Jurnal Mantik
Volume 4, Number 4, Feb 2021, pp. 2629-2636 E-ISSN 2685-4236
https://iocscience.org/ejournal/index.php/mantik

Fuzzy Logic Application to Reduce Reactive Power on The 20 Kvdistribution Network of East Java APJ South Surabaya

Riswan Wahyudi

Program Studi Teknik Elektro, FakultasSains dan Teknologi Universitas Teknologi Surabaya
Jl. BalongsariPraja V No.1 Tandes Surabaya 60186

e-mail: riswan.pohan.rp@gmail.com

A R T I C L E I N F O

Article history:
Received: 15/01/2021
Revised: 30/01/2021
Accepted: 15/02/2021

Keywords: *20 KV Distribution System, Fuzzy Logic, Capacitor on Bus System.*

A B S T R A C T

The voltage used on the distribution channel uses a 20 kV medium voltage which is controlled through a substation in the area. With the normal and reliable operation of the system which can maintain the continuity of the distribution of electrical energy is the hope of consumers as stakeholders of PT. PLN (Persero)DistribusiJawa Timur, Area Pelayanan Jaringan(APJ) Surabaya Selatan. The decline in the quality of electric power is a separate problem for the electricity provider and the customer side due to the complexity of the installed load. Technically, inductive loads with lagging power factor will absorb reactive power (var) on the load buses. To anticipate this, it is necessary to compensate for reactive power by using capacitor banks for various reasons including regulating power flow, improving system stability, correcting power factors, adjusting the voltage display and minimizing power losses. From the results of the power flow simulation (load flow) will be obtained the quantities of voltage and power losses which are input as a membership function required by the fuzzy logic method (fuzzy logic), the resulting output is the determination of the capacitor quantity based on the order of each loading bus on the distribution network.

1. Introduction

The need for electrical energy use is increasing rapidly for the present and in the future, this is due to, among other things, industrial development and also population development. To overcome this, a continuous and comprehensive analysis is required in the planning, design and operation of the power distribution system with optimum utilization of the form of energy consumed by consumers through an effective load distribution system based on demand factors, load factors. and load diversity (diversity factor) with various types of loads [1].

The decline in the quality of electric power at a voltage of 20 kV in the distribution system is a separate problem for the provider of electrical energy and the customer side due to the complexity of the installed load. Technically, inductive loads with a lagging power factor will absorb reactive power (var) on the load buses. To anticipate this, it is necessary to compensate for reactive power using capacitor banks for various reasons, including regulating power flow, improving system stability, power factor correction, adjusting voltage display and minimizing power losses [4].

The distribution network system regulation problems faced are very diverse and complex due to additional burdens both present and future. Many analyzes from experts discuss the distribution system, especially those related to load flow studies with several methods, including using the Newton-Rapshon method [2], to get the effect of the loading effect of a distribution system. related to the stress profile and its effect on network losses [3].

Regulating the voltage and reactive power [4] which is of course to improve system performance with appropriate capacitor placement techniques [5] is needed to compensate for network losses associated with the expected voltage profile [6]. Regulatory systems research methods are carried out as case studies to determine their effectiveness to obtain more accurate results on differences in previous, current or future research.

The method of fuzzy logic (fuzzy logic) [7] is part of the artificial intelligence (AI) computation method which is very helpful to make it easier to make decisions from complex solutions, especially for non-linear systems [8]. With simulation programs [9] Matlab (Matrix Laboratory) and Etap (Electrical Transient

Accredited "Rank 4"(Sinta 4), DIKTI, No. 36/E/KPT/2019, December 13th 2019.

Analyzer Program) [11] which help a lot to analyze various system modeling problems related to the application of fuzzy methods for controlling efficiency and better in terms of getting a the same or near optimal completion.

