2023 IEEE PES 15th Asia-Pacific Power and Energy Engineering Conference (APPEEC) | 979-8-3503-1809-8/23/$31.00 ©2023 IEEE | DOI: 10.1109/APPEEC57400.2023.10561930

The Planning of Distribution System Efficiency Improvement By Selective Capacitor Size and Position Technique

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Abstract — This research presents planning to improve efficiency in distribution system by configuration voltage drop in distribution system simulation model. This simulation model installs with capacitors which has objective is to improve efficiency in 15 buses distribution system model. In order to configure voltage distribution system simulation model, the researcher analyzes with MATLAB Simulink program. There are three study cases of simulation models. The result of mathematic models found out that when capacitor is installed in distribution system can configure the voltage drop back to normal voltage.

Keywords— voltage drop, capacitors, analyzes

I. INTRODUCTION

At the present distribution system in bus far from electric generator, which makes voltage drop frequently. Purpose to improve voltage and power factor, It needs to install capacitor to compensate voltage drop in distribution bus in the end of the bus as shown in Figure 1. In year 1999, there was a study case power factor controller device for distribution system and electric circuit industry include switch breaker compact design capacitor bank install with low-cost component inspector and smart controller unit [1]. In year 2003 there was a study case of voltage quality. If there are more load in distribution, the higher power losses. So, researcher installs capacitor to decrease power loss. This article applies to use capacitor which is suitable in distribution system can improve voltage in distribution [2]. In year 2019, there were planning about voltage improvement in distribution test unit 69 bus. The test found out that it is able to increase voltage in distribution system [3].

So this article studies selective capacitor size technique and position to be install for voltage improvement in distribution system 15 bus which tests by MATLAB/Simulink program by three cases.

II. VOLTAGE DROPS

Voltage defines as the force that pushes electric or voltage between two points. In static electric field, the force become when between two ends of electric wire is different. Electric generator has more electric power than electric device and electric energy runs from higher to lower energy point and stop when electric power is equivalent. Voltage volume defines as volt and can measure voltage value between two points by voltage meter [4]–[5]. Voltage drops is shown Figure 1.

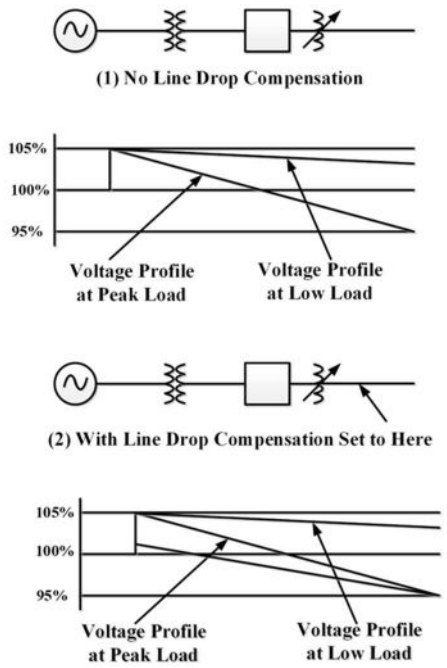

Fig. 1. Voltage drops

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Voltage controlling optimization is when impedance in electric higher or know as weak system. This system characteristic when the more load in the system make the voltage more drop and when to compensate the drop down voltage and become over voltage when the less load in the system. This problem can improve with impedance value or voltage drop impedance compensation [6]. These methods suitable for voltage level improvement. First, installs parallel capacitors to make the current lower and current angle closer to voltage angle. Second increases the voltage regulator level to increase the voltage volume. Third, increases the volume of electric supplier wire to make the impedance lower. Fourth increase the supply volume of transformer at electric supplier to make impedance lower. Fifth installs VAR compensation device. Sixth installs capacitor in serial from that nullify the inductive in the system [7].

III. CAPACITOR TYPES

Capacitor is an electronic devices which collect electric energy in electric field form which generate between to insulator that has equivalent capacity. It supplies reactive electric current which leads the voltage to compensate electric current in general circuits which is the lagging current from voltage. It makes of two thin metal which places cascade and has dielectric in the middle between those metal and form in cylinder insulator electric. It supplies electric reactive power which electric current leads to voltage nullifies some component that current phase slower that voltage from inductive load [8].

