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Reliability Indices Evaluation of a Real Time Rural Radial Distribution Feeder

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Abstract: *Estimation of the customer oriented, load and energy orientated indices are very helpful for assess the harshness of the system failure in a radial distribution feeder for the future purpose of prediction analysis. It can be assessed by means past performance of an arrangement. In reality, at the present time, they are extensively used for future presentation. These indices are used in the distribution system operation and planning studies. Distribution system reliability evaluation is a measure of continuity and quality of power supply to the consumers, which mainly depends on interruption profile, based on system topology and component reliability data. The paper primarily presents the real time radial feeder; the reliability is calculated in two stages. One by insertion capacitor at weak voltage nodes for augmentation of voltage profiles and plummeting the total system losses. Second by placing protective apparatus (isolators) in the feeder and enhance the reliability indices. Paper attempts a successful technique for real time valuation of distribution load flow solutions with a goal of obtaining voltage profiles and total system losses. The voltage profiles improvement and reducing losses by placing capacitors at weak voltage profile nodes using Particle Swarm Optimization (PSO) technique. Reliability Indices are premeditated for the existing feeder prior to and after placement of isolator. Load diversity factor is used for analysis of load data for real time system. The paper presents a topological characteristic of a radial distribution feeder have been fully utilized to make the direct load flow solution is possible. This paper also presents an approach that determines optimal location and size of capacitors on existing radial distribution systems to improve the voltage profiles and reduce the active power loss. The performance of the method was investigated on an 11kV real time rural PantramPalli radial distribution feeder as system of case study. A matlab program was developed and results are presented.*

Keywords: *BIBC, BCBV, Diversity Factor, Reliability Indices, Load Flows, PSO.*

I. Introduction

Over the decades the power demand is continuously increasing. Today over 24% (theft apart!!) of the total electrical energy generated in India is lost in Transmission (5-7%) and Distribution (15-18%). The electrical power deficit in the country is currently about 30% yearly but in season of summer more than 50% as on now days. Therefore, it is undoubtedly, reduction in losses can reduce this discrepancy significantly. It is possible to bring down the distribution losses to 6-8% level in India with the help of newer technological options (including information technology) in the Electrical Power Distribution Sector which will enable better monitoring and control [1-6]. The distribution system is a fourth division, which sometimes made is Sub-Transmission system. Electricity distribution is the final stage in the delivery of electricity to end users. A Distribution Network carries electricity from the transmission system and delivers it to consumers. Typically, the network would include medium-voltage (<50kV) power lines, electrical substations and pole-mounted transformers, low-voltage (less than 1000 V) distribution wiring and sometimes electricity meters. Electric power is normally generated at 11-25kV in a power station. To transmit over long distances, it is then stepped-up to 400kV, 220kV or 132kV as necessary. Power is carried through a transmission network of high voltage lines. Usually, these lines run into hundreds of kilometers and deliver the power into a common power pool called the grid. The grid is connected to load centers through a sub-transmission network of normally 33kV (or sometimes 66kV) lines. These lines terminate into a 33kV (or 66kV) substation, where the voltage is stepped-down to 11kV for power distribution to load points through a distribution network of lines at 11kV and lower. The power network, which generally concerns the common man is the distribution network of 11kV lines or feeders downstream of the 33kV substation. Each 11kV feeder which emanates from the 33kV substation branches further into several subsidiary 11kV feeders to carry power close to the load points (localities, industrial areas, villages,etc.,).At these load points, a transformer further reduces the voltage from 11kV to 415V to provide the last mile connection through 415V feeders (Low Tension (LT) feeders) to individual customers, either at 240V (as 1 ph. supply) or at 415V (as 3ph. supply).A feeder could be either an overhead line or an underground cable. In urban areas, owing to the density of customers, the length of an 11kV feeder is generally up to 3 km. On the other hand, in rural areas, the feeder length is much larger (up to 20 km). A 415V feeder should normally be restricted to about 0.5-1.0 km unduly long feeder's lead to low voltage at the consumer end. [20] Over the past few decades distribution systems have considerably less concentration is devoted to reliability modelling than the generating systems. The focal reasons is that generating stations are extremely large capital cost and that generation inadequacy can have terrible penalty for both civilization and its surroundings. Consequently immense importance has been positioned on ensure the sufficiency and meeting the requirements of this part of a power system. A distribution system is relatively cheap and outages have a much confined to a small area effect. Therefore fewer attempts have been dedicated to quantitative evaluation of the sufficiency of various substitute design and reinforcement. The analysis of the client failure information shows most of the utilities that the distribution system makes the maximum individual payment to the unavailability of supply to a purchaser. The reinforce need to be worried with the reliability assessment of distribution systems, to appraise numerically the virtues of various strengthening scheme available to the planner and to ensure that the limited capital resources are used to achieve the maximum possible incremental reliability and improvement in the system. There are number of alternatives are available to the distribution engineer in order to achieve acceptable customer reliability, including substitute reinforcement schemes, allocation of spares, improvement in safeguarding policy, substitute working policy. These problems are now completely recognized and ever-increasing number of utilities [2, 3] during the globe is introducing regularly using quantitative reliability technique. All together, extra valuation technique are being continuously developed and enhanced in this area. The greatest momentum is in the year is 1964—65, when a set of papers [6, 7] was published and proposed a technique based on approximate equations for evaluating the rate and duration of outages. This technique has formed the basis and starting point. The technique is mandatory to examine the distribution system based on the nature of system being measured and the deepness of analysis desired. Measurement of system act is a precious practice for three significant reasons:

