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Improvement of Power Quality in Primary Distribution Systems Based on Static-Var Compensators

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Abstract:

A flexible AC Transmission Systems (FACTS) is a new technology offers a fast and reliable control over the transmission and distribution parameters like voltage and phase angle between the sending end voltage and receiving end voltage. Distribution static synchronous compensator (DSTATCOM) is a second generation member of the (FACTS) controllers. Reactive power compensation is an important aspect in the control of distribution systems. Reactive current in addition to increasing the distribution system losses, introduces voltage drop at lead point and finally it causes poor power quality in power systems. Primary radial distribution feeders have high resistance to reactance ratio, which causes voltage drop and high power loss in radial distribution systems. providing high demanding power to entire load while maintaining voltage magnitude at acceptable range is one of the major system constraints, using of capacitor banks to improve the reactive power have not quite enough at high reactive power feeder, because it have more slow in step by step response and have not capable to generate continuously variable reactive power.

In some primary distribution feeders at the state of Khartoum, it is observed that there are some appropriate drops in voltage and quality service at high reactive power loads although some individual capacitor banks have been connected at these feeders, from here we researched for a new technology to overcome this problem. A steady-state model of (DSTATCOM) is proposed and developed to compensate the reactive power by using a Voltage Source Converter (VSC) with Pulse Width Modulation (PWM) and cascade control of four direct proportional integral controllers (PI) in synchronous reference frame. The detailed modeling and control design of (DSTATCOM) with specific typical radial primary distribution feeders (industrial, commercial, residential) are presented and implemented along necessary mathematical model equations in the Matlab software. Simulation schemes of (DSTATCOM) are done with help of control block diagrams and stability analysis. Load flow is an important method for analysis, operation and planning studies of any power system in a steady-state condition. In this research backward forward sweeps load flow method (Kirchhoff's Laws) has been proposed rather than Newton-Raphson and Fast decoupled methods because the distribution feeders have a high R/X ratio which make the systems are ill-conditioned iterations analysis. (DSTATCOM) was installed on specific typical radial feeders at the (DSTATCOM) which using for distribution lines and load compensation has been the subject of considerable interest beside it is a new technology for a good power quality solution.

Keywords: Power System, Flexible AC Transmission Systems (FACTS) Devices, STATCOM, PI Controller

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1. Introduction and Literature Review

Due to the expansion of world industries, communities and population, the need of generating electric power from renewable resources and fossil fuels are increased [1-23]. Extra high voltage transmission line will transmit the large power generated over long distance emitting electromagnetic fields [24-41] and have also some problems such as the voltage drop and reactive power shortage. Technology as a shunt static synchronous compensation (DSTATCOM) at the required point with specific loads to the modern power distribution network is constantly being faced with an ever-growing load demand. Distribution networks experience distinct change from a low to high load level every day. Electric load growth in higher regional power sectors which transferred in a largely interconnected network becoming more complex and less secure power system operation. Power generation and transmission facilities are unable to meet these new demands [42-44]. Many loads at various distribution ends like domestic utilities, computers, process industries, adjustable speed drives, printers, microprocessor based equipment etc. have become intolerant to great increasing in reactive power, voltage fluctuations, and interruptions. Growth of electronic loads has made the quality of power supply a critical issue [2, 3].

Power quality is set of electrical boundaries that allow the piece of equipment to function in its intended manner without significant loss of performance or life expectancy. The electrical devices like electric motor, a transformer, a generator, a computer, a printer, communication equipment, or a house hold appliance. All of these devices and others react adversely to power quality issues, depending on the severity of problems. Reactive power cannot be transmitted across large power angle even with substantial voltage magnitude gradient. Reactive power should be generated close to the point of consumption. We can make several reasons to minimize reactive power transfers [44- 46].

- It is inefficient during high real power transfer and require substantial voltage magnitude gradient.
- It causes high real and reactive power losses.
- It can lead to damaging temporary overvoltage's following load rejections.
- It requires larger equipment size for transformers and cables.

