Real Power Loss Minimization using Fuzzy logic Controller

T. Hariharan, S. Raja and S. Hareesh

Abstract: The real power loss minimization is an optimization problem with one or more objective of maintaining the reactive power. The ancillary service for a generator has two components that have been recently recognized, i.e., one for sustaining its own real power communication and the other for providing reactive demand, enhancing system security, and scheming system voltage; and that only the next part should get financial compensation in aggressive power markets. The power flow equations and the inequality constraints of basic system operation are the equality constraints, such as voltage magnitude limits. In this paper planned incorporated technique will be united with fuzzy logic controller. One of the knowledge base intelligence techniques which will be utilized for verifying the generator reactive power operating limits, voltage profile and the power loss was the fuzzy logic. Representative results are presented using the IEEE 14 bus system by using MATLAB working platform and the ORPF presentation will be estimated.

Keywords: **Real Power Loss, Optimum Reactive Power Flow (ORPF), Fuzzy Logic Controller (FLC)**

I. INTRODUCTION

The important operating task of power utilities is to keep voltage within an allowable range for high quality customer services [1] [3]. Electric power loads vary from hour to hour and voltage can be varied by change of the power load [2]. Power utility operators in control centers handle various equipment such as generators, transformers, static condenser, and shunt reactor, so that they can inject reactive power and control voltage directly in target power systems in order to follow the load change [4] [5]. Voltage stability constrained reactive power dispatching in deregulated power networks is a difficult task facing an Independent System Operator (ISO) that is mandated to provide equitable ancillary services [6]. Optimal Reactive Power Flow (ORPF) is an important tool for power system operators both in planning, operating stages and avoids instability [8]. The loads acquire reactive power for magnetizing purposes at no load conditions and the electric power loads vary from hour to hour. The change of load causes variation in the reactive power requirement [7]. Newton approach, interior point methods and dynamic programming have been developed to solve ORPF problem [11]. Generally these techniques suffer due to algorithmic complexity, insecure convergence, and sensitivity to initial search point. The soft computing techniques fuzzy logic, fuzzy linear programming, and evolutionary programming (EP) are used for setting optimal reactive power limits [9] [10].

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The problem of supporting its own real power transmission and the other for supplying reactive demand [12]. At the minimization of the voltage deviations, the more optimum result was taken as the cost function[13]. The total reactive cost was separated into generators duty and loadings duty[14]. J. V. Parate *et al.* [15] have generalized the problem of reactive power control viewed from two aspects: load compensation and voltage support. Kursat Ayan *et al.* [16] have studied optimal reactive power flow (ORPF) based on ABC algorithm to minimize active power loss in power systems. Peschon *et al.* [17] have proposed the general problem of minimizing the operating cost of a power system by proper selection of the active and reactive productions.

In power markets, the amount of generator's reactive power that can be traded is usually considered as generator's actual reactive power output, or the reactive power output beyond certain mandatory operational ranges. If the reactive power exceeding the operating range which maximized the charge for reactive power as well as aspire to active energy limitation, in result, increasing the fare for electrical energy. In this power flow tracing method, the optimal allocation of reactive power is based on the objective function of the system. So, an alternative method required for allocating reactive power losses.

In this paper we have intended to propose an integrated Real power loss minimization with optimized power flow tracing method. In the proposed integrated technique will be based on fuzzy logic controller technique. The fuzzy logic is one of the knowledge base intelligence techniques which will be used for determining the real power loss for the corresponding generator reactive power operating limits.

II. PROPOSED METHOD

The Optimal Reactive Power Flow (ORPF) is the important case of the power system, which makes the secured and economic operation of the power system. The ORPF is obtained by minimal assessment of the reactive power of the generating units. The adjustment of the control variables with certain limits makes the efficient operation, because the reactive power control of the generator depends on the control variables of the power system. The power system control variables are given in the following sections.

A. ORPF Control Variables

The control variables of the power system are voltage magnitude of the buses; real power loss, economic dispatch, power flow equality and in equality constraints and the transformer tap settings. The control variables of the power system are given in the following equation (1).

$$CV = [PP_G, VV_G, T, QQ_{SC}] \quad (1)$$

Where, PP_G is the active power generation of buses, VV_G is the voltage magnitude of the generator, T is the transformer ratio, QQ_{SC} is the shunt compensator reactive power. The control variables are given in the following.

