently being employed by the system planners. This motivates the development of KB system, which is capable of combining the distribution system engineer‟s heuristic rules with mathematical method in its problem solving strategy. The artificial neural network process information by its dynamic state response to external inputs and the computational elements in neural network are non linear models and are faster. Hence the KBS and the ANN are used for planning, load forecasting and expansion, planning of distribution system. The proposed methodology is capable of locating the substations, designing the primary feeders, forecasting the load for any lead time and for this forecasted load conditions, it provides the expansion planning strategy. The method incorporates all physical constraints which makes it more practical. The developed methodology is tested on a practical system having „40‟ load points of home city, India. The resulted obtained are acceptable.

As mentioned earlier that the DAS is a concept which not only includes the familiar functions of distribution automation but all the functions encountered in the distribution system. Sequence switching is one the basic and principal operational items in electrical substation. Automatic sequence switching has been an important pursuit in the field of automation switching network under normal operations or after abnormal events and requires solutions of the optimal sequence problem. But, finally both depend upon a sequence switching strategy. Further, most distribution system maintain radial structure with each feeder linked by normally open witches to its neighboring feeders. Feeder switching in distribution system is also an important aspect of distribution automation. Service restoration is the top priority matter in the DA and hence must be reached in a very short time and the out of step area must be minimized to enhance the reliability. By changing the states of the feeder switched. The process of reconfiguration is carried out which will result in the distribution of line

flows, bus voltages and losses. The issue here is to find a particular combination of the open and close switches to achieve the operational goals. A knowledge based system for the optimal sequence switching and service restoration is developed which uses the stochastic process in conditional probability. A simple fault identifier is developed which uses the stochastic process in conditional probability. A simple fault identifier is developed which uses the information from the protective relays to identity the type of fault and the distance of fault point from the relay measuring point. The developed methodology is tested on a practical system to home city, India, having 4 U.G. cable feeders „36" load points and „8" RTU"S. The results obtained are encouraging.

The next function of DA considered for the study is the volt/var control of distribution system. The shunt capacitors which are installed on a distribution feeder can mitigate the total system losses, improve the voltage profiles, and reduce the KVA capacities of apparatus in the system. Maximization of benefits depends greatly on how capacitors are placed in the system. Hence, general capacito0r placement problem consists of determining the location to install capacitors, control schemes for the capacitors in the nodes of a redial distribution network such that the objective function is optimized, where the load constraints and operational constraints at different load levels are satisfied. The simulated annealing (SA) which is a general purpose optimization technique along with the set voltage magnitude (SVM) method for initial location prediction for capacitors and initial estimate for reactive power compensation is successfully used to develop a knowledge - based system for optimal reactive power control for voltage improvement and reduction of losses in the distribution system. The developed methodology is tested on a practical „85" node redial distribution system of home city, India. The results obtained are encouraging and practically acceptable.

The research work concludes by giving salient conclusions drawn from the study and the scope for further research.

CONCLUSION

The present work is an attempt to understand the physics involved in the application of knowledge based methodology for power distribution system planning and operation. Various Artificial Intelligence tools are successfully utilized in the development procedure. The research work is mainly concentrated on:

1. Planning of distribution system,

2. Sequence switching in substations and service restoration of distribution system, and

3. Reactive power optimization of distribution system.

Based on the results of the research work undertaken, some salient conclusions are drawn. While these conclusions are drawn from a particular study, they are general in nature and form guide lines for any practical system.

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The role of knowledge based system, artificial neural network on planning; load forecasting and expansion planning is established. The knowledge based system is capable of incorporating the practical aspects which improves the reliability of planning. Concentric relaxation technique provides an optimal design of feeders. The installation and running cost are considerably' reduced. The back prorogation algorithm provides the better results of forecasted loads for various lead times. The expansion planning provides a clear idea about the optimal planning.

FUTURE ASPECT FOR RESEARCH

Statistical reasoning process is an added advantage for system operator to take a decision during emergency state. The probabilistic approach is capable of predicting the future state of the node in the search procedure and provides alternative plans. The probability of energizing each node is calculated using highest spare capacity available during restoration and hence the proposed method is more justified with some special nature requirement of research in power and energy system with analysis of demand of supply and demand of state. Further, the method developed produces an inherent feature of local reconfiguration (loss minimization). This lessens the mental stress and burden of the operator. This can serve as an operational aid for the system operators at the dispatching centre.

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