Review on "Loss Minimization by Optimal Capacitor Placement in Distribution System Using ETAP Software"

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Abstract: **Electrical power system provides an imperative service to the humanity. For well operation of electrical power generation, transmission and distribution, it is important that system should be balanced. Power flow analysis stands out as the organization of power system initial research as well as design. They are really necessary for planning, operation, economic scheduling and interchange of power between utilities. The load flow study in a power system comprises a study of tremendously important implication. The analysis uncovers the electrical performance and power flows (real and reactive) for stipulated conditions whenever the system is functioning under the consistent state. This paper gives an overview of various techniques useful for load flow study under distinctive stipulated conditions The main objectives of this survey are to collect the information from the previous literatures.**

Key Words: **Under voltage overcome, Reactive power compensation. Load flow Analysis, Voltage Sensitive Load, Power Constant.**

I- INTRODUCTION

1.1 Electrical Power System

Electrical power is usually transmitted at high voltage from generating units to primary substations. The voltage is then stepped down at the receiving-end substation to a lower value (say 11kV or 33kV or 66kV). The power from this substation is then transferred to secondary substation. A secondary substation has two or more step down transformers simultaneously with voltage regulating equipment, switchgear and buses. Voltage is then stepped down to 11kVat this substation. The network that connects these secondary substations and consumers is referred to distribution system. This distribution system can be categorized into two parts namely primary and secondary system [1].

A secondary substation may further have its primary and secondary distribution systems as the area under any secondary substation may be large. The primary distribution system has main feeders and laterals. The main feeders run from low voltage buses and are main source of supply for sub-feeders or laterals and direct connected distribution transformers. The lateral extends through the load area with connection to distribution transformers.

The distribution transformers may be located in specifically constructed enclosures or might be pole mounted. Here the voltage is further stepped down to 400V and after that the power is received by the secondary distribution systems. A secondary distribution system consists of distributors that are laid along road sides. The connections to regulars are tapped off from these distributors. The main feeders, distributors and laterals consist of either overhead lines or cables or sometimes both. For distribution generally 3 phase, 4 wire circuits are used, where the neutral wire is mandatory so that power can be supplied single phase loads. Usually major part of consumers (residential or commercial) is fed with single phase power supply.

The consumers receive electric power from the distribution system. A distribution system broadly consists of a receiving substation, sub-transmission lines, distribution substation generally located nearer to the load center, secondary circuits connected to LV side of the distribution transformer and service mains. Service mains are the connections of consumers.

The main difference between a transmission system and distribution system is in the network structure. Transmission system has a loop structure whereas the latter generally, a radial structure [1].

A distribution systems has several service lines, distribution transformers, one or two receiving substations and associated primary or secondary circuitry. Distribution systems are much complicated and have problems like drop in voltage magnitude during peak load time and sudden or gradual rise in voltage during off peak load. Transformer overload is also one of the major problems.

1.2 Stations and Substations

Transmission and distribution stations exist at various scales throughout a power system. In general, they represent an interface between different levels or sections of the power system, with the capability to switch or reconfigure the connections among various transmission and distribution lines. On the largest scale, a transmission substation would be the meeting place for different high-voltage transmission circuits.

At the intermediate scale, a large distribution station would receive high-voltage transmission on one side and provide power to a set of primary distribution circuits. Depending on the territory, the number of circuits may vary from just a few to a dozen or so.

The central component of the substation is the transformer, as it provides the effective interface between the high- and low-voltage parts of the system. Other crucial components are circuit breakers and switches. Breakers serve as protective devices that open automatically in the event of a fault, that is, when a protective relay indicates excessive current due to some abnormal condition. Switches are control devices that can be opened or closed deliberately to establish or break a connection.

