Application of Shunt Capacitor Compensation Technique on Electrical Power Distribution System: A Review

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Abstract

The performance and quality of service of the electrical power distribution system are one of the utmost issues bothering the power system operator. This matter is important in order to fulfil load demands, which increase significantly. The progress in enhancing the efficiency of the system is plagued by high real power losses and poor voltage profile especially in the conventional radial distribution system. Hence, researchers have adopted a variety of different approaches to solve these problems in electrical power distribution system. One of the techniques employed is installation of shunt capacitor (using Capacitor Switching Compensation). Studies have shown that when Capacitor Switching Compensation is incorporated into the distribution system, the system losses can be minimized by reducing the reactive power component. Capacitor Switching Compensation is a widely used technique in electric power distribution system to improve the power system performance. This study therefore, reviews some of the applications of Capacitor Switching Compensation in electrical distribution system based on voltage and reactive power control. Thus, the usage of Capacitor Switching Compensation help to control the reactive power on a distribution system, maintenance of the flat voltage profile, improve the system efficiency and the stability of the electrical power distribution system.

Keywords: Electrical Power Distribution System, Reactive Power, Voltage Control, Capacitor Switching Compensation, System Losses, Load Demand.
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1. Introduction

The electrical power distribution system completes the electricity value chain of an electrical power system and offers the last mile services. Distribution sector of power system provides the connection between end users of electricity and the electricity grid and at the same time responsible for the marketing and sale of electricity to customers. In electrical power distribution system, load varies over the day, with very low load from midnight to early morning and peak values occurring in the evening due to the load demand by the consumer. However, due to varying load demand patterns and its inability to meet both active and reactive power demand during operation, there is large number of disturbances occurring continuously, resulting in violation of bus voltages and poor power quality [1], [2], [3]. This results in a negative influence on the system stability control and analysis of the electrical energy distributed with huge power losses [4].

In addition, one of the several disadvantages of electrical energy distributed and utilized as Alternating Current (AC) is the necessity of reactive (imaginary) power that needs to be supplied along with active (real) power. Reactive power is either generated or consumed. The impedance of a branch of circuit in an AC framework comprises of two parts, resistance and reactance. Reactance can either be inductive or capacitive, which add to reactive power in the circuit [1], [5]. Reactive power neither consumes nor supplies energy. The reactive power is estimated in volt-ampere reactive (VAR). As the length of a line builds, its inductive reactance increases and the more capacitive reactive power expected to counterbalance the impact and to keep up satisfactory voltage [2], [6].

At the point when the circuit is resistive (that is current and voltage are in phase), the power is equivalent to the voltage times the current. If the AC circuit contains reactance, there is power component associated with the magnetic and/or electric fields. The power associated with these fields is not consumed as it is in a resistive circuit, but rather stored and then discharged as the alternating electric current/voltage goes through its cycle [7]. Reactive power is the electrical energy that is needed to energize the portions of the power system that behaves like capacitor (for example the overhead conductors that are continuously charged and discharged by the AC waveform); and inductors (for example electric motors and transformers which store a considerable amount of energy in magnetic field that are essential for device operation) [8], [10].

Reactive power can be leading or lagging. Under light load or open line, there is high voltage; but if the system is heavily loaded (at lagging power factor) the voltage is reduced. Capacitors are connected to minimize the losses and voltage drops. Since most loads are inductive and consume lagging reactive power, the compensation required is usually supplied by leading reactive power [9]. This can be employed either at load level in the distribution network, substation level or at transmission level using shunt capacitors (such as Capacitor Switching Compensation) to improve voltage and reactive power in the system. It is economical to supply this reactive power closer to load in the distribution network [7], [11].

Shunt capacitor is normally employed on electrical power systems due to its outstanding performance especially in long power lines and its control of reactive power flow. Shunt capacitors Compensation is used extensively all over the world as reactive power compensation. Shunt capacitors improve the overall performance of power system and consists of field and rotating capacitors that use mechanical switching mechanism. These functions are normally carried out with mechanically controlled shunt banks of capacitors and non-linear reactors. Shunt Capacitor bank in power system is essential in providing reactive power support and improvement of voltage profile at any required point within the grid system [2], [12], [14].