2. Research Methodology

In general, the research method uses fuzzy logic reasoning (Fig. 1) which can be divided into 3 reasoning steps, namely; fuzzy input, fuzzy output and defuzzification, can be explained as follows;

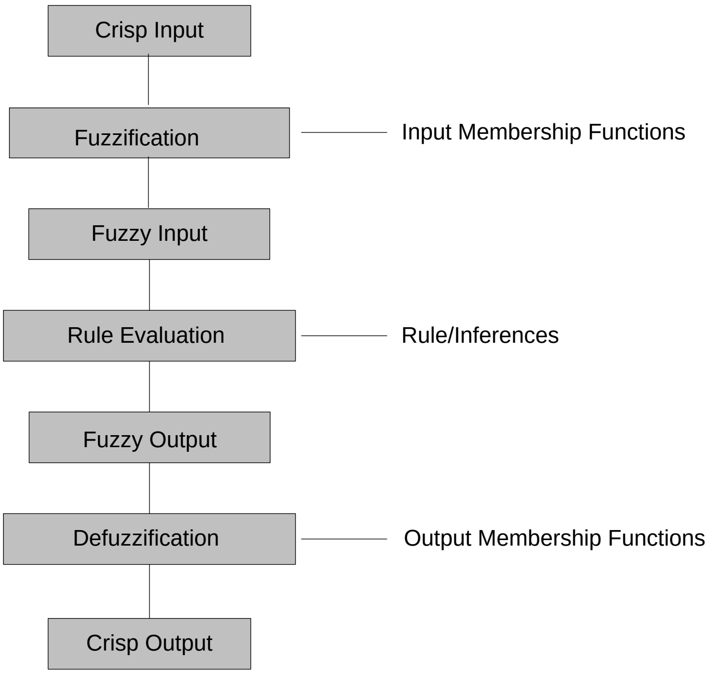


Fig. 1. Fuzzy system operation process

2.1. Fuzzy Input

The crisp (exact) set values for the application consist of voltage (V), power losses (P) and capacitor placement (S) according to the scale as shown in Fig. 2.

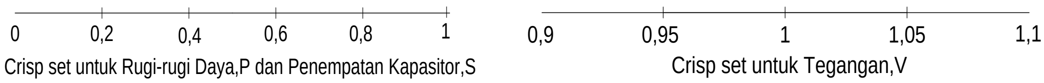
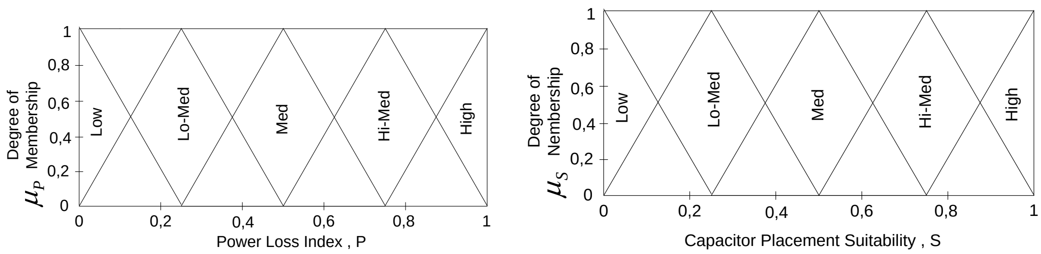


Fig. 2. P, S and V scales

For fuzzy variables power loss index, P (power loss index) and capacitor placement suitability, namely Low-Medium (Med), Medium, High-Medium, High, with a triangular curve shape as shown in Figure. 3.



Accredited "Rank 4"(Sinta 4), DIKTI, No. 36/E/KPT/2019, December 13th 2019.

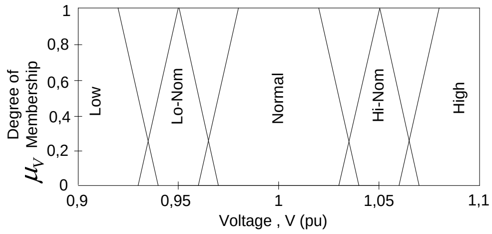


Fig. 3. Membership function
(a) Power Loss Index (b) Voltage (c) Capacitor Placement Suitability

2.2. Fuzzy Output

By evaluating fuzzy rules (rule evaluation) which is determined by the term IF premeise (antecendent), THEN conclusion (consecquent). To determine the capacitor placement on the loading buses, a fuzzy set multiplication rule is constructed in Table-1 (matrix image) showing the consequent rules.

Tabel 1.
Decision Matrix For Determining Suitable Capacitor Locations

Power Loss Index \ Voltage	Low	Low - Normal	Normal	High - Normal	High
Low	Low-Med	Low-Med	Low	Low	Low
Low - Med	Med	Low-Med	Low-Med	Low	Low
Med	High-Med	Med	Low-Med	Low	Low
High - Med	High-Med	High-Med	Med	Low-Med	Low
High	High	High-Med	Med	Low-Med	Low-Med

2.3. Defuzzification

In the defuzzification stage, a value of a solution variable will be selected which is a consequence of the fuzzy area. The method often used is the centeroid method. The reason for using this method is because it is the most consistent and has a sensitive fuzzy total area height and width.