(a) It establishes the sequential modifications in system presentation and so helps to recognize feeble areas and the necessity of reinforcement.

(b) It establishes current indices which provide a channel for suitable values in future reliability assessment.

(c) It provides the past prediction and to compare with genuine working knowledge.

II. Diversity Factor And Line Losses

The probability that a particular piece of equipment will come on at the time of the facility's peak load. It is the ratio of the sum of the individual non-coincident maximum demands of various subdivisions of the system to the maximum demand of the complete system. The diversity factor is always greater than 1. The (unofficial) term *diversity*, as distinguished from *diversity factor* refers to the percent of time available that a machine, piece of equipment, or facility has its maximum or nominal load or demand (a 70% diversity means that the device in question operates at its nominal or maximum load level 70% of the time that it is connected and turned on).Diversity factor is commonly used for a number of mathematics-related topics. One such instance is when completing a coordination study for a system. This diversity factor is used to estimate the load of a particular node in the system. The total I^2R loss (P_{Lt}) in a distribution system having n number of branches is given by

$$P_{Lt} = \sum_{i=1}^{n} I_i^2 R_i \text{ --------- } 1$$

Here I_i and R_i are the current magnitude and resistance, respectively, of the i^{th} branch. The branch current can be obtained from the load flow solution. The load flow algorithm described in is used for this purpose. The branch current has two components; active (I_a) and reactive (I_r). The loss associated with the active and reactive components of branch currents can be written as

$$P_{La} = \sum_{i=1}^{n} I_{ai}^2 R_i \text{ -------- } (2)$$

$$P_{Lr} = \sum_{i=1}^{n} I_{ri}^2 R_i \text{ -------- } (3)$$

Note that for a given configuration of a single-source radial network, the loss P_{Lt}, associated with the active component of branch currents cannot be minimized because all active power must be supplied by the source at the root bus. However, the loss P_{Lr} associated with the reactive component of branch currents can be minimized by supplying part of the reactive power demands locally.