The purpose of voltage and reactive power control is to maintain acceptable standard (acceptable voltage and reactive power) at the service entrance of all consumers served by the feeder under all possible operating conditions [13]. Electric utilities traditionally maintain distribution system voltage within the acceptable range using different methods. Also, by reducing the amount of reactive power flowing on the distribution feeder, the electric utility can reduce electrical losses and improve the voltage profile along the feeder. Without such adjustments, voltage and reactive power at one end of some feeders might sag to unacceptable low levels at peak periods, while voltage and reactive power close to the substation might rise to unacceptably high levels at minimum load [13], [15].

2. Electrical Power Distribution Systems

An electrical power distribution system is the final stage in the delivery of electric power, whose main function is to provide power to individual consumer premises. Distribution of electrical power to different consumers is done with much low voltage level relatively to that of transmission. It holds a very significant position in the power system since it is the main point of the line between bulk power and consumers and it contributes to about 2-3 % of the total losses in power systems. The distribution network is usually designed to operate at specified power capability and voltage level. Operating outside the allowable tolerance of these values affect the quality of power reaching the consumers of electricity [1], [5], [16].

A typical distribution substation will serve from one to as many as ten feeder circuits. A typical feeder circuit may serve numerous loads of all types. A light to medium industrial customer may take service from the distribution feeder circuit primary, while a large industrial load complex may take service directly from the bulk transmission system. All other customers, including residential and commercial, are typically served from the secondary of distribution transformers that are in turn connected to a distribution feeder circuit [17], [18].

In practice, the distribution networks are classified majorly into two: Ring main distribution network and Radial distribution network. Generally the ring main system is more expensive than the radial system because more switches and conductors are required to construct the ring main system. It is not preferred when the voltage level is a low voltage and its constructional cost is also high. Due to these factors, the radial system is widely used in distribution system [3], [14], [19].

A radial distribution system is a separate feeder which radiates from a single sub-station and feed the distributors at only one end. It is a distribution network where power is delivered from the main branch to the sub-branch, it then splits out from the sub-branches again to the load as seen in Figure 1. The radial structure implies there are no loops in the networks and each bus is connected to the source via exactly one path. Thus, these network types are weakly meshed with high R/X ratios, unbalanced with multi-phase operation and random or unbalanced distributed load [16].

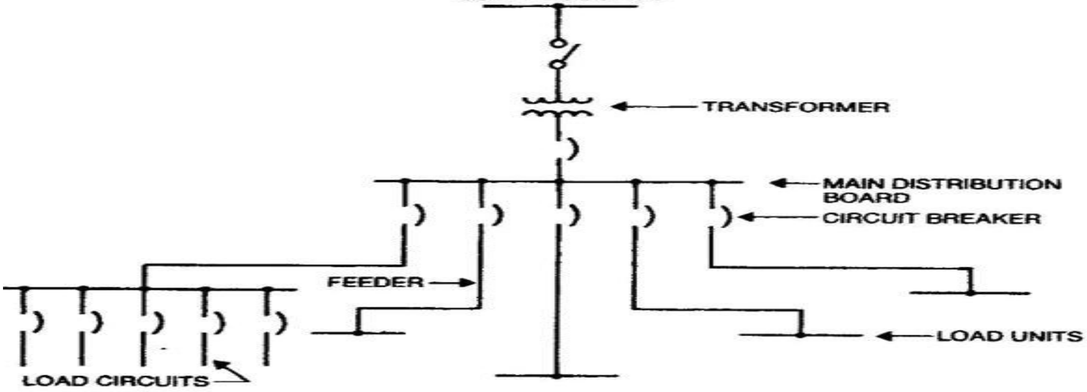

Figure 1: A Radial Distribution Network

3. Reactive Power Compensation

Reactive power compensation techniques comprises of both series and shunt compensators, it enhances the system flexibility, reliability and as well as quick system restoration response to operational challenges. Reactive power compensation is frequently best approach to improve both power transfer capacity and voltage stability. Shunt capacitors and reactors as well as series capacitors give passive compensation. They are either permanently connected to the transmission and distribution system or switched. They contribute to voltage control by modifying the network characteristics [18], [20]. When designing a compensation scheme, attempt should be made to accomplish the most economical solution in which the saving accomplished in the equipment cost is essentially more prominent than the procurement cost of the reactive power [14], [21].