Based on Table-1, there are two rules as follows;

a. if power loss index in high-medium AND voltage is low-normal then suitability is high-medium.
b. if power loss index is medium AND voltage is low-normal then suitability is medium

The inference process in rule one is shown in Fig. 3 (a) and inference to rule two in Fig. 3 (b). Aggregation for the output of the two rules uses the Mamdani max-prod inference inference technique.

For example, a node in a distribution system has a Power loss index of 0.7 and Voltage per unit of 0.96, then the capacitor placement suitability S is obtained according to Fig. 4.

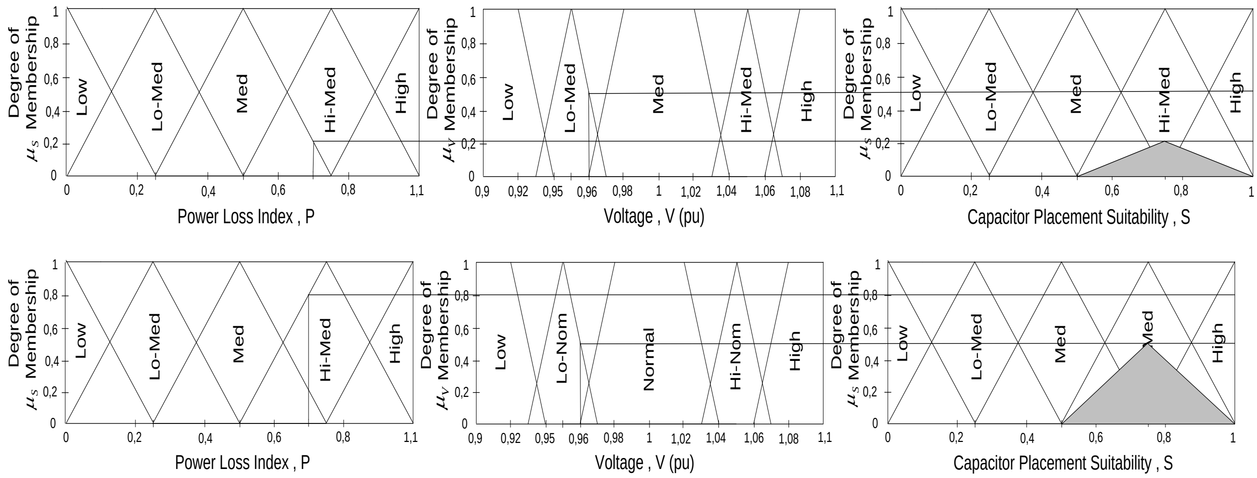


Fig. 4. (a) Inference from rule 1 (b) Inference from rule 2

The membership function relationship is shown by merging together the two consequent membership functions.

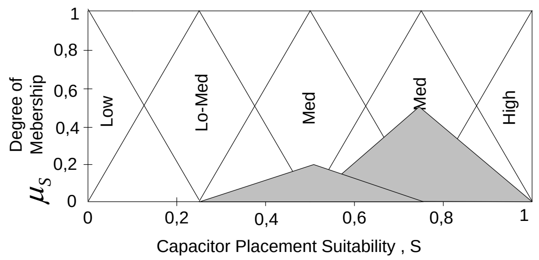


Fig. 5. Aggregated membership function and defuzzification prices

The framework or framework for resolving the optimal allocation of capacitors is carried out based on Fig. 6. To get the power losses at each load node or bus is done using a power flow program (Newton-Raphson).

Power losses indicate the voltage drop at each load node, which is an input to the fuzzy system for determining the appropriate capacitor placement based on the order (ranking) of fuzzy inference, using a simulation program. To determine the kVar size of the capacitor, with a marginal voltage limit (voltage marginal limit 98%) at each load node or bus.

