A Study of Economic Load Dispatch Problem Solution in Soft Computing Electrical Power System

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Abstract

In power systems, system frequency decreases if load exceeds generation and increases when power generation is greater than load demand. Load shedding is highly required in power systems to stabilize frequency in electrical power systems. Though conventional load shedding techniques are being used in many power system applications, soft computing techniques such as artificial neural networks (ANNs), fuzzy logic, genetic algorithm and particle swarm optimization have been presented by many researchers to provide optimum load shedding. However, there are many problems associated with machine learning based control techniques in real time. In this work, the utilization of soft computing algorithms and its benefits and drawbacks are discussed. A comprehensive survey is presented about the soft computing based load shedding and comparison is made among these techniques and conventional techniques. Neural network based learning rule is applied with back propagation network to minimize the error. In fuzzy based technique, load shedding position at each node was predetermined by applying certain fuzzy rules.

Keywords: *Load Shedding, Frequency Stabilization, Soft Computing, Fuzzy Logic Control, Neural Networks, Machine Learning*

1. INTRODUTION

Power system blackouts happen in many areas due to natural reasons or technical reasons. The natural reasons are tree falling on stormy weather, transmission pole falling due to accident. Technical reasons are damaged distribution wires, frequency instability issues and transmission line overloading. The blackouts have serious impacts in healthcare system maintenance and internet breakdown in important urban areas. The main reason for blackout is the voltage instability due to transmission line overloading at some specific instances [5]. These voltage instability issues have the cascading effect on power outages and power system blackouts. Electricity generation and consumption need to be balanced continuously, but it is impossible due to the varying demand. The varying demand leads to power system frequency increase or decrease [6]. To address the problems due to imbalance, overall demand is lowered by cutting back the supply voltage to prevent power outages and equipment damage. Load shedding is intended in power systems to shed some of the electrical load so that damage to the power system could be avoided. Under frequency load shedding scheme is applied to provide the frequency stability, but there is a requirement for an effective scheme to provide optimum load shedding. The conventional load shedding techniques like under frequency and under voltage shedding schemes are being used in many power system applications, but optimum load shedding is not obtained in many applications [2]. Machine learning based techniques provide the option of training the system and make them to learn from the experience [1]. These intelligent machine learning based computational intelligent techniques are widely known as soft computing methods. Soft computing techniques such as artificial neural networks (ANNs), fuzzy logic, genetic algorithm and particle swarm optimization have been presented by many researchers to provide optimum load shedding [11]. Though these techniques are attractive in many engineering applications and power systems, there are many problems associated with machine learning based control techniques in real time. This paper provides the application of different soft computing algorithms in achieving optimum load shedding. The benefits and drawbacks of all these techniques are discussed in detail and compared. Energy production is a key in the development of any country and it needs to be environment friendly. Recently the developed and developing countries focus more on electricity generation from renewable energy sources [4]. The renewable energy sources like wind, water, solar and sea waves are used to reduce the carbon emission. Keeping in view of the advantages of renewable energy and environment friendly nature, distributed generation gained a huge attention among industrialists and researchers [15]. In distributed generation with renewable sources, it is necessary to take care of power quality, stability and acceptance level of voltage and amplitude. Neural network based learning rule is applied with back propagation network and counter to minimize the error. In fuzzy logic based load shedding, load shedding position can be predetermined by applying fuzzy membership functions and certain fuzzy rules. To improve the load shedding performance of neural network and fuzzy logic based methods, neuro fuzzy techniques are applied, widely known as adaptive neuro fuzzy inference system. Optimization techniques are used in many control applications and communication systems for extracting optimum performance of systems. Genetic algorithm and particle swarm optimization are robust and applied to solve many nonlinear and multi-objective problems.

2. REVIEW OF LITERATURE

Voltage Stability Assessment and Analysis Tamura, et.al (1983) analyzed the relationship between a pair of closed power flow solution and voltage instability. In stressed power system two closely located power flow solution exists, which is called multiple power flow solutions. The high voltage solution can be obtained by conventional power flow methods.