III. LOAD FLOW STUDIES

The load-flow study in a power distribution system has great importance because it is the only system which shows the electrical performance and power flow of the system operating under steady state.A load-flow study calculates the voltage drop on each branch, the voltage at each bus, and the power flow in all branch and feeder circuits. Losses in each branch and total system power losses are also calculated. Load-Flow studies are used to determine the system voltages, whether they remain within specified limits, under various contingency conditions, and whether equipment such as transformers and conductors are overloaded. Load-flow studies are often used to identify the need for additional Generation, Capacitive/Inductive VAR support or the placement of capacitors and/or reactors to maintain system voltages within specified limits. An efficient load-flow study plays vital role during planning of the system and also for the stability analysis of the system. Distribution networks have high R/X ratio whereas the transmission networks have high X/R ratio and the distribution networks are ill-conditioned in nature. Therefore, the variables for the load-flow analysis of distribution systems are different from those of transmission system.Many modified versions of the conventional load-flow methods have been suggested for solving power networks with high *R/X* ratio. The following are the effective load flow techniques used in the distribution networks: which are Single-Line Equivalent Method, Very Fast Decoupled Method, Ladder Technique, Power ssummation Method and Backward and Forward Sweeping Method. The proposed algorithm is tested for standard test system on a Real Time system.

IV. FORMULATION OF LOAD FLOW MODEL

(a) *Algorithm development*:

The proposed method is developed based on two derived matrices, the bus-injection to branch-current matrix and the branch current to bus-voltage matrix, and equivalent current injections. In this section, the development procedure will be described in detail. For distribution networks, the equivalent current-injection based model is more practical [5-13]. For bus, the complex load S is expressed by

$$S_i=P_i+jQ_i \qquad \text{------------ (4)}$$

Where i = 1, 2, 3… *N*

And the corresponding equivalent current injection at the –kth iteration of solution is

$$I_i^k=I_i^k(V_i^k)+jI_i^k(V_i^k)=(P_i+jQ_i/V_i^k)^* \qquad \text{--------- (5)}$$

Where V_i^k and $I_i^k$are the bus voltages and equivalent current injection of bus i at k^{th} iteration respectively.

(b) *Relationship Matrix Development*

Simple distribution network shown in fig.1 is used as an example the current equations are obtained from the equation (4) .The relationship between bus currents and branch currents can be obtained by applying Kirchhoff's current law (KCL) to the distribution network. Using the algorithm of finding the nodes beyond all branches proposed by Gosh et al.

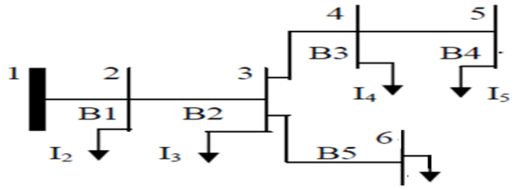


Figure 1. Simple distribution system

A The branch currents then are formulated as functions of equivalent current injections for example branch currents B_1, B_3 and B_5 can be expressed as

$$\left.\begin{aligned} B_1 &= I_2+I_3+I_4+I_5+I_6 \\ B_3 &= I_4+I_5 \\ B_5 &= I_6 \end{aligned}\right\} \qquad \text{------------ (6)}$$

Therefore the relationship between the bus current injections and branch currents can be expressed as

$$\begin{bmatrix} B1 \\ B2 \\ B3 \\ B4 \\ B5 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} I2 \\ I3 \\ I4 \\ I5 \\ I6 \end{bmatrix}$$

Eq (4a) can be expressed in general form as

$$[B]= [BIBC]\ [I] \qquad \text{-------------------- (7)}$$

Where BIBC is a bus injection to branch current matrix, the BIBC matrix is a upper triangular matrix and contains values of 0 and 1 only. The relationship between branch currents and bus voltages as shown in Figure