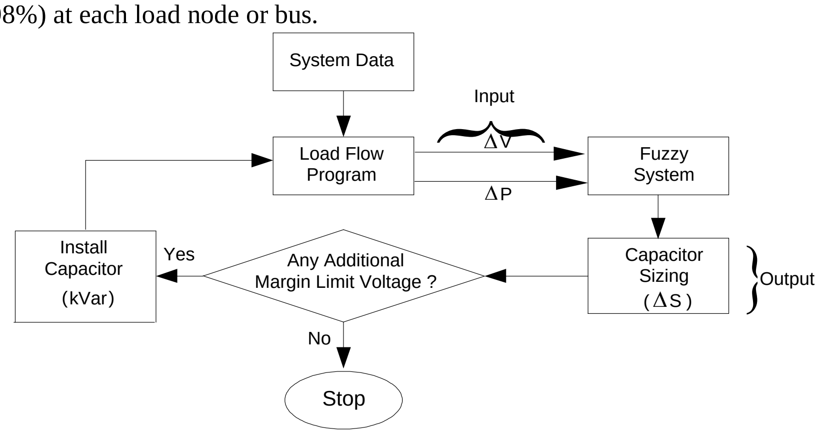


Fig 6. Framework of Fuzzy system

Accredited "Rank 4"(Sinta 4), DIKTI, No. 36/E/KPT/2019, December 13th 2019.

3. Results and Discussion

This research data application using data and diagrams of one line distribution channel of PT. PLN (Persero) East Java Business Unit-Surabaya Distribution Regulatory Unit GI. Rungkut (Fig. 6).