In some residential, commercial and industrial distribution feeders at the state of Khartoum, it is observed that there are some appropriate drops in voltage and quality service at high reactive power loads although some individual capacitor banks have been connected at these feeders. Using new technologies as (FACTS) to compensate excess reactive power and to overcome voltage profile of the distribution systems has become a main goal to supply stable service for the consumers [42-46]. This thesis considers the most recent methods used in reactive power compensation by a new technology (DSTATCOM) as:-

1. DSTATCOM control stability methods [43, 44, 50, 51]
2. Steady- state modeling of DSTATCOM methods [42-45]
3. Backward Forward load flow analysis method [46, 61-65]
4. Phasor diagram for DSTATCOM rating method [62-67]

5. Voltage stability indicator method [75-76]

The actual amount of power being used, or dissipated, in a circuit is called true power. It is measured in watts and is symbolized mathematically by the capital letter P. True power is a function of the circuit's dissipative elements, such as resistances (R). Reactive loads such as inductors and capacitors dissipate zero power, but in the fact that they drop voltage and draw current gives the perception that they do dissipate power. This "dissipated power" is called the reactive power and is measured in Volt-Amps-Reactive (VAR). Reactive power is represented by the capital letter Q, and is a function of a circuit's reactance (X). The combination of true power and reactive power is called apparent power. It is the product of a circuit's voltage and current, without reference to phase angle. Apparent power is measured in the unit of Volt-Amps (VA) and is symbolized by the capital letter S. Apparent power is a function of a circuit's total impedance (Z).

2. Flexible AC Transmission Systems (FACTS) Devices

Flexible AC Transmission Systems (FACTS) comprise first generation type as Static Vars Compensation (SVC) and second generation type which operates with Voltage Source Converters (VSC) and contains Static Synchronous Compensation (STATCOM), Dynamic Voltage Restoration (DVR), Unified Power Quality Conditioner (UPQC) and Solid –State Breaker (SSB).(FACTS) technology used also in renewable sources energy. Distribution power losses can be considerably reduced by installing Custom Power Devices or Controllers at suitable location. These controllers which are also named Distribution Flexible AC Transmission System (D-FACTS) are a new generation of power electronics-based equipment aimed at enhancing the reliability and quality of power flows in low-voltage distribution networks. D-FACTS mean FACTS (Distribution Flexible AC Transmission Systems) that are diverted to distribution systems [41, 42, 76].

The demand on distribution systems has become erratic. Demand is growing against supply; hence improvement of distribution systems has gained vital importance. Quality of distribution systems has been an important part infrastructure of energy sector. Traditional construction and operation practices served the electricity distribution systems well for nearly a century. However, the last decade has seen a marked increase in loads is sensitive to poor quality electricity supply. Some large users are critically dependent on uninterrupted electricity supply and suffer large financial losses as a result of even minor lapses in the quality of electricity supply. The most important cause for the increasing concern about power quality problems is the dramatic increase in sensitive microprocessor and power electronic equipment being used to control assembly, line production, to automate office work, and to enhance the home. Important compatibility gaps have developed between power electronic manufacturers, power producers, and power users, in that many of these systems are too sensitive for the electrical environment in which they are being placed.

Electric power quality has become an increasingly problematic area in power system; distribution power quality may be defined as the measurements, analysis, and improvement of the voltage, usually this voltage should be maintained to be sinusoidal at rated value and frequency. Nowadays there are advanced technologies use to improve performance of utility distribution systems. The technology seeks to integrate modern power electronics – based controllers such as the static compensation.

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3. Distribution Feeder with DSTATCOM Model

3.1 Backward Forward sweep load Flow Method:-

3.1.1 1Introduction:-

Generally, distribution feeder has a high R/X ratio and their configuration is radial. These reasons make that distribution systems are ill-conditioned and thus conventional method as Newton-Raphson, fast decoupled load flow and their modifications to are unsuitable for solving load flow for most cases and fail to converge [46]. he power flow through the branch that makes the loop is simulated by injection of the same power in the dummy bus. The method uses the backward and forward sweeps with initial voltage of all the nodes assumed to be equal to that of the source bus which is took as reference. However the method gives only the voltage magnitude of each node on the basis of algebraic equations. As convergence criterion of the algorithm, author has proposed the difference of the reactive and the active power at the sub-station end of two successive iterations. If this difference is less than 0.1kw and 0.l kvar, the solution is reached. In the present study, my main aim is the development of an efficient method for solving radial distribution feeder. A fast and easy to understand algorithm for determining nodes after branches based on the study is given. Other benefits of the method lies in the evaluation of the voltage phase-angles which becomes necessary if the load flows solution is used in the capacitors sizing problem. The test carried out on several feeders' shows that my model takes few time to reach the solution.