According to Grainger and Stevenson (1994), the performance of power lines can be improved by reactive compensation of a series or parallel type [12]. It has been examined that the percentage compensation is in the range of 25 to 75 percent. Also, stated that line compensation can be done in several ways. Shunt reactors are widely used to reduce high voltage under light load or open line conditions. If the system is heavily loaded, shunt capacitors, static var control, and synchronous condensers are used to improve voltage, increase power transfer, and improve the system stability [12].

Some of the benefits of reactive power compensations include; improving the stability of the AC system by increasing the maximum active power that can be transmitted and distributed. It helps to maintain a substantially flat voltage profile at all levels of power system if properly harnessed. It increases power efficiency, also controls steady-state and temporary over-voltages. Increase in active power distributed and appreciable improvement in system voltage profile both at transmission and distribution level [9]. In addition, reactive power compensation can be supplied with the aid of both discrete and power electronic controllers. The discrete controllers are Load Tap-Changing Transformer (LTC), Capacitor (Series and Shunt) and Synchronous Compensators. However, this study reviews the application of shunt capacitor type of reactive power compensation only [22], [26], [39].

3.1 Shunt Capacitors

Shunt Capacitor is one of the simplest sources for providing the reactive power locally. It is a simple devices where the insulating dielectric is placed between two metal plates. When charged to certain voltage, charges are accumulated on both sides of the dielectric and in this way, the charges are stored. Shunt Capacitors maintain the system voltage levels by modifying the characteristic of inductive load. It draws a leading current that counteracts the lagging component of inductive load current at the point of installation [25], [27], [38].

Shunt capacitor banks are always connected to the bus rather than to the line. They are connected either directly to the high voltage bus or to the tertiary winding of the main transformer. Shunt capacitor banks are breaker-switched either automatically by a voltage relay or manually [10]. The capacitor requirement is developed on a per-transformer basis. The ratio of the kvar connected to kVA per feeder, the position on the feeder of existing capacitor banks and any concentration of present or future load are all considered in determining the position of the new capacitor banks. The feeder type at the location of the capacitor bank determines if the capacitor will be pole-mounted or pad-mounted [26], [27] [36].

Thousands of capacitor banks are installed in the entire distribution network. The primary usage for capacitor banks in the distribution system is to maintain a certain power factor at peak loading conditions. Compensating the load lagging power factor with the bus connected shunt capacitor bank improves the power factor and reduces current flow through the lines, transformers, generators, etc. This will reduce power losses (I^2R losses) in this equipment [11]. Shunt compensation with capacitor banks reduces kVA loading of lines, transformers and generators, which means with compensation, they can be used for delivering more power without overloading the equipment [6], [25], [28], [29], [37].

Shunt capacitors are employed in power system for the following reasons:

i. Voltage Regulation: The main reason that shunt capacitors are installed at substations is to control the voltage within required levels. Load varies over the day, with very low load from midnight to early morning and peak values occurring in the evening between 4 pm and 7 pm. Shape of the load curve also varies from weekdays to weekends, with weekends load typically low. As the load varies, voltage at the substation bus and load bus vary. Since the load power factor is always lagging, a shunt connected capacitor bank at the substation can raise voltage when the load is high. The shunt capacitor banks can be permanently connected to the bus (fixed capacitor bank) or can be switched as needed. Switching can be based on time, if load variation is predictable, or can be based on voltage, power factor, or line current.

ii. Power Losses Reduction: Compensating the load lagging power factor with the bus connected shunt capacitor bank improves the power factor and reduces current flow through the lines, transformers, generators, etc. This will reduce power losses (I^2R losses) in this equipment. Shunt compensation with capacitor banks reduces kVA loading of lines, transformers and generators, which means with compensation, they can be used for delivering more power without overloading the equipment (i.e. it enhances better utilization of power equipment). Shunt capacitors have no moving parts, unlike some other devices used for the same purpose.