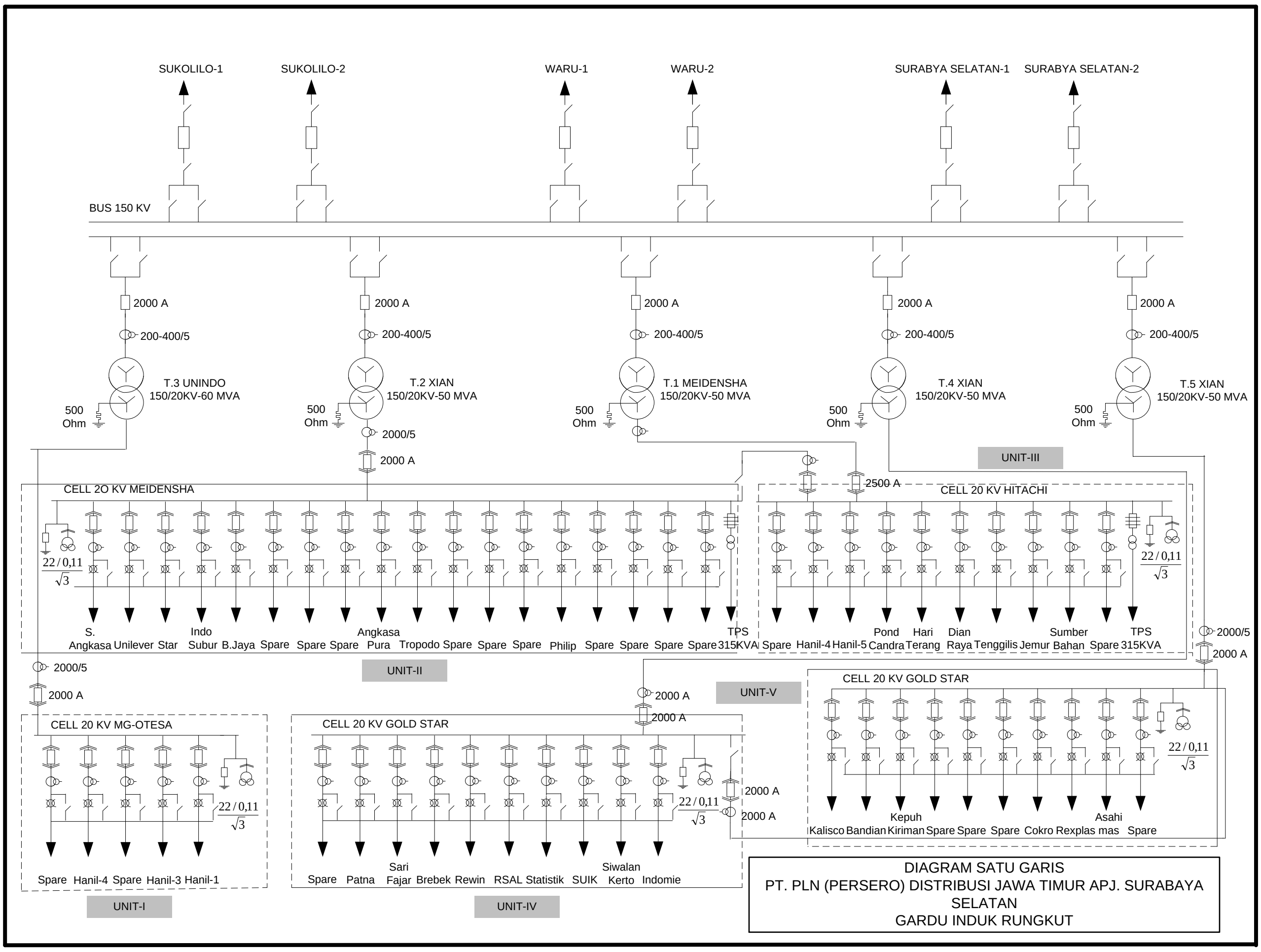


Fig. 7. One line diagram for the GI-Rungkut Distribution System

The 20 kV inline diagram of the distribution system consists of 52 buses distributed based on 5-unit load sharing or grouping, namely Unit-I to Unit-5.

3.1 System Loading Data

Loading data is done with a power factor of 1 () for each loading on each bus as shown in each table.

Table.2

Loading Data System Unit-I

NO	SUBSTATION TRAFO-3 - 3-PHASE RANGKUT SUPPORT	CIRCUIT LENGTH (KMS)	LOAD (A)	INFORMATION
1	HANIL-1	1,174	221	GOOD
2	HANIL-2	1,132	221	GOOD
3	HANIL-3	1,32	221	GOOD
4	SPARE-1	1,132	-	GOOD
5	SPARE-2	1,32	-	BROKEN

Table 3

Unit-II Loading Data

NO	SUBSTATION TRAFO-2 - 3-PHASE RANGKUT SUPPORT	CIRCUIT LENGTH (KMS)	LOAD (A)	INFORMATION
1	SINAR ANGKASA	3,538	60	GOOD
2	UNILEVER	3,873	270	GOOD
3	SIER	4,456	110	GOOD
4	INDO SUBUR	4,783	42	GOOD
5	BAMBANG JAYA	2,4121	32	BROKEN

NO	SUBSTATION TRAFO-2 - 3-PHASE RANGKUT SUPPORT	CIRCUIT LENGTH (KMS)	LOAD (A)	INFORMATION
6	SPARE	-	-	GOOD
7	SPARE	-	-	GOOD
8	SPARE	-	-	GOOD
9	ANGKASA PURA	8,874	80	GOOD
10	TROPODO	1,423	169	GOOD
11	SPARE	-	-	GOOD
12	SPARE	-	-	GOOD
13	SPARE	-	-	GOOD
14	PHILIP	4,925	108	GOOD
15	SPARE	-	-	GOOD
16	SPARE	-	-	GOOD
17	SPARE	-	-	GOOD
18	TPS	3,159	0,01575	GOOD

Table.4
System Unit-III Loading Data

NO	SUBSTATION TRAFO-1 - 3-PHASE RANGKUT SUPPORT	CIRCUIT LENGTH (KMS)	LOAD (A)	INFORMATION
1	SPARE	-	-	GOOD
2	HANIL-4	1,098	74	GOOD
3	HANIL-5	1,122	74	GOOD
4	PONDOK CANDRA	17,039	138	GOOD
5	HARI TERANG	9,033	240	BROKEN
6	DIAN RAYA	4,556	72	GOOD
7	TENGGILIS	16,179	127	GOOD
8	JEMUR SARI	4,958	49	GOOD
9	SUMBER BAHARI	2,918	39	GOOD
10	SPARE	-	-	GOOD
14	PHILIP	-	-	GOOD
15	SPARE	-	-	GOOD
16	TPS	3,159	0,01575	GOOD

3.2 Process Result Simulation

From all existing processes, the form of voltage changes and power losses will be shown as shown in Graph-1 and Graph-2 below;