3.1.2 Nodes and branches numbering:-

The numbering scheme is not required for the proposed load low solution of radial distribution networks. However and for convenience, to perform the numbering scheme that considered of the example line of Fig. 1. The source node is numbered as bus number 0. The node just ahead the source node is labeled node I and so on until the end-node.

3.1.3 Mathematical Formulation of Backward Forward:-

Assumptions: It is assumed that the three-phase radial distribution network is balanced and thus can be represented by its one-line diagram. Distribution lines are of medium level voltage then the shunt capacitances are small and thus ignored. The single-line equivalent diagram of a line is shown on Fig. 2.

3.1.4 Mathematical models of Backward Forward:-

The load flow of radial distribution network can be solved iteratively from two of recursive equations. The first set concern the determination of the branches current by going up the line (backward sweep). The second one allows us to determine the nodes voltage by going down the line (forward sweep).

3.1.5 power and Current of Branches:-

From the branch electric equivalent shown in Fig. below we can write the set of the above equations.

$$P_i = \sum_{k=i}^{if} Pl_k + \sum_{k=i+1}^{if} Ploss_k \qquad (1)$$

$$Q_i = \sum_{k=i}^{if} Ql_k + \sum_{k=i+1}^{if} Qloss_k \tag{2}$$

Where:- Pi = Is the active power fed through bus i. It is equal to the sum of the active power of all the loads beyond node i (node i included) plus the sum of the active power loss in the branches beyond node i (branch i not included). (Active Power in the ith branch).

Q_i = I_s the reactive power fed through bus i. It is equal to the sum of the reactive power of all he loads beyond node i (node i included) plus the sum of the reactive power loss in the branches beyond node i (branch i not included). (Reactive Power in the ith branch)

where:

$$k \text{ is} \rightarrow \quad i \leq k \leq if \tag{3}$$

i= Number of node and branches if= Node and branch final of the network

• P_{lk} =Is the active power of the load at node k.

• Q_{lk} = Is the reactive power of the load at node k.

• P_{lossk} = Is the active power loss in the kth branch.

•Q_{lossk} = Is the reactive power loss in the kth branch.

The active and reactive power losses are given by:

$$Ploss_k = \frac{Pl_k^2 + Ql_k^2}{V_k^2} \cdot R_k$$

$$Qloss_k = \frac{Pl_k^2 + Ql_k^2}{V_k^2} \cdot X_k \tag{4}$$

where:

R_k= Is the resistance of the kth branch. ‘ X_k = Is the reactance of the kth branch.

The current that flowing through the ith branch is given by:

$$\vec{I_i} = \frac{P_i - jQ_i}{conj\vec{V_i}} \tag{5}$$

where:

• I_L Current in the ith branch

• $conjV_i$ = Conjugate Voltage at the node i

If the complex voltage at the node i is:

Vi ($\cos\theta_i$, $+\sin\theta_i$) and can be expressed as:-

$$\vec{I}_i = \frac{P_i \cos\varphi_i + Q_i sen\varphi_i}{V_i} - j\,\frac{Q_i \cos\varphi_i - P_i sen\varphi_i}{V_i} \quad (6)$$

the d and q components of the current are:-

$$Id_i = \frac{P_i \cos\varphi_i + Q_i sen\varphi_i}{V_i}$$

$$Iq_i = \frac{Q_i \cos\varphi_i + P_i sen\varphi_i}{V_i} \quad (7)$$

3.1.6 Voltage of Nodes:-

For the nodes voltage and regarding our numbering scheme, we can write the following complex expression:

$$\vec{V}_{(RE(i))} = \vec{V}_{(SE(i))} - [R_{(RE(i))} + jX_{(RE(i))}] \cdot [Id_{(RE(i))} + jIq_{(RE(i))}] \quad (8)$$

the d and q components of which are:

$$Vd_{(RE(i))} = Vd_{(SE(i))} - [R_{(RE(i))} \cdot Id_{(RE(i))}] - [X_{(RE(i))} \cdot Iq_{(RE(i))}]$$
$$Vq_{(RE(i))} = Vq_{(SE(i))} + [R_{(RE(i))} \cdot Iq_{(RE(i))}] - [X_{(RE(i))} \cdot Id_{(RE(i))}] \quad (9)$$

where:

• RE (i)= Is the receiving end of the branch i

• SE (i) = Is the sending-end of the branch i.

For the first branch the d and q components of sending-end of the branch one are respectively equa1 to 1.0 in p.u. and zero. This corresponds to the source node (node 0) which is also the reference node.