1. For example, the voltages of bus 2, 3, and 4 are

$$V_2=V_1-B_1Z_{12} \qquad \text{------------ (8a)}$$

$$V_3=V_2-B_2Z_{23} \qquad \text{----------- (8b)}$$

$$V_4=V_3-B_3Z_{34} \qquad \text{----------- (8c)}$$

where V_i is the voltage of bus i, and Z_{ij} is the line impedance between bus i and bus j.
Substituting (8a) and (8b) into (8c) can be rewritten as

$$V_4=V_1-B_1Z_{12}-B_2Z_{23}-B_3Z_{34} \qquad \text{----------- (9)}$$

From (9), it can be seen that the bus voltage can be expressed as a function of branch currents, line parameters, and the bus voltage. Similar procedures can be performed on other buses; therefore, the relationship between branch currents and bus voltages can be expressed as

$$\begin{bmatrix} V1 \\ V1 \\ V1 \\ V1 \\ V1 \end{bmatrix} - \begin{bmatrix} V2 \\ V3 \\ V4 \\ V5 \\ V6 \end{bmatrix} = \begin{bmatrix} Z12 & 0 & 0 & 0 & 0 \\ Z12 & Z23 & 0 & 0 & 0 \\ Z12 & Z23 & Z34 & 0 & 0 \\ Z12 & Z23 & Z34 & Z45 & 0 \\ Z12 & Z23 & 0 & 0 & Z56 \end{bmatrix} \begin{bmatrix} B1 \\ B2 \\ B3 \\ B4 \\ B5 \end{bmatrix} \qquad \text{------- (10)}$$

Equation can be rewritten as Where BCBV is the branch –current to bus voltage (BCBV) matrix.

$$[\Delta v]= [BCBV]\, [B] \qquad \text{----------------- (11)}$$

(*c*) ***Building Formulation Development:***

Observing (7), a building algorithm for BBIBC matrix can be developed as follows:
Step1) For a distribution system with m-branch section and n bus, The dimension of the BIBC matrix is m× (n-1).
Step2) If a line branch (B_i) is located between bus i & bus j, copy the column of the ith bus of the BIBC matrix to the column of the jth bus and fill a 1 to the position of the kth row and the jth bus column.
Step3) Repeat step (2) until all line sections is included in the BIBC matrix. From (10) a building algorithm for BCBV matrix can be developed as follows.
Step 4)For a distribution system with m-branch section and n-k bus, the dimension of the BCBV matrix is (n-1) ×m.
Step 5)If a line section is located between bus i & bus j, copy the row of the ith bus of the BCBV matrix to the row of the jth bus and fill the line impedance (Z) to the position of the jth bus row and the kth column.
Step 6) Repeat step (5) until all line sections is included in the BCBV matrix.
It can also be seen that the building algorithms of the BIBC and BCBV matrices are similar. In fact, these two matrices were built in the same subroutine of our test program. Therefore, the computation resources needed can be saved. In addition, the building algorithms are developed based on the traditional bus-branch oriented database; thus, the data preparation time can be reduced.

(d) ***Solution Technique Developments***

The BIBC and BCBV matrices are developed based on the topological structure of distribution systems. The BIBC matrix represents the relationship between bus current injections and branch currents. The corresponding variations at branch currents, generated by the variations at bus current injections, can be calculated directly by the BIBC matrix. The BCBV matrix represents the relationship between branch currents and bus voltages. The corresponding variations at bus voltages, generated by the variations at branch currents, can be calculated directly by the BCBV matrix. Combining (7) and (11), the relationship between bus current injections and bus voltages can be expressed as

$$[\Delta V] = [BCBV][BIBC][I]=[DLF][I] \qquad \text{--------------(12)}$$

And the solution for distribution power flow can be obtained by solving (12) iteratively

$$I_i^k=I_i^r(V_i^k)+jI_i^i(V_i^k)=((P_i+jQ_i)/V_i^k)^* \qquad \text{--------------(13a)}$$

$$[\Delta V^{k+1}]=[DLF][I^k] \qquad \text{-------------(13b)}$$

$$[V^{k+1}] = [V°] + [\Delta V^{k+1}] \qquad \text{------------ (13c)}$$

According to the research, the arithmetic operation number of LU factorization is approximately proportional to N^3. For a large value of N, the LU factorization will occupy a large portion of the computational time. Therefore, if the LU factorization can be avoided, the power flow method can save tremendous computational resource. From the solution techniques described before, the LU decomposition and forward/backward substitution of the Jacobean matrix or the Y admittance matrix are no longer necessary for the proposed method. Only the DLF matrix is necessary in solving power flow problem. Therefore, the proposed method can save considerable computation resources and this feature makes the proposed method suitable for online operation.

