Fuzzy Based Loss Reduction in Distribution System Using Capacitor Allocation

Mayuri P.Dhake [1], Navita G.Pandey[2]

[1] *M.E.Student, Department of Electrical Engineering, A.C.Patil college of Engineering, Maharashtra, India*
[2] *Assistant Professor, Department of Electrical Engineering, A.C.Patil college of Engineering, Maharashtra, India*

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Abstract–Distribution system is most essential part of power system. Among these systems radial distribution system is popular because of low cost and simple design. In past decade or so, with the advances in communication and data processing technology, electric utility companies have become very interested in distribution system automation. In radial distribution system voltage at buses reduces and loss increases as moved away from substation. This happened because of insufficient reactive power. Hence reactive power is provided by shunt capacitor allocation.

This paper proposes for capacitor location and size in radial distribution system to reduce active power loss and to improve the voltage profile of the system using Fuzzy Interference System (FIS).

Key Words: *Radial distribution system, Fuzzy Interference System, Active Power Loss Reduction, Voltage Improvement*

1. INTRODUCTION

Distribution system is very important part of power system. To improve the voltage profile of distribution system, loss reduction of system is required. The system improvement can be achieved by various technique that are system reconfiguration, reactive power compensation and implementation of distributed generator[10].in this reactive power compensation is used. Loss reduction in distribution system can be achieved by placing optimal capacitors at proper locations. Shunt capacitors not only reduce the loss but also improve the voltage profile, power factor and stability of the system

Fuzzy interference system is used for calculating optimal capacitor location and sizing for distribution system and this technique is used to improve the performance of MSEB ,55 bus distribution system.

2.FUZZY INTERFERNCE SYSTEM

Fuzzy logic has two different meanings. In narrow sense, fuzzy logic is a logical system, which is extension of multivalued logic. However in wider sense, fuzzy logic is almost synonymous with the theory of fuzzy sets, a theory which relates to classes of objects with unsharp bound/aries in which membership is matter of degree. Unlike classical Boolean sets allowing only 0 or 1 value, the fuzzy set is a set with a smooth boundaries allowing partial membership. The degree of membership in a set is expressed by a number between 0 and 1,with 0 expressed not entirely in the set,1 indicates entirely in the set and a number in between meaning partial in the set. The fuzzy set can expressed by a function that maps objects in domain of concern to their membership value in the set. This function is called as membership function. The most used membership functions are triangular and trapezoidal function.[11]

The fuzzy interference process is the process of formulating the mapping from a given input to an output using fuzzy logic. The process of fuzzy interference involves all of the pieces that described in Membership Function, Logical Operator and if-then rules.

The fuzzy interference process comprise of five parts:

1. Fuzzification of input variables

In this the number of inputs are decided and determine the degree to which they belong to each of appropriate fuzzy sets via membership functions.

2. Application of fuzzy operator in the antecedent

If the antecedent of rule has more than one part, the fuzzy operator are applied to obtained one number that represents the result of antecedent for that rule. if the inputs to fuzzy operator is two or more membership values then output is single truth value.

3. Implication from the antecedent to the consequent

Before implication weight of each rule is decided, normally weight of rule is 1.a consequent is a fuzzy set represented by membership function. The consequent is reshaped using a function associated with the antecedent. The input to implication process is single number given by the antecedent and the output is fuzzy set. It is applied to each rule.

4. Aggregation of the consequents across the rules

Aggregation is the process by which the fuzzy sets that represent the outputs of each rules are combined into a single fuzzy set. The input of aggregation process is the list of truncated output functions returned by the implication process for each rule. The output is one fuzzy set for each output variable.