The voltage rms value and phase-angle of the receiving-end of the branch i are given by:-

$$V_{(RE(i))} = \sqrt{Vd^2_{(RE(i))} + Vq^2_{(RE(i))}}$$

$$\varphi_{(RE(i))} = atan\,\frac{Vq_{(RE(i))}}{Vd_{(RE(i))}} \tag{10}$$

4. Solution methodology of backward Forward Method:-

To determine the voltage at each node of radial distribution networks, the proposed method can be summarized in the following algorithm.

- STEP 1: Read the line data.
- STEP 2: Initialize the voltage of all the nodes to I p.u. and phase-angle to zero.
- STEP 3: Perform the backward sweep to obtain the current in each branch by using Equations above.
- STEP 4: Perform the forward sweep to calculate the voltage rms value and phase angle at each node by using Equation (7) and (8).
- STEP 5: If the voltage at each node for two successive iterations is within a certain tolerance (0.00001 p.u.) the solution is reached go to step 6 else, repeat step 4 to 6 until the convergence criterion is reached.
- STEP 6: Read the results.

4.1 Steady-State Modeling of Radial Feeder with DSTATCOM:-

4.1.1 Feeder Modeling Equations:-

D-STATCOM is a shunt device that injects or absorbs both active and reactive current. It's diagrams are shown in Figs. below, it can be seen that D-STATCOM consists of energy storage and voltage source converter. In this model, D-STATCOM is capable of injecting active power in addition to reactive power. Since energy storage has a capacity limit, it is not capable to inject active power for a long term for voltage regulation purpose Therefore for the steady state application D STATCOM consists of a small dc capacitor and a voltage source converter and the steady state power exchange between D STATCOM and the ac system is reactive power [73, 74].

The single line diagram of two buses of a distribution system and it's phasor diagram are shown in Fig below Generally voltage of buses in the system is less than 1 p.u. and it is desired to compensate voltage of interested bus (V_{oj}) to 1 p.u. by using D STATCOM

In Fig (b) the relationships between voltage and current can be written as

$$V_{0j}\angle\alpha_0 = V_{0i}\angle\delta_0 - (R + jX)I_{0i}\angle\theta_0 \tag{11}$$

$V_{0j}\angle\alpha_0$ Voltage of bus j before compensation

$V_{0i}\angle\delta_0$ Voltage of bus i before compensation

$Z = R + jX$ Impedance between buses i and j

$I_{0L}\angle\theta_0$ Current flow in line before compensation

Voltages V_{oj} and V_{oi} and current $I_{\theta L}$ are derived from load flow calculations.

Subscript L in P_{Li} and Q_{Li} refers to the load connected to each bus.

4.3.2 Feeder and DSTATCOM Modeling by Phasor Diagram method:-

As noted earlier, D-STATCOM is used for voltage regulation in the steady-state condition and can inject only reactive power to the system. Consequently, 'I $_{dstatcom}$ must be kept in quadrature with voltage of the system. By installing D-STATCOM in distribution system, all nodes voltage, especially the neighboring nodes of D-STATCOM location, and branches current of the network change in the steady-state condition. The schematic diagram of buses i and j of the distribution systems, when D-STATCOM is installed for voltage regulation in bus j, is shown in Figs. below. Phasor diagram of these buses with D-STATCOM effects is shown in Fig. after below. Voltage of bus j changes from V_j to V_{jnew} when D-STATCOM is used. For the sake of simplicity, the angle of voltage V_i i.e. is assumed to be zero in phasor diagram. It can be seen from two Figs. that:-

$$\angle I_{D-STATCOM} = \frac{\pi}{2} + \alpha_{new} \quad , \quad \alpha_{new} < 0$$

$$V_{j\ new}\angle\alpha_{new} = V_i\angle\delta - (R + jX)I_L\angle\theta - (R + jX)I_{D-STATCOM}\angle(\alpha_{new} + \frac{\pi}{2}) \tag{12}$$

Where:

$I_{D-STATCOM}\angle(\frac{\pi}{2} + \alpha_{new})$ injected current by D-STATCOM