In this way, shunt capacitors are providing the reactive power when it is needed and the capacitors and reactive power loads are exchanging the reactive power back and forth. With the use of Shunt Capacitor on feeder, there is a significant reduction in the source current magnitude, appreciable improvement of power factor and consequently the voltage drop between the sending end and the load is reduced drastically [30], [34].

Most loads in power system are inductive and consume lagging reactive power, the compensation required is generally provided by leading reactive power. Shunt capacitor switching compensation of reactive power can be utilized either at load level, distribution substation level along the distributed feeder or at transmission substation level. It can be capacitive (leading) or inductive (lagging) reactive power. At load level, at the distribution substation, along the distribution feeder, compensation is generally capacitive. In a transmission substation, both inductive and capacitive reactive compensation are introduced [29], [31].

Consider a distribution feeder with capacitor switching compensation shown in Figure 2. The network is represented by their equivalent models where impedance has been converted to per unit admittances on a common MVA base [28], [32], [33], [35].

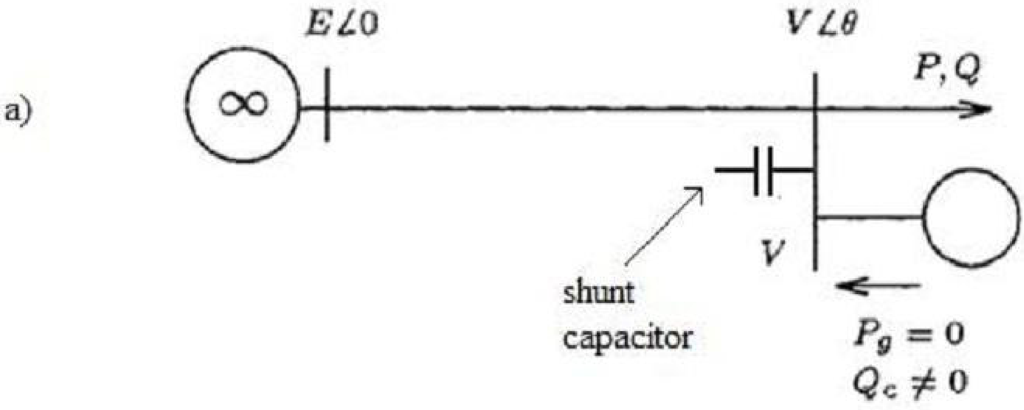

Figure 2: Single Line Diagram of Distribution System Connections with Capacitor Bank

By application of KCL, the reactive power injected to the system due to shunt capacitor is given as [33]:

$$Q_c = I_c^2 X_c \tag{1}$$

where

Q_c	is the reactive power injected by the capacitor in MVAR
I_c	is the current injected by the capacitor
X_c	is the reactance of the capacitor

This will reduce the voltage drop as [24]:

$$\Delta V = \frac{RP + X(Q - Q_c)}{V_i^*} \tag{2}$$

It will also decrease the feeder current

$$I_i = \frac{\sqrt{P^2 + (Q - Q_c)^2}}{V_i^*} \tag{3}$$

The apparent power (S) when capacitor is used is given as [19}:

$$S_{new} = \frac{PF_{old}}{PF_{new}} X\, S_{old} \tag{4}$$

The reactive power (Q) when capacitor is used is computed from

$$Q_{new} = \sqrt{S_{new}^2 - P^2} \tag{5}$$

The voltage magnitude (V) when capacitor is used is given as [13]:

$$V_{new} = \frac{S_{new}}{P} X\, V_{old} = \frac{V_{old}}{PF_{new}} \tag{6}$$

where:

S_{new}	is the apparent power when capacitor is used

S_{old}	is the apparent power when capacitor is not used
Q_{new}	is the reactive power when capacitor is used
V_{new}	is the voltage when capacitor is used
V_{old}	is the voltage when capacitor is not used
P	is the active power
PF_{old}	is the base power factor when capacitor is not used (0.8)
PF_{new}	is the expected power utility power factor when capacitor is used (0.95)

With equations (4) to (6), the apparent power (S) and reactive power (Q) will reduce, while voltage (V) will increase.