5. Defuzzification

The input to defuzzification process is a fuzzy set and the output is a single number.[11]

3. PROCEDURE OF CAPACITOR LOCATION AND SIZING BASED ON FUZZY TECHNIQUE

The distribution feeders of MSEB distribution network is considered. The loss reduction is achieved by testing load and line data. The simulation is done for before and after capacitor placement to achieved loss reduction. The procedure for calculating capacitor locations and sizes are as follows:

1. Read line and load data of each on distribution feeder.
2. Calculate bus voltage and power loss of distribution system.
3. Bus voltage and power loss index are the input of fuzzy interference system for calculating capacitor locations.
4. After finding optimal capacitor location, the bus voltage and load at each bus are the inputs of fuzzy interference system for calculating capacitor sizes for above specified locations the sizes are calculated.
5. After calculating capacitor locations and sizes from simulation the results are obtained for before and after capacitor placement to find loss reduction in distribution system.[10]

3.1 IMPLEMENTATION OF FUZZY INTERFERENCE SYSTEM FOR CAPACITOR LOCATION

A set of multiple antecedent fuzzy rules are established for finding the suitable location of capacitor at particular node. The inputs to the rules are bus voltage at each node and the power loss index and the output is the suitability of capacitor of capacitor placement.The rules are summarised in fuzzy decision matrix as shown in Table11.[7]

The fuzzy variables are described by linguistic terms are described by fuzzy terms that are low, low medium, low normal, medium, normal, high medium, high.[7]the linguistic terms are described by membership function. The membership functions of input and output variables are shown in Figure 1, 2, 3 respectively.

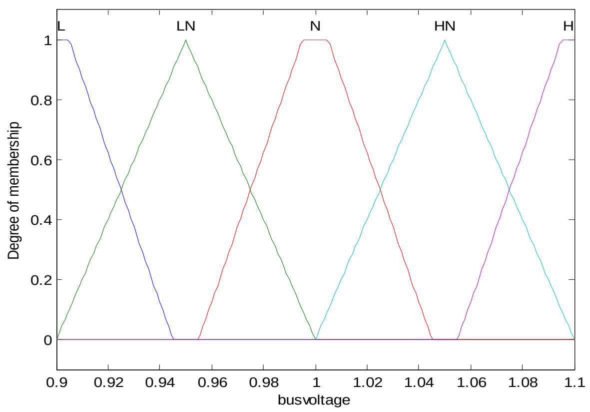

Fig -1: Membership Function for Bus Voltage

Table -1: Fuzzy Decision Matrix For Capacitor Location

AND		Bus Voltage				
		L	**LN**	**N**	**HN**	**H**
Power Loss Index	**L**	LM	LM	L	L	L
	LM	M	LM	LM	L	L
	M	HM	M	LM	L	L
	HM	HM	HM	M	LM	L
	H	H	HM	M	LM	LM

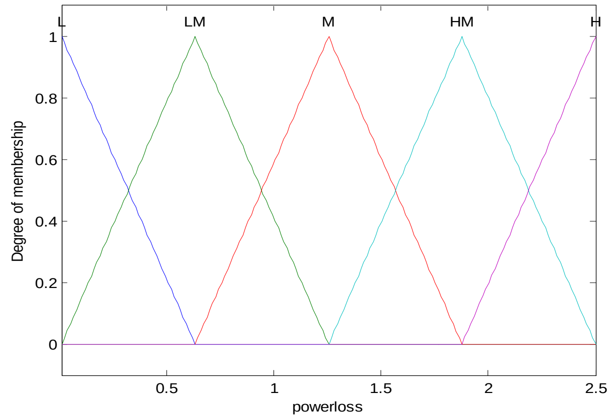

Fig -2: Membership Function for Power Loss Index

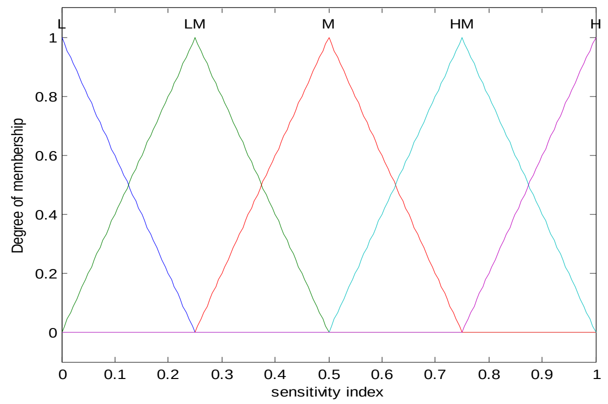

Fig -3: Membership Function for Capacitor Suitability Index

The output of fuzzy interference system is as follow:

Table 2-: Bus Voltage, Power Loss Index at Each Bus and Capacitor Suitability Index

Bus no.	VI (p.u)	PLI(p.u)	CSI(p.u)
1	0.9887	3.7416	0.5
2	0.9842	1.5028	0.4523
3	0.9819	0.2802	0.2084
4	0.9814	0.0503	0.196
5	0.9737	0.7604	0.3231
6	0.9701	0.2665	0.2306
7	0.9606	0.6794	0.2767
8	0.9805	0.7292	0.304
9	0.9796	0.1664	0.2025

10	0.9788	0.1323	0.2052
11	0.9725	0.9586	0.3798
12	0.9683	0.5452	0.2465
13	0.9668	0.1703	0.238
14	0.9653	0.1469	0.2405
15	0.964	0.1253	0.2426
16	0.9628	0.0783	0.2443
17	0.962	0.0459	0.2453
18	0.9618	0.007	0.2455
19	0.9615	0.0069	0.2459
20	0.9613	0.0037	0.2461
21	0.9613	0.0007	0.2461
22	0.9613	0.0001	0.2461
23	0.9986	0.1062	0.1462
24	0.9967	0.1652	0.1727
25	0.9933	0.2984	0.2127
26	0.993	0.0216	0.1393
27	0.9919	0.0679	0.1467
28	0.9917	0.012	0.1473
29	0.9917	0.000	0.1473
30	0.9603	0.0172	0.2471
31	0.9593	0.0593	0.248
32	0.9591	0.006	0.2481
33	0.959	0.0037	0.2482
34	0.9584	0.0151	0.2487
35	0.9583	0.0003	0.2487
36	0.9908	0.0425	0.1527
37	0.9896	0.0428	0.1592
38	0.9894	0.003	0.1603
39	0.9892	0.0015	0.1611
40	0.9952	0.5838	0.2488
41	0.9923	0.2293	0.1947
42	0.9897	0.2001	0.1854
43	0.9881	0.1003	0.1669
44	0.985	0.1932	0.839
45	0.984	0.055	0.1856
46	0.9817	0.1073	0.1949
47	0.9813	0.0104	0.1962
48	0.9812	0.0018	0.1966
49	0.9806	0.0092	0.1988
50	0.9943	0.0358	0.1305
51	0.9927	0.0552	0.1416
52	0.9925	0.0059	0.1428
53	0.9922	0.0047	0.1444
54	0.9921	0.0008	0.1447
55	0.992	0.0011	0.1456

3.2 IMPLEMENTATION OF FUZZY INTERFERENCE SYSTEM FOR CAPACITOR SIZING

In this optimal sizes of capacitor are calculated which are installed at pre-specified location from above capacitor placement result. The buses having higher capacitor suitability index are considered as optimal locations.To find capacitor sizes the inputs to fuzzy interference system are bus voltage and load at each node and the output is size of capacitor. The fuzzy variables are described by fuzzy terms that are down very very small, very very small, very small, small medium ,large, acceptable. The fuzzy variables are described by membership functions. The membership functions are shown in figures 4,5,6.