(e)Losses Calculation

The Real power loss of the line section connecting between buses i and i+1is computed as

$$P_{RLOSS}(i,i+1) = R_{i,i+1}\frac{P^2{}_i + Q^2{}_i}{\|V_i\|^2} \qquad \text{----------} \ (14)$$

The Reactive power loss of the line section connecting between buses i and i+1is computed as

$$P_{XLOSS}(i,i+1) = X_{i,i+1}\frac{P^2{}_i + Q^2{}_i}{\|V_i\|^2} \qquad \text{-----------} \ (15)$$

The total Real and Reactive power loss of the feeder P_{FRLOSS} is determined by summing up the losses of all sections of the feeder, which is given by:

$$P_{FRLOSS}(i,i+1) = \sum_{i=1}^{N-1} P_{RLOSS}(i,i+1) \qquad \text{-----------} \ (16)$$

$$P_{FXLOSS}(i,i+1) = \sum_{i=1}^{N-1} P_{X\,LOSS}(i,i+1) \qquad \text{-----------} \ (17)$$

V. RELIABILITY INDICES:

Reliability indices have been evaluated by means of traditional concepts that are average failure rate, average outage duration and average annual outage time. These indices are inference the system behaviour, other reliability indices are regularly evaluated.

(A)*Customer-orientated indices*

(i)System Average Interruption Frequency Index (SAIFI)

The System Average Interruption Frequency Index (SAIFI) is the average number of time that a system customer experiences an outage during the year (or time period under study). The SAIFI is found by divided the total number of customers interrupted by the total number of customers served. SAIFI, which is dimensionless number, is

$$SAIFI = \frac{Total\ number\ of customer\ \text{int}\ eruptions}{Total\ number\ of customers\ served} = \frac{\sum \lambda_i * N_i}{N_i} ....(18)$$

(ii)Customer average interruption frequency index (CAIFI)

It is mostly helpful for a given calendar year is compared with other calendar years, any known calendar year the all the customers are not affected at time for continuity of the supply. The worth of CAIFI is extremely helpful in recognizing sequential trends in the distribution system. Index relevance, the clients affected need to be counted only one time, apart from the number of interruption occur in the year.

$$CAIFI = \frac{Total\ number\ of customer\ \text{int}\ eruptions}{Total\ number\ of customers\ affected} ....(19)$$

(iii)System Average Interruption Duration Index (SAIDI)

The most often used performance measurement for a sustained interruption is the System Average Interruption Duration Index (SAIDI). This index measures the total duration of an interruption for the average customer during a given period. SAIDI is normally calculated on either monthly or yearly basis; however, it can also be calculated daily, or for any other period. To calculate SAIDI, each interruption during the time period is multiplied by the duration of the interruption to find the customer-minutes of interruption. The customer-minutes of all interruptions are then summed to determine the total customer-minutes. The formula is,

$$SAIDI = \frac{Sum\ of\ customer\ \text{int}\ erption\ duration}{Total\ number\ of customers} = \frac{\sum U_i * N_i}{\sum N_i} ....(20)$$

To find the SAIDI value, the customer-minutes are divided by the total customers. Where U_i=Annual outage time, Minutes, N_i=Total Number of customers of load point i. SAIDI is measured in units of time, often minutes or hours. It is usually measured over the course of a year, and according to IEEE Standard 1366-1998 the median value for North American utilities is approximately 1.50 hours.