The total active power loss and reactive power loss become:

$$P_{LT(C)} = \sum_{i=1}^{n} I_{i(C)}^{2} R_i \qquad (7)$$

$$Q_{LT(C)} = \sum_{i=1}^{n} I_{i(C)}^{2} X_i \qquad (8)$$

where:

$P_{LT(C)}$	is the total active power loss after compensation in MW
$Q_{LT(C)}$	is the total reactive power loss after compensation in MVAR
$I_{i(C)}$	is the magnitude of current in Amps after compensation

The total power loss of the distribution system after compensation is

$$S_{(C)} = \sqrt{P_{LT(c)}^{2} + Q_{LT(c)}^{2}} \quad \text{in MVA} \qquad (9)$$

The kVAr capacity of the capacitor required to carry out full compensation of the network is given as

$$kVAr \text{ required} = P(\tan \emptyset_1 - \tan \emptyset_2) \qquad (10)$$

This corresponding size and µF capacity of the capacitor required to carry out full compensation of the network is given as:

$$C = \frac{1}{2\pi f X_c} \qquad (11)$$

3.2. Applications of Shunt Capacitor Switching Compensation

Some of the applications of Capacitor Switching Compensation in electrical distribution system considered in this paper are voltage and reactive power control on electrical power distribution system. The technique provides voltage and reactive power control to compensate for reactive power losses when large inductive loads occur. Capacitor Switching Compensation is less expensive, easy to maintain and needs no additional protective equipment [1], [7], [19].

4.1 Reactive Power Control

The power system supplies power to a vast number of loads and is feeding from many generating units. However, the high demand of reactive power increases the reactive output of generators. When the generator hits the reactive power limit its terminal voltage decreases. A lot of reactive power demand is then transferred to another generator from critical area. This will prompt cascading over-loading of generators. The strategy will in the long run lead to system collapse, possibly leading to loss of synchronism of generating units and a major blackout. For efficient and reliable operation of power system, the control of reactive power should be minimized so as to reduce I^2R and I^2X losses. This ensures the power system operates basically for real power [1], [5], [12], [24], [27], [34].

There is an issue of maintaining reactive power within required limits. As load changes, the reactive power requirements of the transmission system vary. The reactive power cannot be transmitted over long distances and across large power angles, even with significant voltage sizes. Large angles are a direct result of long lines and high power transfers. Real losses should be minimized for economic reason, reactive losses ought to be minimized to reduce investments in reactive power devices. Both active and reactive losses depend on reactive power transfer [13], [21]. Hence to minimize losses, there is the need to minimize reactive power transfer in the network by application of Capacitor Switching Compensation [37].

4.2 Voltage Control

Voltage stability (control) is the ability of the system to maintain steady state voltage at all the system buses when subjected to a disturbance. If the disturbance is large, then it is called as large disturbance voltage stability and if the disturbance is small it is called small disturbance voltage stability. The main factors affecting voltage stability are: line length, active load demand, reactive load demand, shunt compensation, short-circuit, system power factor and load tap changer (LTC) transformer. The main purpose for voltage stability is that the reactive power cannot be transmitted over long distance and has to be delivered directly to the point, where reactive power needs support. There are a couple of reasons behind diminishing reactive power transfer [32], [33] [38].

In case voltage fluctuations occur due to fast acting devices like induction motors and power electronic drives, then the time frame for understanding the stability is in the range of 10-20 s and hence can be treated as short term phenomenon. On the other hand, if voltage variations are due to slow change in load, over loading of lines, generators reaching reactive power limits and tap changing transformers, then time frame for voltage stability can stretch from 1 minute to several minutes [24], [31], [33] [34], [39].