$V_{j\ new}\angle\alpha_{new}$ voltage of bus j after D-STATCOM installation

$V_i\angle\delta$ voltage of bus i after D-STATCOM installation

$I_L\angle\theta$ Current flow in line after D-STATCOM installation

Voltage V_{jnew} and current I $_{L<\theta}$ are derived from the load flow calculations. Separating the real and imaginary parts of equation (4.12) yields to:-

$$V_{j\ new}\cos\alpha_{new} = Real(V_i\angle\delta) - Real(ZI_L\angle\theta) - RI_{D-STATCOM}\cos(\frac{\pi}{2}+\alpha_{new}) + XI_{D-STATCOM}\sin(\frac{\pi}{2}+\alpha_{new}) \tag{13}$$

and:

$$V_{j\ new}\sin\alpha_{new} = Imag(V_i\angle\delta) - Imag(ZI_L\angle\theta) - XI_{D-STATCOM}\cos(\frac{\pi}{2}+\alpha_{new}) - RI_{D-STATCOM}\sin(\frac{\pi}{2}+\alpha_{new}) \tag{14}$$

Using the notations shown below, equation (4.16) are obtained from equations (4.13),(4.14)

Fig. above shows Single line diagram of two buses of a distribution system with consideration of D-STATCOM

$$\begin{aligned} a_1 &= Real(V_i\angle\delta) - Real(ZI_L\angle\theta) \\ a_2 &= Imag(V_i\angle\delta) - Imag(ZI_L\angle\theta) \\ b &= V_{j\ new} \\ c_1 &= -R \\ c_2 &= -X \\ x_1 &= I_{D-STATCOM} \\ x_2 &= \alpha_{new} \end{aligned} \tag{15}$$

$$\begin{aligned} b\cos x_2 &= a_1 - c_1x_1\sin x_2 - c_2x_1\cos x_2 \\ b\sin x_2 &= a_2 - c_2x_1\sin x_2 + c_1x_1\cos x_2 \end{aligned} \tag{16}$$

where a_1, a_2 and $c_1$and c_2 are constants and b is the magnitude of compensated voltage (for example 1 P.u.) and x_1,x_2 are variables and must be determined Rearranging equation

(3.70) for x_1 yields to:

$$x_1 = \frac{b\cos x_2 - a_1}{-c_1\sin x_2 - c_2\cos x_2} \tag{17}$$

And:

$$x_1 = \frac{b\sin x_2 - a_2}{-c_2 \sin x_2 + c_1 \cos x_2} \tag{18}$$

By equating equations (3.75) and (3.76) it can be shown that:-

$$(a_1c_2 - a_2c_1)\sin x_2 + (-a_1c_1 - a_2c_2)\cos x_2 + bc_1 = 0 \tag{19}$$

Considering x=sinx$_2$ and squaring both sides of equation (4.19). the following equation will be derived:-

$$(k_1^2 + k_2^2)x^2 + (2k_1bc_1)x + (b^2c_1^2 - k_2^2) = 0 \tag{20}$$

where:

$$k_1 = a_1c_2 - a_2c_1$$
$$k_2 = a_1c_1 + a_2c_2$$

Therefore

$$x = \frac{-B \pm \sqrt{\Delta}}{2A} \tag{21}$$

Where:

$$\Delta = B^2 - 4AC$$
$$B = 2k_1bc_1$$
$$A = k_1^2 + k_2^2$$
$$C = b^2c_1^2 - k_2^2$$

After identifying x; $x_2 = \alpha_{new}$ (angle of corrected voltage) is defined as:-

$X_2 = \sin^{-1}x$ (22)

Thus, $x_1 = I_{DSTATCOM}$ is defined by (4.17) or (4.18).

It can be seen from (4.21) there are two roots for x. To determine the correct answer, these roots are examined under the following boundary conditions in the load flow program.

After testing this condition on load flow, $x = \dfrac{-\mathbf{B}-\sqrt{\Delta}}{2A}$ is selected upon feeder data as the correct answer for equation (3.79) and then x_2 and x_1 are calculated from (4.22) and (4.17) ,respectively.

Finally, injected reactive power by DSTATCOM can be written as:-

$$Q_{j\ DSTATCOM} = V_{jnew} .I_{\ DSTATCOM} \tag{23}$$

where:-

$V_{jnew} = V_{jnew} < \alpha_{new}$

$$I_{\ DSTATCOM} = I_{\ DSTATCOM}\ (\ \ \alpha_{new} + \pi /2) \tag{24}$$

Where, symbol ”*” denote conjugate of complex variable.