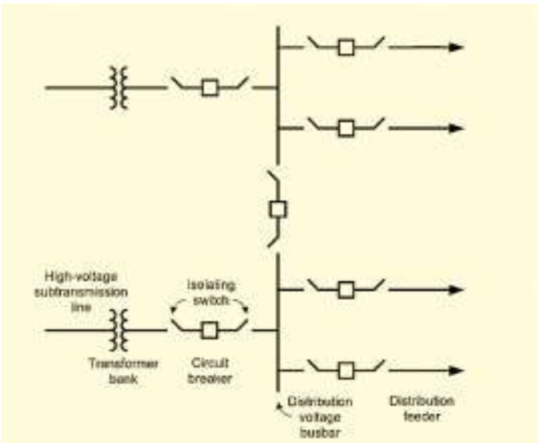

Figure 1.1 Distribution Substation Layout

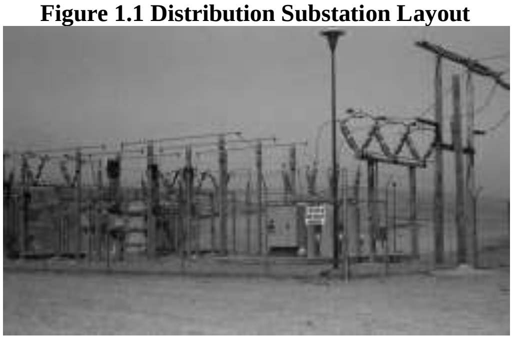

Figure 1.2 Distribution Substation

A sample layout for a distribution substation is shown in Figure 1.1. Note that schematic diagrams like this are not drawn to scale, nor do they necessarily provide a good sense of the actual spatial arrangement of the switchyard for those unfamiliar with the physical equipment represented here. Figure 1.2 shows a photograph of a similar substation.

1.3 Load Flow Analysis

The chief use of load-flow analysis in distribution system planning is to assess the impact on system performance of a variety of changes, including load growth, and changes in the configuration of the system. Typical performance indices include maintaining the system within operational constraints, meeting service continuity and reliability obligations, and minimizing power losses.

The steady state power and reactive power supplied by a bus in a power network are expressed in terms of nonlinear algebraic equations.

1.4 Motivation and problem statement

The power triangle and its components can be best illustrated as shown in Figure 1.3.

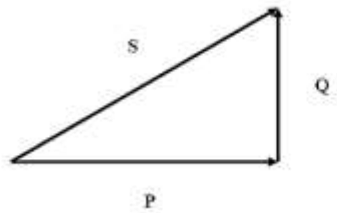

Figure 1.3 Power Triangle

The Active power (P), also known as working power, is the energy converted into useful work. Apparent power (S), on the other hand, is the total energy consumed by a load or delivered by the utility. The power that is not converted into useful work is called reactive power (Q). However, this power is needed in order to generate the magnetic field in inductors, motors, and transformers. Nevertheless**,** it's undesirable because it causes a low power factor. A low power factor means a higher apparent power, which translates into excessively high current flows and inefficient use of electrical power. These currents cause elevated losses in transmission lines, excess voltage drop, and poor voltage regulation.

Power factor is given by the proportion of active power (P) to apparent power (S), as shown in Figure 1.3. The power factor is the proportion of power converted into useful work to the total power consumed by the loads or delivered by the power source. Improving power factor can reduce system and conductor losses, boost voltage levels, and free up capacity. However, improper techniques can result in over-correction, under-correction, and/or harmonic resonance, so it can be helpful to understand the process for determining the correct methods of sizing capacitors for various applications. It's also important for calculating the values of system and conductor losses, power factor improvement, voltage boost, and freed-up system capacity (kVA) you can expect to realize from their installation.

The most common method for improving power factor is to add capacitors banks to the system. Capacitors are attractive because they're economical and easy to maintain. Not only that, they have no moving parts, unlike some other devices used for the same purpose. A power triangle as shown in Figure 1.2 is used to represent the proportion and calculate the reactive power, using the Pythagorean Theorem as stated in the equation (1.1)

$$S^2 = \sqrt{(P^2 + Q^2)} \quad \text{……….. (1.1)}$$

1.4.1 Problems of Low Power factor

When the overall power factor of a generating station's load is low, the system is insufficient and the cost of electricity correspondingly high. Disadvantages of low power factor are:

1. Because of flowing high current to full load power due to low power factor, line losses increase and then running cost increase.
2. Install capacity is more necessary for generators because of increasing losses due to over excitation.
3. The rating of transformers, switch gear and transmission and distribution lines have to more install. So, capital cost and fixed charges increase.
4. Higher line losses, lower voltage regulation.

A poor power factor due to an inductive load can be improved by the addition of power factor correction, but a poor power factor due to a distorted current wave form requires a change in equipment design or expensive harmonic filters to gain an appreciable improvement [6].