Obadina and Berg (1988) proposed a formation to determine the load limit of a multi-machine power system. The method maximizes the load MVA demand of the system subject to distribution constraints at load buses, MW and MVA limits on generators, generator’s MW participation, constant power factor of MVA demand and limits on controlled voltages and On-load Tap Changing transformer taps. This nonlinear constrained optimization problem is solved by using the Sequential Quadratic Programming algorithm. The effect of voltage dependence of load in voltage stability margin is studied. From the result it is shown that constant power representation of loads is the most sever from voltage stability view point.

Schlueter (1991) gave a method for method for determining the proximity to voltage collapse. An algorithm, which help in computing voltage control area and groups of interconnected busses, is developed. It has shown that proper system and operation planning must be undertaken in each voltage control area if collapse is to be prevented. A measure of proximity to voltage collapse is shown to be the reactive reserve in a voltage control area boundary.

Abdul-Rahman and Shahidehpour (1993) introduced a concept of voltage instability caused by heavily loaded system where large amount of real and reactive power are transported over long transmission lines. The situation becomes worse in the absence of reactive power support in order to maintain normal voltage profile at the receiving end buses.

Mohamed A (1994) proposed a technique of weak bus clusters which were determined by utilizing the line stability factors. In this paper, the line stability factors are ranked from the smallest to the largest values and the lines with large stability factor values are eliminated above a cut-off value. The bus clusters were then formed in which all the lines that connect the buses in a cluster have stability factor values of less than the cut-off values and that the voltage and angles changes coherently within the group.

Muhammad Nizam, et.al, (2006) made an evaluating study on the performance of several voltage stability indices used for dynamic voltage collapse prediction in power system. Based on the studies a new voltage stability index has been proposed as power transfer stability index for the prediction of voltage collapse in power system. The results are compared with the other voltage stability prediction indices for voltage margin, power margin and line index. The proposed and the comparative indices are implemented in a small real time power system and its results are compared.

Yuta Wakabayashi and Akihiko Yokoyama (2009) investigated on steady state voltage stabilities which can be evaluated using maximum loading of P-V curves, by the total reactive power loss of the power system. A new method was proposed, which estimated how much improve of voltage should be injected with UPFC at the given location, based on the information on line power flow and bus voltage in the network without installing the UPFC at the location. In this paper, many types of power system configuration and load conditions are considered when UPFC location is given.

Suganyadevia and Babulal (2009) have estimated the margin in the loadability of the power system for assessing the real time voltage stability. Voltage stability Indices were used for estimating the distance from the current operating point to voltage collapse point. The indices used to reveal the critical bus of a power system or the stability of each line connected between two buses in an interconnected network or evaluate the voltage stability margins of a system.

Althowibi F A, et.al (2010) presented a detailed theory about the various methods and causes for voltage instability and collapse. Few methods of voltage instability or collapse in power system are operating the power system closer to its stability limits or transferring large amount of power from/to a long distance or an inadequate supply of reactive contributes to system voltage. Eventually for any one of the above causes voltage collapse would occur.

Magnus Perninge and Lennart Soder (2011) have suggested a method for calculating the distance from a point on the loadability surface to the closest point of non-smoothness of loadability surface. Although the method has its main application in estimating the validity of local approximations of the loadability surface, it can also be used, combined with other methods, when computing the distance from an operating point to the loadability surface. Agha Mohammedi M R, et.al, (2011) implemented a novel line voltage stability was proposed based upon the correlation characteristics of network voltage profile. Voltage profile compresses of all the bus voltage containing the effect of network topology, load generation patterns reactive power compensation and voltage stability margin. The main feature of this index is that they are fast and easy to calculate from the measured voltage profile, without the need of any simulation modeling or dependency of the network size. Measurement is made at any instants of time and compared with the reference voltage profile pre-specified. This method of analysis was demonstrated with the IEEE 39 bus system and results show its applicability and effectiveness of the index which is suitable for on-line applications.