(iv)Customer Average Interruption Duration Index (CAIDI)

Once an outage occurs the average time to restore service is found from the Customer Average Interruption Duration Index (CAIDI). CAIDI is calculated similar to SAIDI except that the denominator is the number of customers interrupted versus the total number of utility customers. CAIDI is,

$$CAIDI = \frac{Sum\ of\ customer\ \mathrm{int}\ erption\ duration}{Total\ number\ of\ customer\ \mathrm{int}\ eruptions} = \frac{\sum U_i * N_i}{\sum \lambda_i * N_i} ....(21)$$

Where U_i=Annual outage time, Minutes, N_i= Total Number of customers of load point i. λ_i=Failure Rate. CAIDI is measured in units of time, often minutes or hours. It is usually measured over the course of a year, and according to IEEE Standard 1366-1998 the median value for North American utilities is approximately 1.36 hours.

$$SAIFI = \frac{Total\ number\ of\ customer\ \mathrm{int}\ eruptions}{Total\ number\ of\ customers} = \frac{\sum \lambda_i * N_i}{\sum N_i} ....(22)$$

$$SAIFI = \frac{SAIDI}{CAIDI} ....(23)$$

Where N_i=Total Number of customers interrupted. λ_i=Failure Rate. SAIFI is measured in units of interruptions per customer. It is usually measured over the course of a year, and according to IEEE Standard 1366-1998 the median value for North American utilities is approximately 1.10 interruptions per customer.

(v)Average Service Availability Index (ASAI)

The Average Service Availability Index (ASAI) is the ratio of the total number of customer hours that service was available during a given period of the total customer hours demanded. This is sometimes called the service reliability index. The ASAI is usually calculated on either a monthly basis (730 hours) or a yearly basis (8,760 hours), but can be calculated for any time period. The ASAI is found as,

$$ASAI = \left(\frac{\sum (N_i * T) - \sum U_i * N_i}{(\sum N_i * T} \right) *100.........(23)$$

$$\text{ASUI=1-ASAI} \qquad .... \quad (24)$$

Where T= Time period under study, hours. r_i=Restoration Time, Minutes, N_i=Total Number of customers interrupted., N_T=Total Customers served.

(B)Load- and energy-orientated indices

The important parameter required to found load and energy oriented indices is

(i) Average Load (L_a)

$$L_a = L_p *f................ (25)$$

Where L_p peak load, f=Load factor or

$$L_a = \frac{\text{total energy demanded in period of interest } (L_d)}{\text{Period of interest (t)}}$$

(ii)Average Energy Not Supplied (AENS)

This is also called as Average System Curtailment Index (ASCI)

$$AENS = \frac{Total\ energy\ not\ \mathrm{sup}\ plied}{Total\ number\ of\ customers\ served} = \frac{\sum L_{a(i)} * U_i}{\sum N_i} ....(26)$$

(iii) Energy not supplied index (ENS)

$$\text{ENS= total energy not supplied by the system} = \sum L_{a(i)} * U_i..............(27)$$

VIII. INVESTIGATED REAL TIME SYSTEM & RESULTS

In this article a real time radial feeder is considered which is Pantram Palli (Rural feeder) located at Santha pet 33kV substation in Chittoor(Dt),Andhra Pradesh, India. The feeder is very lengthy and bulk number of customers are present, the feeder not installed by any capacitor banks for reactive power compensation. At the outlook, the demand may increases on feeder then which may cause to installed the capacitor banks by using PSO technique. Real time radial feeder system data Base Voltage = 11KV. Base MVA=100. Conductor type = AAA Conductor Resistance = 0.55 ohm/KM., Reactance = 0.351 ohm/KM. Matlab was chosen as the simulation tool for this research because of the ease of manipulation of matrix structures and inputs, PSO for placement of capacitor to analyzing the results for Radial Distribution feeder. To show the effeteness of the projected idea, a 47-node 11kV PantramPalli Rural distribution feeder is selected. The original and modified lay out of the system is shown in below figure 2 and 3. Line data and Load data for this feeder is shown in Table I & II.