1.4.2 Use of Shunt Capacitor in Power Factor Improvement

Shunt capacitors can be used on the distribution system to improve the voltage regulation of the system. The shunt capacitors if connected to utilization equipment and switched on in accordance with the load, reduce the voltage drop in the distribution system and thus help in obtaining better voltage regulation. If the utilization equipment draws a current which is fairly constant, the voltage regulation by the shunt capacitor is more effective.

The capacitor units are made up of individual capacitor elements arranged in series/parallel connected groups within a steel enclosure. Capacitors connected inparallel make a group and series connected groups form a capacitor bank. Capacitor units are available in a variety of voltage ratings and sizes. When a capacitor bank unit fails, other capacitors in the same parallel group contain some amount of charge. This charge will drain off as a high frequency transient current that flows through the failed capacitor unit and its fuse. The fuse holder and the failed capacitor unit should withstand this discharge transient [5].

The degree of compensation being decided by an economic point of view between the capitalized cost of compensator and the capitalized cost of reactive power from supply system over a period of time. In practice a compensator such as a bank of capacitors can be divided into parallel sections, each switched separately, so that discrete changes in the compensating reactive power may be made according to the requirements of load.

Reasons for the application of shunt capacitor units are because of:

1. Increase voltage level at the load.
2. Improves voltage regulation if the capacitor units are properly switched.
3. Reduces I^2R power loss in the system because of reduction in current.
4. Reduces I^2X loss in the system because of reduction in current.
5. Increases power factor of the source generator.
6. Decreases kVA loading on the source generator and circuits to relieve an overloaded condition or release capacity for additional load growth.[2]

II-RESEARCH OBJECTIVES

There are several objectives that need to be completed at the end of this project.

1. To study "Actual record of three parameters, namely, Bus Voltage, Load on Transformer and Power factor of load with one transformer in service under maximum load condition; With and Without Shunt Capacitor in circuit." On the basis on previous research papers.
2. To study how to calculate the percentage of power losses reduction of the selected system.
3. To study all the calculation in minimizing the power losses by applying the tools that can be used different software like ETAP software.

Fig 1.3 The substation under study

III- LITERATURE REVIEW

Basically, Reactive Power compensation is management of reactive power to improve the performance of ac power systems. Reactive Power compensation revolves round two key issues, namely, system and customer problems, related with power quality issues. Most power quality problems can be resolved with an adequate control of reactive power.

Some of the work has been carried out by different researchers with different but related aims.

- ***Analysis of the Load Flow Problem in Power System Planning Studies***, Olukayode A. Afolabi, Warsame H. Ali, Penrose Cofie, John Fuller, Pamela Obiomon, Emmanuel S. Kolawole, Energy and Power Engineering DOI: 10.4236/epe.2015.710048 Oct 09, 2015

Load flow is an important tool used by power engineers for planning, to determine the best operation for a power system and exchange of power between utility companies. In order to have an efficient operating power system, it is necessary to determine which method is suitable and efficient for the system's load flow analysis. A power flow analysis method may take a long time and therefore prevent achieving an accurate result to a power flow solution because of continuous changes in power demand and generations.

This paper presents analysis of the load flow problem in power system planning studies. The numerical methods: Gauss-Seidel, Newton-Raphson and Fast Decoupled methods were compared for a power flow analysis solution. Simulation is carried out using MATLAB for test cases of IEEE 9-Bus, IEEE 30-Bus and IEEE 57-Bus system.

The simulation results were compared for number of iteration, computational time, tolerance value and convergence. The compared results show that Newton-Raphson is the most reliable method because it has the least number of iteration and converges faster.

- ***Design Analysis of 220/132 KV Substation Using ETAP*** Kiran Natkar, Naveen Kumar For healthy operation of electrical power generation, transmission and distribution, it is important that system should be balanced. This research paper deals with the simulation of 220/132 kV substation. The analysis is done by using advance software Electrical Transient Analyzer Program (ETAP) with detailed load flow analysis. All the data used for analysis is real time and collected from 220/132 KV substation under M.S.E.T.C.L.

- ***Power Devices Implementation & Analysis in ETAP,*** VanchaAbhilash, ,Kamlesh Pandey, International Journal of Engineering and Technical Research (IJETR) ISSN: 2321-0869, Volume-2, Issue-5, May 2014

In this paper Load Flow study using ETAP software is carried out with an approach to overcome the problem of harmonics and to increase the flexibility of the system.