4.4 Voltage Stability Indicator Method (VSI):-

VSI is derived from voltage equation of the radial distribution system. The proposed indicator is given below considering a line of impedance R+jX is connected between two nodes as shown in the following Fig. below, where i and j are respectively two nodes of the branch and node i is sending end node [V(i)] and node j is receiving end node [V(j)] Therefore, power flow direction is from node i to node j. The load at node j is {P(j)+jQ(j)}. The impedance of the branch is R(i)+jQ(i) If line shunt admittances are neglected, [73, 74] the current flowing through the line is given by:

$$I(i) = \frac{V(i)\angle\theta_i - V(j)\angle\theta_j}{R(i) + jX(i)} \quad \ldots\ldots\ldots\ldots\ldots \tag{25}$$

The complex power is given as :S=VI*

$$I(i) = \frac{P(i) - jQ(j)}{V^*(j)} \quad \ldots\ldots\ldots\ldots\ldots \tag{26}$$

Equating (4.25) and (4.26)

$$\frac{V(i)\angle\theta_i - V(j)\angle\theta_j}{R(i) + jX(i)} = \frac{P(j) - jQ(j)}{V(j)\angle - \theta_j} \quad \ldots\ldots \quad \ldots\ldots \tag{27}$$

$$[V(i)\angle\theta_i - V(j)\angle\theta_j][V(j)\angle - \theta_j] = [P(j) - jQ(j)][R(i) + jX(i)] \quad \ldots\ldots\ldots\ldots \tag{28}$$

Equating real and imaginary parts of (4.28) , we get

$$V(i) * V(j)\cos(\theta_i - \theta_j)V(i)^2 = P(j) * R(i) + Q(j) * X(i) \quad \ldots\ldots\ldots \tag{29}$$

$$X(i) * P(j) - R(i) * Q(j) = V(i) * V(j)sin(\theta_i - \theta_j) \quad \ldots\ldots\ldots \tag{30}$$

As in radial distribution systems voltage angles are negligible, hence $(\theta_i - \theta_j) \approx \mathbf{0}$, equation (4.29), (4.30) becomes

$$V(i) * V(j) - V(j)^2 = P(j) * R(i) + Q(j) * X(i) \quad \ldots\ldots\ldots \tag{31}$$

$$X(i) = \frac{R(i) * Q(j)}{P(j)} \quad \text{……..} \quad (32)$$

From equation (4.31), (4.32)

$$V(j)^2 - V(i) * V(j) + P(j)R(i) + \frac{R(i)Q(j)^2}{P(j)} = 0 \quad \text{……….} \quad (33)$$

$$V(j)^2 - V(i) * V(j) + \frac{R(i)[P(j)^2 + Q(j)^2]}{P(j)} = 0 \quad \text{…………} \quad (34)$$

The roots of equation (4.31) are real if

$$V(i)^2 - \frac{4R(i)\{P(j)^2 + Q(j)^2\}}{P(j)} \geq 0$$

$$\frac{4R(i)\{P(j)^2 + Q(j)^2\}}{V(i)^2 P(j)} \leq 1 \quad \text{……….} \quad (35)$$

Voltage Stability Indicator (VSI)= $\frac{4R(i)\{P(j)^2 + Q(j)^2\}}{V(i)^2 P(j)}$ (36)

Hence equation (4.35) is termed as voltage stability indicator (VSI). For stability of particular node the value of VSI must be VSI<1. The range of VSI values is 0<VSI<1. If the value of VSI approaches or greater than unity, then that node is highly unstable.

5. Conclusions

Reactive power compensation is an important aspect in the control of distribution systems. Reactive current in addition to increasing in the distribution losses, introduces power quality problems like poor load power factor, harmonics distortions and voltage variations. When consumption of electrical energy is high the demand on inductive reactive power increases at the same proportion, in this moment the distribution link (that are well loaded) introduce an extra inductive reactive power beside the voltage on consumers' side will decrease also. Capacitor banks have low time response and it could not absorb reactive power from the distribution feeders.

In this paper DSTATCOM technology is proposed to be connected in the specific typical radial primary feeders (industrial, commercial, residential) load areas and the comparison between them were applied.

This research has several application methods of modeling, simulation, and load flow analysis and rating and best location of DSTATCOM were obtained. The validity of the results has been confirmed through Matlab™ software and the comparisons of different three feeders were obtained. It is observed that from the simulation results as presented in the paper that the DSTATCOM's mode (inductive to capacitive) changes upon changing in the voltage of the Distribution feeder to give fast compensated power within stable terminal voltage.