Capacitor install in electric system are various types and capacitor that install to nullify the electric power loss. There are two types of capacitors that can suitable in use, one a capacitor is fixed value capacitor and the other one is variable capacitor. There are characteristic in 2 types of capacitor description as follow [9].

Fixed capacitor which is capacitor that always supplies reactive electric power all the time and unable to control the supplies of reactive electric power that optimizes a little alternative load change and never changes reactive electric power volume [10]. So the circuit needs to calculate, design and select capacitors for installation to prevent over voltage when during circuit has a few load that can make electric device has dysfunction [11]. Fixed capacitor is shown Figure 2 and installation fixed capacitor is shown Figure 3.

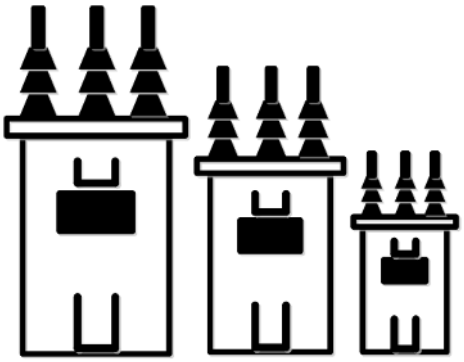

Fig. 2. Fixed capacitor

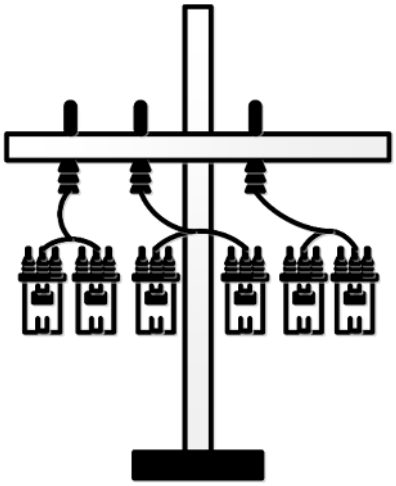

Fig. 3. Installation of fixed capacitor

Variable capacitor responses to variable power factor that synchronize depend on volume of load in some period of the time which better than fixed capacitor. Due to when install capacitor in circuit with automatic controller depend on volume of load in some period of the time. When variable capacitor type has installed on the circuit the volume of reactive electric power is variable. The controlling reactive electric power supply that has many methods divide the controlling to 5 methods which are electric current controlling, power factor controlling on time, self-automatic open/closed switch on time controlling by specify timing, reactive electric power controlling and voltage controlling[12]. So when considerate to choose variable capacitor to install in use need to calculate on when the lowest load in use. because it cause over voltage at installation point. Variable capacitor is shown Figure 4 and installation of variable capacitor is shown Figure 5.