Bastin Solai Nazaran J and Selvi K, (2014) investigates about the dispatch of generation in an economical manner in a deregulated electricity market and to ensure security under different operating conditions. Also different evolutionary computation based solution for optimal power flow is attempted. Social welfare optimization is taken as the basic objective with inclusive of generation cost, transmission cost and customer benefit functions. Severity index is applied as a constraint to measure the security of power system. The objective function is calculated for post and pre contingency period. Real power generation, real power load and transformer tap setting are selected as control variables. Differential bilateral and multilateral conditions are considered for analysis in this paper. These processes are applied in a medium size real time power system netwok.

Yang Wang, et.al, (2014) introduced a new Transfer Impedance Based System Equivalent Model for voltage stability analysis. The equivalent model is used to determine the weak buses and system voltage stability, even to calculate the real and reactive power transferred from the generator nodes to the vulnerable nodes causing voltage instability. By, this full-scale view of voltage stability of the whole system can be presented before the system operators. These parameter values would be very much useful to the operator to take proper action to avoid voltage collapse in power system network.

3. ECONOMIC LOAD DISPATCH PROBLEM IN ELECTRICAL POWER SYSTEM USING SOFT COMPUTING

The Unit Commitment is the essential and vital step in power system operational planning. In addition to the ED objective, environmental concern that arises from the emission produced by fossil fuel electric power plants becomes a major problem to be addressed. Now methods for solving this ELD problem are discussed below:

Lambda Iteration: In Lambda iteration method lambda is the variable introduced in solving constraint optimization problem and is called Lagrange multiplier [1]. It is important to note that lambda can be solved at hand by solving systems of equation. Since all the inequality constraints to be satisfied in each trial the equations are solved by the iterative method. This method has used equal increment cost criterion for systems without transmission losses and penalty factors B matrix for considering the losses.

Gradient Search Method: This method works on the principle that the minimum of a function, f(x), can be found by a series of steps that always take us in a downward direction. In this method the fuel cost function is chosen to be of quadratic form. However, the fuel cost function becomes more nonlinear when valve point loading effects are included.

Newton Method: Newton's method goes a step beyond the simple gradient method and tries to solve the economic dispatch by observing that the aim is to always drive the gradient of function to zero. Generally, Newton's method will solve for the correction that is much closer to the minimum generation cost in one cost in one step than would the gradient method.

Linear Programming: Linear programming (LP) is a technique for optimization of a linear objective function subject to linear equality and linear in-equality constraints. Informally, linear programming determines the way to achieve the best outcome (such as maximum profit or lowest cost) in a given mathematical model and given some list of requirements represented by linear equations. A linear programming method will find a point in the optimization surface where this function has the smallest (or largest) value. Such points may not exist, but if they do, searching through the optimization surface vertices is guaranteed to find at least one of them.

Base Point and Participation Factor: This method assumes that the economic dispatch problem has to be solved repeatedly by moving the generators from one economically optimum schedule to another as the load changes by a reasonably small amount. It is started from a given schedule called the base point. Next assumes a load change and investigates how much each generating unit needs to be moved in order that the new load served at the most economic operating point.

4. CONCLUSION

Soft computing based load shedding and conventional techniques are presented in this survey paper. The merits and associated problems in each of these techniques have been presented and elaborated in detail. In Neural network based load shedding, back propagation network is utilized to minimize the error. In fuzzy based technique, load shedding position at each node was predetermined by applying certain fuzzy rules. Genetic algorithm and particle swarm optimization are also discussed to overcome the existing issues in load shedding. Since accurate load shedding is crucial in many real time applications, neuro fuzzy technique can be preferred that utilized the advantages of both the neural network and fuzzy logic concepts. Though the survey gives an idea about the load shedding schemes, it is required to apply in real time scenario to conclude the best possible load shedding scheme for power systems.

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