It was found that the typical (industrial ,commercial ,residential) feeders have gained complete solution for the power quality problems after connecting DSTATCOM at it, but for the typical residential feeder the reactive power is low since DSTATCOM introduced extra power quality improvement. The numerical results shown that the installation of this new technology (DSTATCOM) at specific typical(industrial ,commercial

,residential) feeders, introducing rapidly compensation for reactive power (VARs) and improving voltage drop and reducing power losses beside increasing in power transfer capability.

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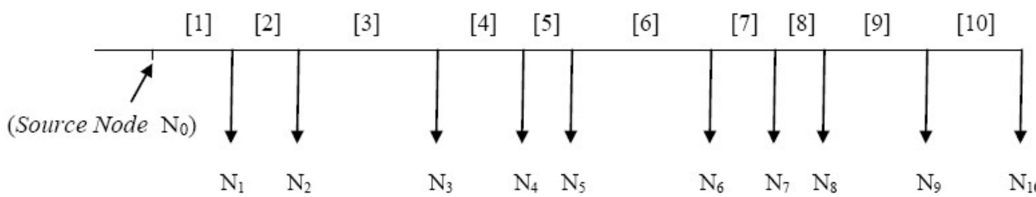

Fig.1: Radial Distribution Feeder

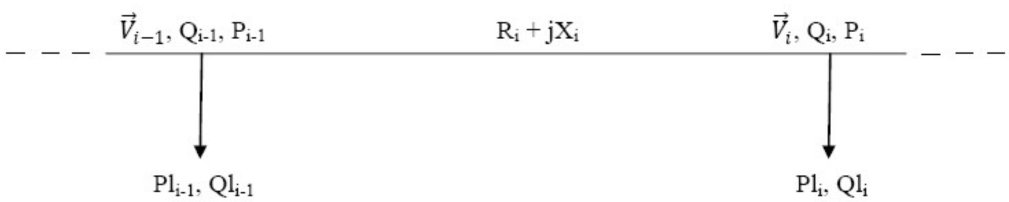

Fig.2: Sending and Receiving Nodes on Feeder

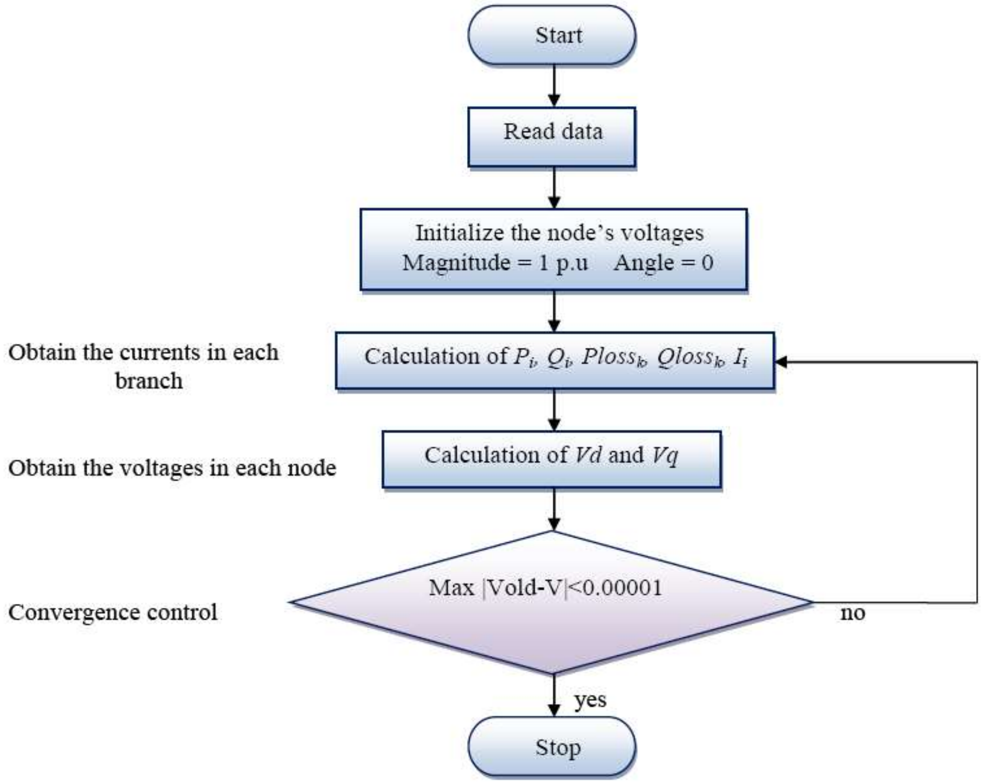

Fig.3 Flow chart of backward Forward sweep load Flow Method.