B. Determination of Power Loss

The control variables are the important factor for assessing minimum reactive power of the generator. In this proposed system the higher power loss bus is identified and needed to optimize using the fuzzy rules, which is used to identify the problem and compensate the ORPF problem. The fuzzy rules are generated depends on the control variables values for the bus system. The optimization process is obtained by using the fuzzy rules. The real power loss of the bus is given in the following equation (2).

$$PP_{Loss} = \sum_{k=1}^{N_B} \sum_{l=1}^{N_B} G_{kl}[VV_k^2 - 2VV_k VV_l \cos \delta_{kl} + VV_l^2] \qquad (2)$$

Where, PP_{Loss} is the active power loss, G_{kl} is the conductance of the kl^{th} transmission line, V_k and V_l are the voltage magnitude of the k and l line respectively, δ_{kl} is the angle difference of the k and l line respectively, N_B is the number of buses.

The active power generation, reactive power generation and the generator bus voltages are restricted by their upper and lower limits and the generator constraints are given in the following equations (3)(4) and (5).

$$PP_{Gk}^{\min} \le PP_{Gk} \le PP_{Gk}^{\max} \qquad (3)$$

$$QQ_{Gk}^{\min} \le QQ_{Gk} \le QQ_{Gk}^{\max} \qquad (4)$$

$$VV_k^{\min} \le VV_k \le VV_k^{\max} \qquad (5)$$

Where, $VV_k^{\min}$ and $VV_k^{\max}$ is the minimum and maximum bus voltage generated, $PP_{Gk}^{\min}$ and $PP_{Gk}^{\max}$ is the minimum and maximum active power generated, $QQ_{Gk}^{\min}$ and $QQ_{Gk}^{\max}$ is the minimum and maximum reactive power generated. The objective of the proposed system is minimizing the reactive power generator limits; it can be minimize the real power loss of the power system.

The proposed objective function is reliable for the ORPF and the minimization of the power loss of the buses. The fuzzy logic controller is a reliable rules base controller, it is used to determine the real power loss for the corresponding reactive power limit.

C. Fuzzy Logic Controller Used To Determine the Reactive Power Generation

The Fuzzy Logic Controller is the flexible technique to adapt all the problems. In this FLC the control strategy is represented by a set of rules and it is no need to accurate set of equations to represent the system. The FLC consists of three process, i.e., fuzzification, interference engine and defuzzification. Depending on the complication of the system different defuzzification techniques have been initiated [18].

Table.1. Voltage Profile and the Reactive Power Limit

Generator or bus	Generators real and reactive power generation limits in (MW)				Best DG real and reactive power limits		Voltage
	$P_{\min}$	$P_{\max}$	$Q_{\min}$	$Q_{\max}$	P_{best}	Q_{best}	pu
1	30	40	0	0	32.27	0	1.06
2	0	232	-40	50	212.56	4.38	1.045
3	0	131	0	40	81.69	21.98	1.00
5	0	10	0	0	6.14	0	1.00
9	0	41	0	0	37.48	0	0.995

The schematic diagram of the proposed FLC is shown in figure 1.

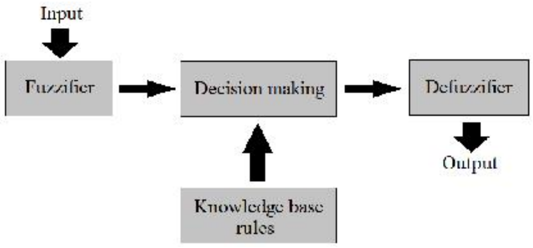

Figure.1. Structure of the proposed FLC

In this proposed system, the real power is the physical input of the fuzzy logic and the rules are generated depending on the real power input. The fuzzy rules has been generated by the three categories i.e., low, medium and high. These rules are used to assign the generator reactive power generation. In this generation limit is given to the optimization algorithm, it can be provide the minimized power loss of the system.

III. RESULTS AND DISCUSSION

The IEEE 14 bus system is generator reactive power limits, voltage stability and power loss are analyzed in the MATLAB platform. The IEEE 14 bus system has 5 generator bus, 8 load bus and 20 transmission lines. The generator reactive power limit is determined by the FLC depending on the expert knowledge rules base. It is optimization algorithm, which determines the minimized power loss of the bus system and corresponding reactive power limits of the generators. The proposed IEEE 14 system structure is shown in figure 2.