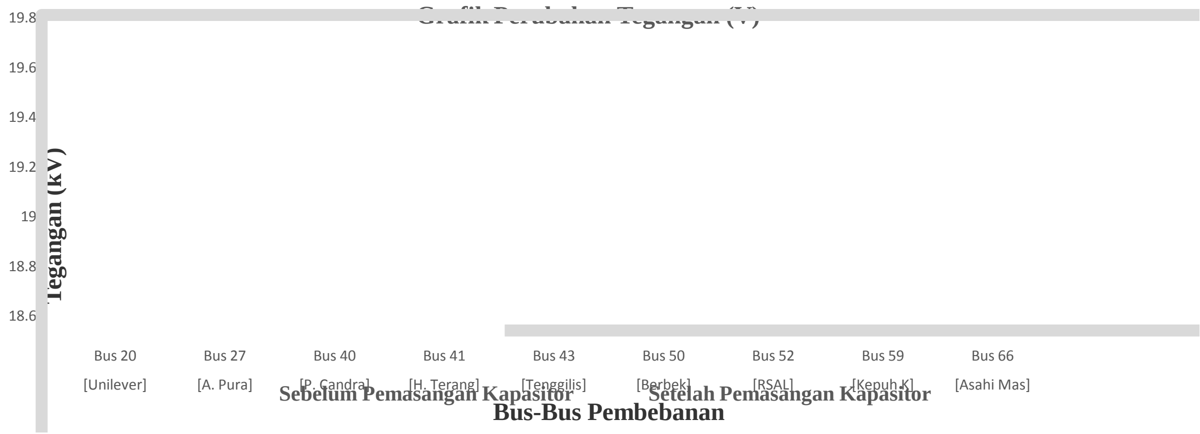


Fig. 8. Graph of Change in Voltage (V)

Accredited "Rank 4"(Sinta 4), DIKTI, No. 36/E/KPT/2019, December 13th 2019.

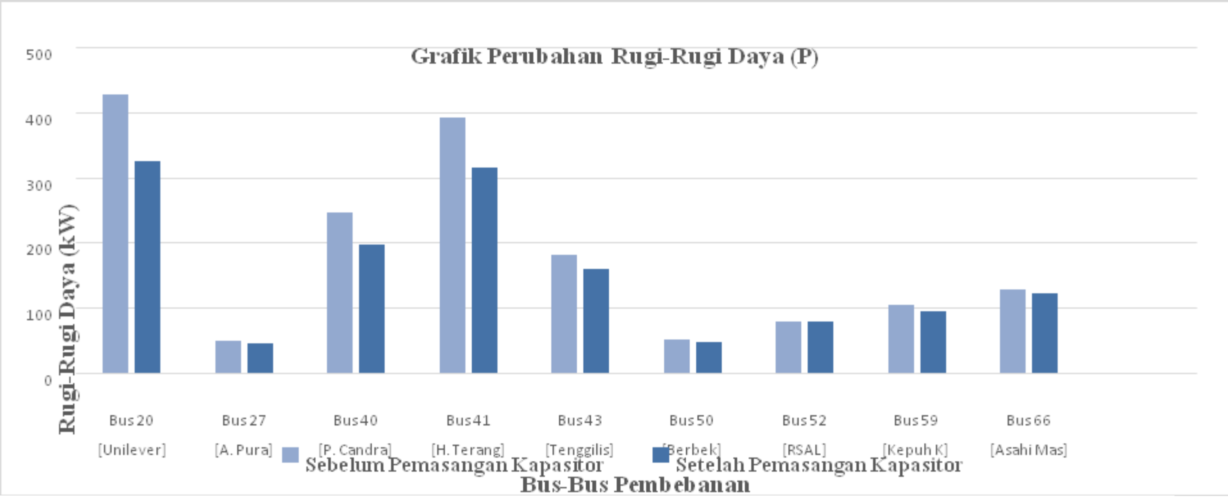


Fig. 9. Graph of Change in Power Losses (P)

4. Conclusion

Capacitive or inductive reactive loads will greatly affect the stability of the distribution system, especially those related to the stress profile on the load, this effect will be felt in conditions of voltage drop and a large number of kVar or vice versa.

To overcome the changes with the lagging power factor, it is necessary to place a capacitor to get the best power factor, although there are indications of overcompensation (leading) this can be overcome by using a reactor as a counterweight.

The Fuzzy logic method as an applied method makes it very easy to determine the position of the capacitor based on the ranking results or the order of the loading buses with optimal results, this means that with the results of the defuzzification process with the largest value, the capacitor placement is done first, this is done because it is related to the amount of kVar to be applied.