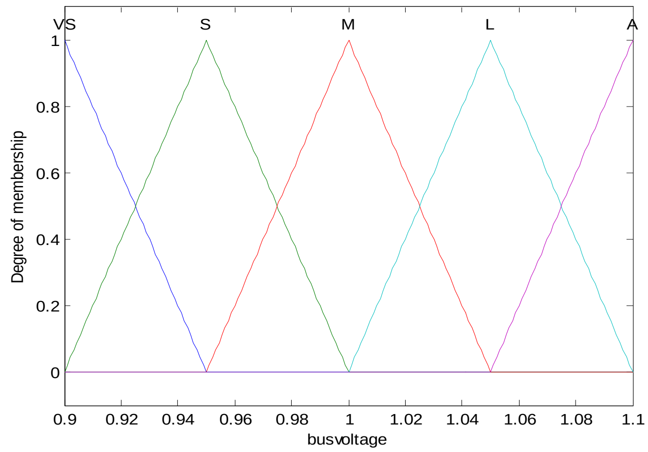

Fig -4: Membership Function For Bus voltage

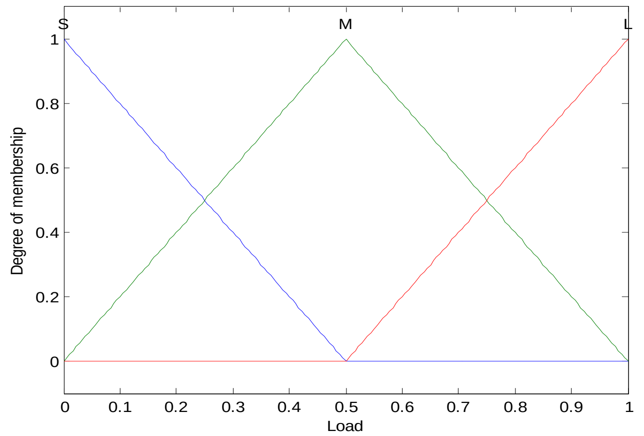

Fig -5: Membership Function For Load At Each Bus

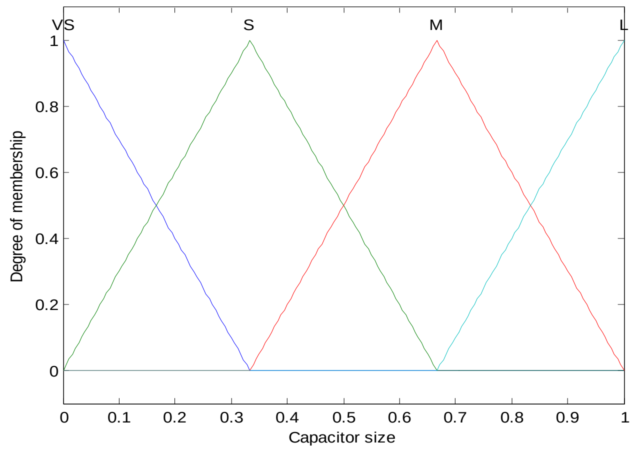

Fig -6: Membership Function For Capacitor Size the rules are summarized in fuzzy decision matrix as shown in Table 3

Table -3: Fuzzy Decision Matrix For Capacitor Size

AND		Load		
		S	**M**	**L**
Bus voltage	**VS**	VVS	VS	S
	S	VS	DVVS	S
	M	VVS	VVS	VVS
	L	DVVS	S	VS
	A	none	none	none

The proposed sizes for optimal capacitor locations that are pre-specified in above results are shown in Table 4

Table -4: Capacitor Size For Calculated Optimal Locations of Capacitor

Bus no.	Bus Voltage(p.u)	Load(p.u)	Capacitor Size(p.u)
1	0.9887	0.0309	0.4210
2	0.9842	0.0130	0.4494
5	0.9737	0.0736	0.5132
8	0.9805	0.0043	0.5020
11	0.9725	0.0043	0.4704

The loss reduction in MSEB distribution system is achieved by calculating the losses before and after capacitor placement. and the results are shown in Table 5.

Table -5: Results of 55 Bus System Before And After Capacitor Placement

Parameters	Without Capacitor	With Capacitor
Minimum Voltage	10.54	10.60
Capacitor Location(Bus)	……..	1,2,5,8,11
Capacitor Size(Kvar)	……..	26455,28242, 31547,29557, 32248
Realpower Loss(KW)	128.44	110.60
Loss Reduction(%)	……..	13.88

4. CONCLUSION

The fuzzy interference system based loss reduction in distribution system has been presented. The optimal locations of capacitor and sizes are obtained from fuzzy interference system. The results are observed for before and after capacitor placement. and loss reduction is achieved.

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