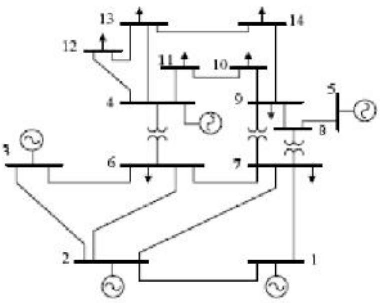

Figure.2. IEEE 14 Bus System Structure

The Figure 2 shows the proposed IEEE 14 bus tested system structure, which consists of 5 generator bus, 8 load bus and 20 transmission lines. Table 1 illustrates the best real and reactive power generation limits of the five generator bus, i.e., *1, 2, 3, 5 and 9 respectively* of IEEE 14 bus system. The voltage stability of the five generator bus is *1.0600, 1.0450, 1.00, 1.00 and 0.995 (all values are in pu) respectively*. The Normal loss of the proposed IEEE 14 bus system is *19.4366 MW* and it could be reduced at 7.81*MW*. It also has the generator real power minimum and maximum operating limits. Figure 3 illustrates the proposed system voltage stability at every bus, which would be represents IEEE 14 bus system voltage variation. In this proposed IEEE 14 bus system 1 to 14 buses are maintained at various voltage levels, which is on stable condition. The standard voltage stability limit of the power system is lies between *1.00 to 1.10 pu*. The figure 4 shows the power loss variation of the proposed system, i.e., IEEE 14 bus system. The power loss is varies with the increasing number of iterations. At the first iteration the power loss is *19.4366 MW,* which is assign to the normal power loss of the system. The iteration range has been increased into the 50 of the proposed technique; the power loss could be reduced at 7.81*MW*. The above discussion shows proposed system perfectly maintains the voltage profile of the bus and the power loss.

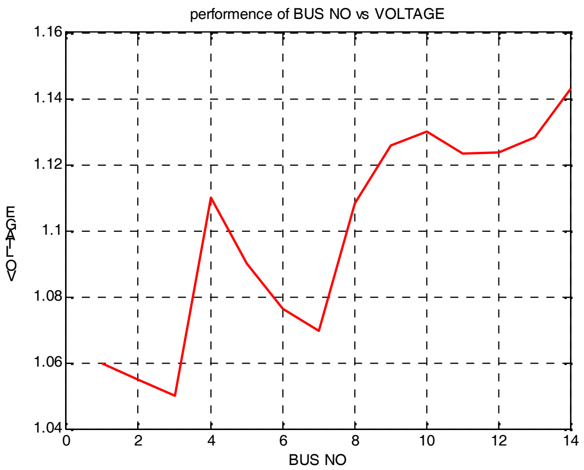

Figure.3. Voltage Variation of The Proposed System

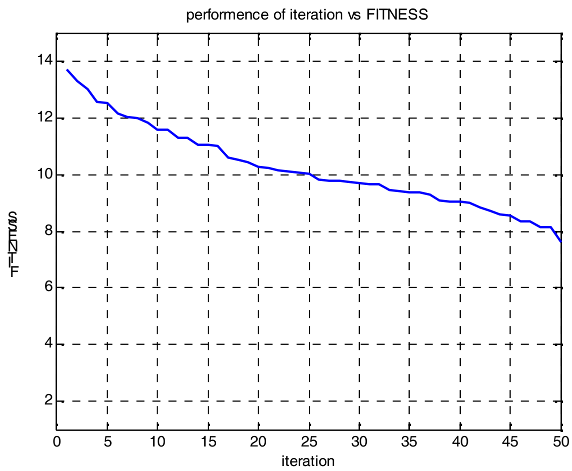

Figure.4. Power Loss Variation of The Proposed System

IV. CONCLUSION

Fuzzy Logic Technique for Real power loss minimization for the corresponding Reactive Power limit has been proposed by us in this paper. The planned method has been applied in the MATLAB platform. The quantity of generator's reactive power that could be operated was generally considered as the generator's actual reactive power output, or the reactive power output away from assured mandatory operational ranges in power markets. Because the reactive power beyond the operating range which maximized the charge for reactive power as well as desire to active energy limitation, in effect, raising the fare for electrical energy. The real power loss minimization problem was conquered by the planned method. In the planned incorporated method will be united with fuzzy logic technique. One of the knowledge base intelligence techniques was the fuzzy logic which would be utilized for verifying the generator reactive power operating limits. The planned examined IEEE 14 bus system best true and reactive power generation limits, voltage stability, power loss would be evaluated. The examined results confirmed that the planned technique consist of the improved presentation which is practiced over other techniques.

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