The author carried out the Load Flow Analysis of the 400Kv substations and the tool used for the analysis is ETAP in which Newton-Raphson method is used and it is concluded that the some Buses are under and over voltage.

Voltage level in busses has been increased by adding compensating device (FACTS) initially bus voltage was 89.64% but after addition of the devices it has been increased to 90% and above by introducing Mvar into the power system. Finally the overall performance has increased.

- ***Load Flow Analysis of 132 kV substation using ETAP Software,*** Rohit Kapahi International Journal of Scientific & Engineering Research Volume 4, Issue 2, February-2013 ISSN 2229-5518

Power is essentially required for the development of any country. To maintain the generation of electric power at adequate levelthe power has to be transmitted in proper form and quality to the consumer. This research paper deals with the simulation of 132 kVsubstation in Electrical Transient Analyzer Program (ETAP) with detailed load flow analysis and also to overcome the problem of an undervoltage. The results are based on actual data received from 132 kV substation.

- ***Reduction of Power Losses in Distribution Systems,***Y. Al-Mahroqi, I.A. Metwally, A. Al-Hinai, and A. Al-Badi, World Academy of Science, Engineering and Technology International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering Vol:6, No:3, 2012

In this paper, different techniques for losses reduction in Mazoon Electricity Company (MZEC) are addressed. In this company, high numbers of substation and feeders were found to be non-compliant with the Distribution System Security Standard (DSSS). Therefore, 33projects have been suggested to bring non-complying 29 substations and 28 feeders to meet the planed criteria and to comply with the DSSS. The largest part of MZEC's network (South Batinah region)was modeled by ETAP software package.

The model has been extended to implement the proposed projects and to examine their effects on losses reduction. Simulation results have shown that the implementation of these projects leads to a significant improvement in voltage profile, and reduction in the active and the reactive power losses. Finally, the economic analysis has revealed that the implementation of the proposed projects in MZEC leads to an annual saving of about US$ 5 million

- ***Improve Power Factor and Reduce the Harmonics Distortion of the System*** Jain Sandesh, Thakur Shivendra Singh and Phulambrikar, S.P. Research Journal of Engineering Sciences, ISSN 2278 – 9472, Vol. 1(5), 31-36, November (2012)

When the reactive power captivate by the load is eminent than the compensator rating, the power factor could not be near about to unity, but definitely it could be refined and the apparent power supplied by the ac supply will be reduced.

The better power quality can be achieved by reducing the apparent power warned from the ac supply and reduces the power transmission losses. Apart of this, no harmonics disturbing the power system network are allowed, and hence no filtering is necessary. The author proposed that the system performs better than the existing methods in diminishing harmonics and power factor improvement.

- ***A Method of Finding Capacitor Value for Power Factor Improvement*** Gagari Deb, Partha Sarathi Saha and Prasenjit Das, International Journal of Electrical Engineering. ISSN 0974-2158 Volume 4, Number 8 (2011), pp. 913-922

In recent years, increasing attention has been paid to minimize the energy cost and inefficiency in electricity generation, transmission and distribution. This paper presents an approach in order to determine the size of capacitor in power system to minimize investment cost and energy loss and for improving power factor. The distribution system has been designed Using Lab view software. Different components of Lab View Software are used for calculation of the rating of capacitor bank required installing in the proposed system.

Power factor correction is one of the techniques recently applied to the electric distribution system. In this paper the power factor of the circuit without the use of capacitor bank has been assumed .Then to improve the power factor to a desired value the size of the capacitor bank required to compensate the load reactive power has been calculated. The results of the developed circuit are compared with the manual calculations.

Shunt capacitor banks are used to improve the quality of the electrical supply and the efficient operation of the power system. Shunt capacitor banks are relatively inexpensive and can be easily installed anywhere on the network. Finally, loss reduction and power factor improvement economically justified the use of this method.

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Conclusion

At the present study it is concluded that the Software is an outstanding tool for system development. Several operating procedures can be analysed such as the loss of generator, a transmission line, a transformer or a load. Load flow studies can be accustomed govern the optimum size and location of capacitors to overcome the problem of an under voltage and Power factor correction.

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