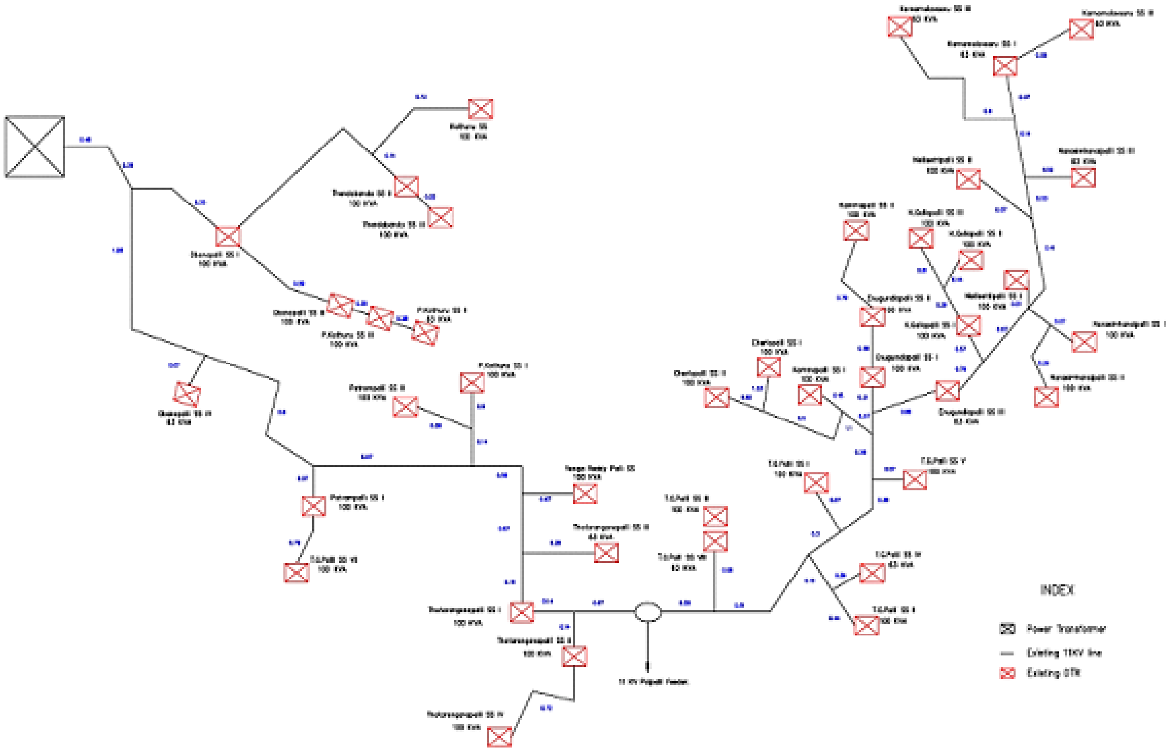
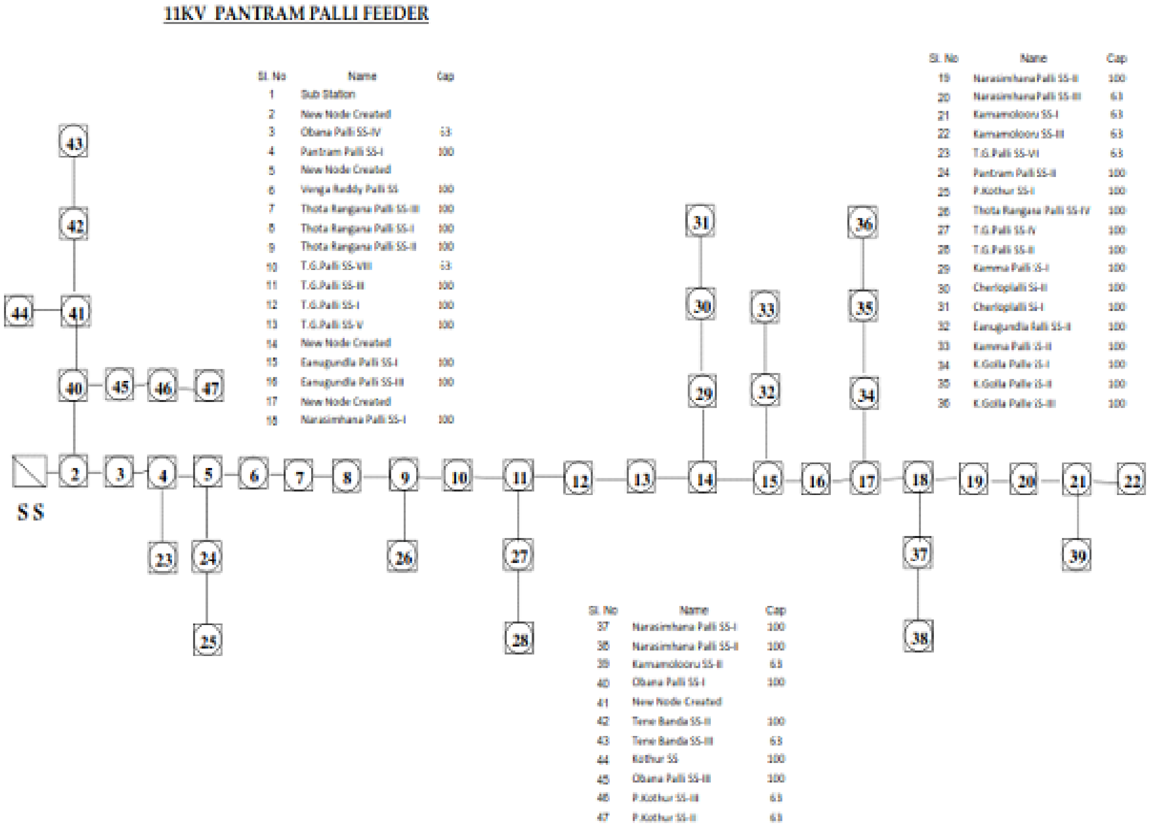