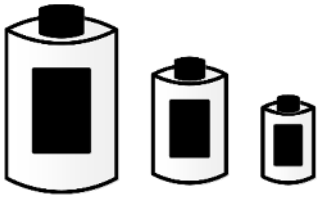

Fig. 4. Variable capacitor

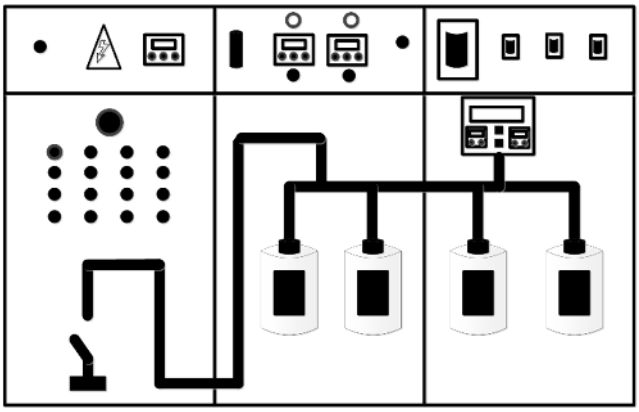

Fig. 5. Installation of variable capacitor

IV. CASE STUDY

There are many solution to improve voltage drop such as, installs parallel capacitors to make the current lower and current angle closer to voltage angle, increases the voltage regulator level to increase the voltage volume, increases the volume of electric supplier wire to make the impedance lower, increase the supply volume of transformer at electric supplier to make impedance lower, installs VAR compensation device and installs capacitor in serial from that nullify the inductive in the system. In this article choose installation of capacitor in electric power system because it is able to improve two problems which are decrease electric current and make electric current angle closer to voltage angle and capacitor also supplies electric reactive power too. Both methods are able to improve voltage drop in this article choose in this topic. The planning of electric distribution system efficiency improvement by selective capacitor size technique test in mathematical model simulator by MATLAB/Simulink program which tests in electric distributor 15 bus. Line data of IEEE 15 bus system shown in table I.

TABLE I. LINE DATA OF IEEE 15 BUS SYSTEM [13]

Branch Number	Send Bus	End Bus	P (kW)	Q (kVAR)
1	1	2	44.10	44.991
2	2	3	70.00	71.414
3	3	4	140.00	142.82
4	4	5	44.10	44.991
5	2	6	140.00	142.82
6	6	7	140.00	142.82
7	6	8	70.00	71.414
8	2	9	70.00	71.414
9	9	10	44.10	44.991
10	3	11	140.0	142.82
11	11	12	70.00	71.414
12	12	13	44.10	44.991
13	4	14	70.00	71.414
14	4	15	140.0	142.82

In this article researches in to three cases study. There are three study cases. The First case does not install capacitor in distribution system(base case).The first case shown in Figure 6.

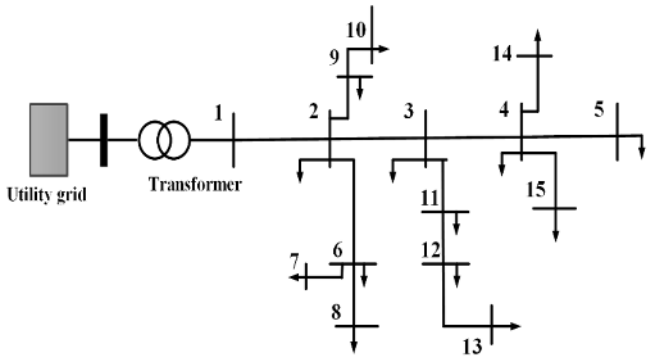

Fig. 6. The first case does not install capacitor.

The second case installs distribution capacitor on bus 3, 5, 8, 10 and 13 in electric distributor and has capacity 250, 200, 150, 100 and 50 kVAR respectively. Which use capacitor descending order by capacity of capacitor the second case shown in Figure 7.

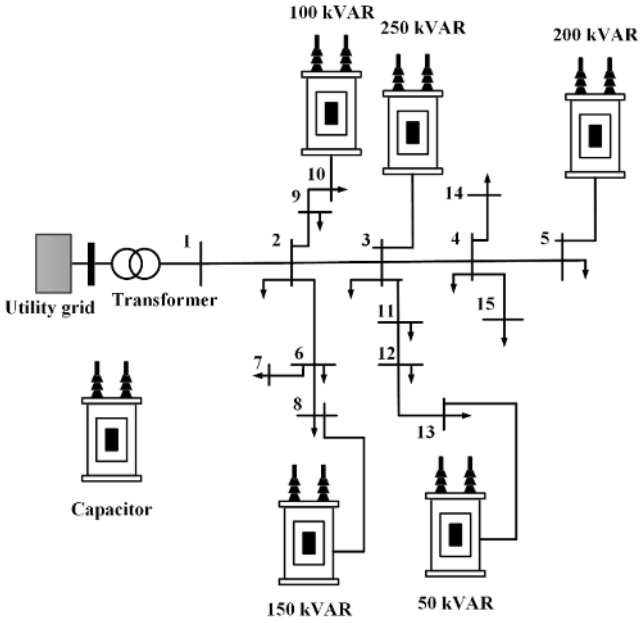

Fig. 7. The second case Installation of capacitor in distribution system.

Third case which installs distribution capacitor 3, 5, 8, 10, and 13 in electric distributor and has capacity 100, 100, 100 and 50 kVAR respectively. Which is the optimum capacity of capacitor. The third case shown in Figure 8.