Fig.4 Types of DSTATCOM (a)with Energy Storage (b)with DC Capacitor

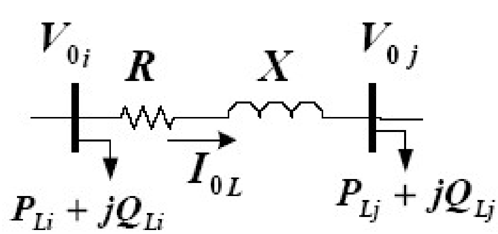

Fig..5 Supply and load Buses On Feeder

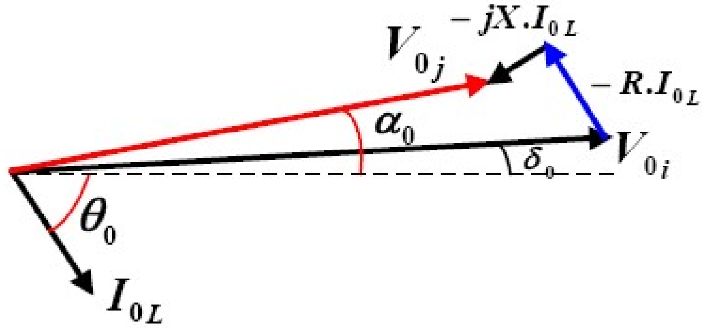

Fig..6 Sending and Receiving Voltage of Feeder

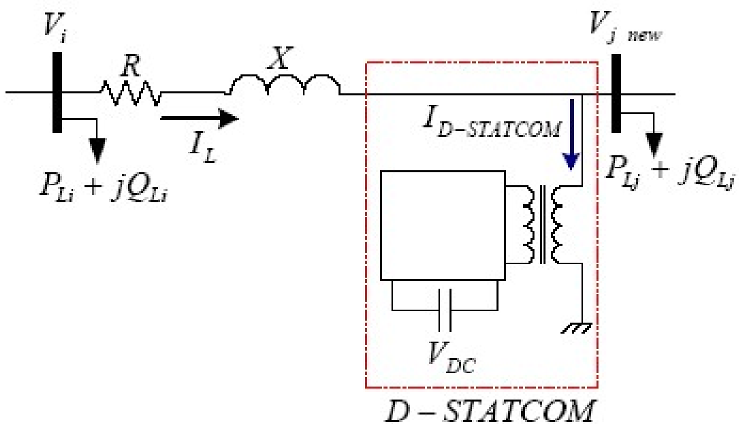

Fig. 7 DSTATCOM Shunted To Radial Distribution Feeder.

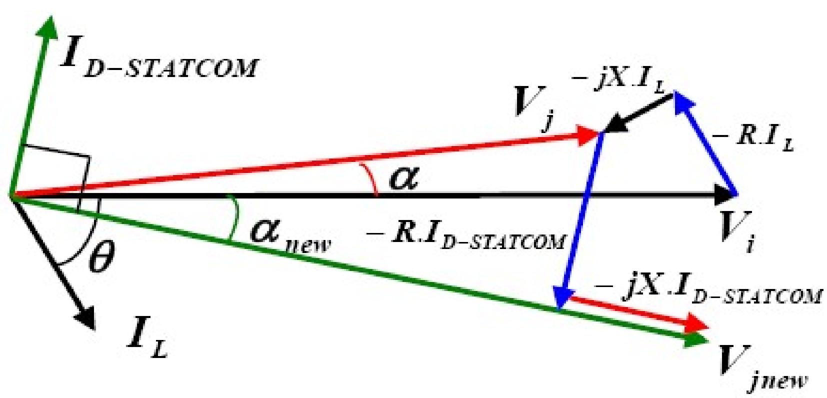

Fig 8. Sending and Receiving Voltage of Feeder with DSTATCOM.

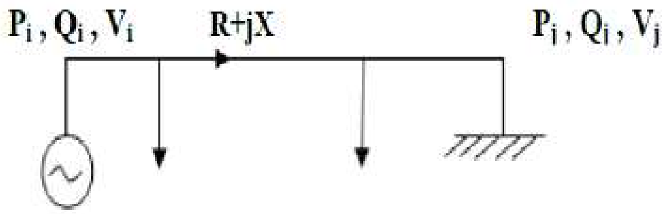

Fig..9 Voltage Stability Indicator for Radial Feeder