Reactive power cannot be transmitted across large power angles, even with significant voltage sizes. Large angles are a direct result of long lines and high power transfers. Real losses should be minimized for economic reasons, reactive losses ought to be minimized to reduce investments in reactive power devices. Both active and reactive losses depend on reactive power transfer [12], [26]. Hence to minimize losses, there is the need to minimize reactive power transfer and keep voltage high. This is to keep voltage within required purpose of control and ensure improvement in both power transfer and voltage dependability. Minimizing over-voltage load rejection, reactive power transfer requires bigger equipment sizes for transformers and links [31].

5. Review of Related Works

According to Grainger and Stevenson (1994), the performance of power lines can be improved by reactive compensation of a series or parallel type [12]. It has been examined that the percentage compensation is in the range of 25 to 75 percent [36]. It also stated that line compensation can be done in several ways. Shunt reactors are widely used to reduce high voltage under light load or open line conditions. If the system is heavily loaded, shunt capacitors, static var control and synchronous condensers are used to improve voltage, increase power transfer and improve the system stability [36].

Thatte and Ilic (2006) examined an assessment of reactive power/voltage control devices in distribution networks. The study considered an assessment of voltage/reactive power control devices for distribution system. The recent trend towards Distributed Energy Resources (DERs), and Distributed Generation (DG), in particular, is often based on the rationale to support voltage and compensate for reactive power closer to the end users. This situation calls for a systematic approach to assessing alternatives for voltage control, both old and new. The study illustrated a simplified distribution network on various voltage control devices, such as DERs, DGs, Under-Load-Tap-Changing Transformers (ULTCs), Static Var Compensators (SVCs) and Super Var controllers. It illustrated how their real characteristics differ [38].

Neelima and Subramanyam (2011) examined efficient optimal sizing and allocation of capacitors in radial distribution systems using Dimension Reducing Distribution Load Flow (DRDLF) and Differential Evolution (DE). The installation of the shunt capacitors on the radial distribution system is basic for power flow control, improving system stability, power factor correction, voltage profile management and loss minimization. Differential Evolution (DE) Algorithm, Dimension Reducing Distribution Load Flow (DRDLF) was utilized to decide the position of the capacitors with suitable size. The above technique was tried on IEEE 69-bus system and was observed to be better contrasted with different strategies like Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) [26].

Thompson *et al.* (2011) investigated Wind farm volt/var control using a real-time automation controller. The authors focused on wind generating facilities that often require significant reactive power support to maintain voltage and power factor within operating limits prescribed by the transmission grid entity element. This controller incorporates the ability of a total interchange processor to trade voltage, control flow and status data alongside control directions to microchip based transfers all through the system. It additionally incorporates a powerful IEC 61131-3-compliant soft programmable logic controller (PLC) logic engine to execute the control calculations. A versatile calculation is used to manage this test. The controller likewise incorporates a modern sequencing calculation to guarantee that the two reactors and capacitors are not in service at the same time, to optimize power factor through multiple step-up transformers, to reduce losses and exchanging activities between reactive banks. The system exhibits a simple, incorporated and coordinated system that can control a substantial number of capacitor and reactor banks. It is one of a kind in that it can deal with concurrent guideline of both power factor and voltage at the point of utility interconnection [39].

Manikandan *et al.,* (2012) investigated analysis of optimal AVR placement in radial distribution systems (RDS) using discrete particle swarm optimization (DPSO) to achieve optimal voltage control, decrease the total cost and losses and to obtain the maximum net savings. Proposed method made the initial selection, installation and tap setting of the voltage regulators to provide a smooth voltage profile along the network. Optimal AVR placement in radial distribution systems deals with initial selection of nodes by using power loss index (PLI) and then Discrete Particle Swarm Optimization (DPSO) has been used for optimal tap setting of the voltage regulators to maintain voltage profile within the desired limits and reduce the losses. The algorithm was tested on 15 node and 33 node RDS. The result revealed reduction in power losses [19].