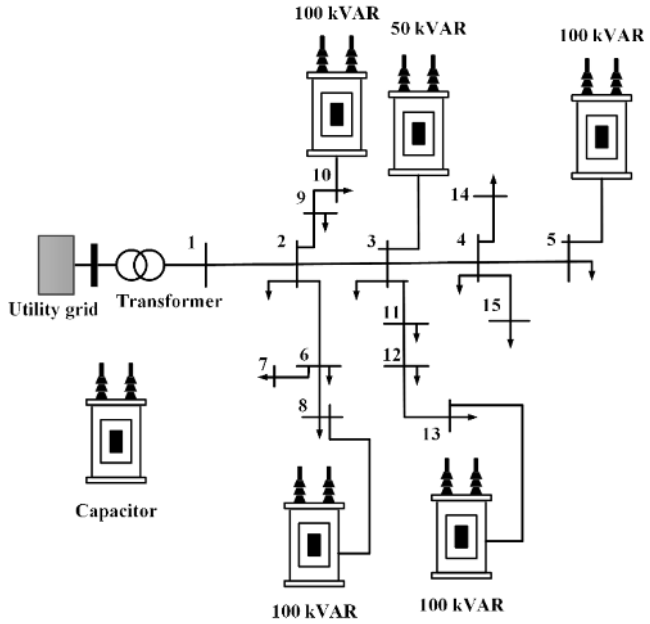

Fig. 8. Third case Installation of capacitor in distribution system.

V. RESULT

The First case does not install capacitor in distributor. The second case installs distribution capacitor on 3, 5, 8, 10 and 13 which has capacity 250, 200, 150, 100 respectively and the Third case installs distribution capacitor on 3, 5, 8, 10 and 13 which has capacity 100, 100, 100, 100 and 50 kVAR respectively. Voltage in 3 case show in table II. Graph shows the comparison of voltage in first case, second case and third case show in Figure 9.

TABLE II. VOLTAGE IN 3 CASE

Bus	Voltage (p.u.)		
	Case 1	Case 2	Case 3
1	1.0000	1.0000	1.0000
2	0.9713	0.9813	0.9766
3	0.9567	0.9725	0.9646
4	0.9509	0.9685	0.9596
5	0.9498	0.9698	0.9597
6	0.9637	0.9757	0.9701
7	0.9588	0.9711	0.9653
8	0.9617	0.9758	0.9695
9	0.9663	0.9786	0.9738
10	0.9655	0.9787	0.9739
11	0.9487	0.9658	0.9574
12	0.9437	0.9623	0.9536
13	0.9421	0.9617	0.9529
14	0.9482	0.966	0.9569
15	0.948	0.9658	0.9567

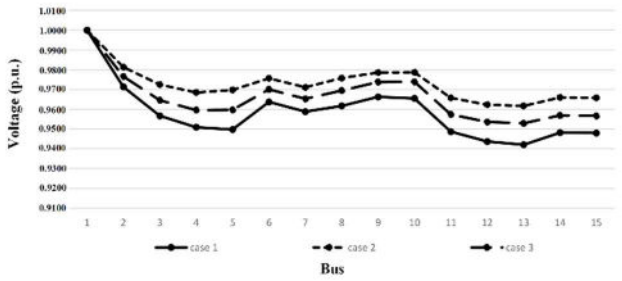

Fig. 9. All of three cases.

VI. CONCLUSION

This article presents the improvement of voltage in distribution system by installation of capacitor. Test with mathematic simulation model which divides in 3 cases. The first case which is normal case has no installation of capacitor. The second case which installs capacitors at 3, 5, 8, 10, 13 bus and size 250, 200, 150, 100, 50 kVAR respectively found that voltage buffer rises to normal voltage in every bus but use descending order capacitor which are over size capacitors. The third case which installs capacitors at 3, 5, 8, 10, 13 bus and size 50, 100, 100, 100, 100 kVAR respectively found that voltage rises to normal voltage in every bus and use capacitors in size enough to buffer voltage back to voltage standard.

ACKNOWLEDGMENT

The authors would like to express his sincere thanks to the Rajamangala University of Technology Phra Nakhon (RMUTP), Thailand for supporting.

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