To install capacitors on the load side with a larger amount of loading will result in a larger number of kVar

5. References

[1] Chi Kwan Lee, Kai Lok Cheng, and Wai Man Ng,“Load Characterisation of Electric Spring”, Published in: IEEE Energy Conversion Congress and Exposition, 2013.

[2] Mohammad Ghiasi, “A Detailed Study for Load Flow Analysis in Distributed Power System”, International Journal of Industrial Electronics, Control and Optimization .Vol. 1, No. 2, pp. 153-161, June 2018.

[3] Deepinder Kaur Mander, and GS Virdi, “Result Analysis on Load Flow by UsingNewton Raphson Method”, International Journal of AdvancedResearch in Electrical,Electronics and Instrumentation Engineering,Vol. 6, Issue 7, July 2017.

[4] L.Ramesh, S.P.Chowdhury, S.Chowdhury, A.A.Natarajan, and C.T.Gaunt, “Minimization of Power Loss in DistributionNetworks by Different Techniques”, International Journal of Electrical Power and Energy Systems Engineering 2:1 2009.

[5] Goryunov, V., Girshin, S., Kuznetsov, E., Bigun, A., Petrova, E. and Lyashkov, A,“Optimal Sizing of Capacitor Banks to Reduce Power Losses”. Proceedings of the 6th International Conference on Smart Cities and Green ICT Systems (SMARTGREENS 2017), pages 174-179, 2017.

[6] D.Amaranatha, R. Madhan Mohan, and Dr.M.Padma Lalitha,“Power Loss Reduction in Radial DistributionSystems by Optimal Capacitor Placement toDistribution Transformers”, International Journal of Engineering and Applied Sciences (IJEAS), Volume-2, Issue-11, November 2015.

[7] Jan Jantzen, “Design Of Fuzzy Controllers”, Technical University of Denmark, Department of Automation, Bldg 326,DK-2800 Lyngby, DENMARK., 15 May 1998.

[8] Yan Xu, Zhao Yang Dong,Kit Po Wong, Evan Liu,and Benjamin Yue,“Optimal Capacitor Placement to DistributionTransformers for Power Loss Reduction in RadialDistribution Systems”, IEEE Transactions On Power Systems, 2013.

[9] Adel Ali Abou El-Ela, Ragab A. El-Sehiemy, Abdel-Mohsen Kinawy, and Mohamed Taha Mouwafi, “Optimal capacitor placement in distributionsystems for power loss reduction and voltageprofile improvement”, IET Generation, Transmission & Distribution, 2015.

[10] Shane, Phoo Ngone Si, and Su Su Win, "Fuzzy Algorithm for Capacitor Allocationand Sizing in Radial Distribution system toReduce Losses", International Journal of Science, Engineering and Technology Research (IJSETR), Volume 3, Issue 12, December 2014.
[11] Syairozi, M. I., & Fattah, A. (2018). "Youth Creative Enterpreneur Empowerment (Youtivee)": Solusi Bagi Kaum Muda Untuk Berkonstribusi Pada Perekonomian Dan Mengurangi PengangguraN. *Jesya (Jurnal Ekonomi dan Ekonomi Syariah)*, *1*(2), 43-55.
[12] J. Arockiya Xavier Prabhu, Sudhanshu Sharma, M.Nataraj, and Divya Prakash Tripathi, "Design of Electrical System Based On Load Flow
Analysis Using ETAP For IEC Projects", Electrical DepartmentFluor Daniel India LTDNew Delhi, India, 2016.
[13] Luis Alejandro Rojas1 , Oscar Danilo Montoya2(B), and Javier Campillo, "Analysis of Power Lossesin Electric Distribution SystemUsing a MATLAB-BasedGraphical User Interface (GUI)", October 2019.
[14] H. N. Ng, Student, M. M. A. Salama, and A. Y. Chikhani, "Capacitor Allocation by Approximate Reasoning:Fuzzy Capacitor Placement, 2000.
[15] H. N. Ng, M. M. A. Salama, and A. Y. Chikhani, "Classification of Capacitor Allocation Techniques", 2000.
[16] Rohit Kapahi, "Load Flow Analysis of 132 kV substation usingETAP Software", International Journal of Scientific & Engineering Research Volume 4, Issue 2, February-2013.
[17] Kiran Natkar1, Naveen Kumar, "Design Analysis of 220/132 KV Substation Using ETAP", International Research Journal of Engineering and Technology (IRJET), Volume: 02 Issue: 03 | June-2015.