Rouholamini *et al.* (2012) investigated optimal placement of reactive power sources for loss minimization and voltage profile improvement. They presented an applicable method to define the number of static reactive power generating units and their optimal position in a radial network. The proposed method improved voltage profile and power losses simultaneously. Simulated annealing algorithm was used to minimize a dual fitness function that consists of voltage drop and power losses. The method used an economic criterion to choose the best number and location of reactive power sources. The proposed algorithm was implemented on a test network called "seda sima" which was one of the middle voltage networks in Bardsir city, Kerman, Iran. The simulation result was done using Matlab 2009a. Optimal location of reactive power sources in radial distribution networks was studied using simulated annealing algorithm based on Geo Data bank. In addition, to compare the influence of number of reactive power sources, a special economical ratio was used. This ratio would make decision-making process easier for system operators. The proposed method was implemented on a real radial network as a test system. The result of the simulation revealed loss minimization and voltage profile enhancement [35].

Aravind *et al.* (2013) examined Artificial Neural Network (ANN) Based SVC Switching at Distribution level for Minimal Injected Harmonics. Electrical distribution system experienced various issues like reactive power trouble, unbalanced loading, voltage regulation and harmonic distortion. Despite the fact that DSTATCOMS wesre perfect answers for such systems, they were not well known in view of the expense and unpredictability of control included. Phase wise balanced reactive power compensations were required for quick changing loads requiring real power factor correcting devices prompting terminal voltage adjustment. Static Var Compensators (SVCs) remain ideal choice for such loads and because of low cost and simple control technique. These SVCs while correcting power factor, inject harmonics into the lines causing genuine worries about nature of the distribution line supplies. To limit the harmonics infused into the distribution system, the activity of TSC-TCR type SVC is utilized related to quick changing loads at LV appropriation level. Fuzzy logic system and ANN were utilized to take care of this nonlinear issue, giving ideal activating defer points used to trigger switches in TCR. The plan with Artificial Neural Network (ANN) is appealing and can be utilized at distribution level where load harmonics are within limits. The contextual investigation demonstrates that the percentage Total Harmonic Distortion (THD) under improved condition is substantially less than the percentage THD under unity power factor condition [5].

Azimi and Esmaeili (2013) examined Multi-objective daily Voltage/Reactive power control in distribution systems with distributed generation using binary ant colony optimization (BACO). The main purpose is to determine optimum dispatch schedules for on-load tap changer (OLTC) settings at substations, substation exchanged capacitors and feeder-exchanged capacitors dependent on the day-ahead load estimate. The targets are chosen to limit the voltage deviation on the optional bus of the main transformer, absolute electrical losses, the quantity of OLTC and capacitors activity and voltage variance in distribution systems for the following day. Since this model is the weighted entirety of individual target works, an Analytic Hierarchy Process (AHP) is embraced to decide the loads. To show the viability of the proposed technique, the Volt/VAr control was performed in IEEE 33-bus and 69-bus distribution system and its performance was contrasted with Genetic Algorithm (GA), just as hybrid binary genetic algorithm and particle swarm optimization algorithms (HBGAPSO). Simulation results confirmed that the BACO calculation gave preferred exhibitions over different calculations [6].

Some of the above researches have indicated that the application of reactive shunt compensation in power system increased the bus voltage and reduce the reactive power in the system. Also the reactive shunt compensation reduced the load (MVA demand) and load current of electric power system with improved power factor after compensation. This indicated that, variation in load demand on the distribution system resulted in variation in the reactive power component. Therefore, based on the above reviewed work, in order to ensure reliable energy distribution even in the presence of load and reactive power variations, application of Capacitor Switching Compensation as an efficient compensation technique that can reduce the severity of voltage and reactive power variation on distribution system is hereby suggested in this research paper..

6. Conclusion

The fundamental achievements and application of incorporation of shunt capacitor (using Capacitor Switching Compensation) in electrical power distribution system have been reviewed. Studies have shown that incorporation of shunt capacitor into the power system improved the system voltages and reactive power as well as reduced the system losses thereby improving the power system performance. Thus, the usage of Capacitor Switching Compensation help to control the reactive power on a distribution system, maintenance of the flat voltage profile, improve the system efficiency and the stability of the electrical power distribution system. This study therefore, helps power system operators to provide effective solutions for the reliable functioning of the electrical power distribution system via Capacitor Switching Compensation incorporation.

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