Figure 2 original Layout of the Pantram Palli feeder



Sl. No	Name	Cap
1	Sub Station	
2	New Node Created	
3	Obana Palli SS-IV	63
4	Pantram Palli SS-I	100
5	New Node Created	
6	Venga Reddy Palli SS	100
7	Thota Rangana Palli SS-III	100
8	Thota Rangana Palli SS-I	100
9	Thota Rangana Palli SS-II	100
10	T.G.Palli SS-VIII	63
11	T.G.Palli SS-III	100
12	T.G.Palli SS-I	100
13	T.G.Palli SS-V	100
14	New Node Created	
15	Eanugundla Palli SS-I	100
16	Eanugundla Palli SS-III	100
17	New Node Created	
18	Narasimhana Palli SS-I	100

Sl. No	Name	Cap
19	Narasimhana Palli SS-II	100
20	Narasimhana Palli SS-III	63
21	Kamamolooru SS-I	63
22	Kamamolooru SS-III	63
23	T.G.Palli SS-VI	63
24	Pantram Palli SS-II	100
25	P.Kothur SS-I	100
26	Thota Rangana Palli SS-IV	100
27	T.G.Palli SS-IV	100
28	T.G.Palli SS-II	100
29	Kamma Palli iS-I	100
30	Cherlopllalli Si-II	100
31	Cherlopllalli Si-I	100
32	Eanugundla Palli SS-II	100
33	Kamma Palli iS-II	100
34	K.Golla Palle iS-I	100
35	K.Golla Palle iS-II	100
36	K.Golla Palle iS-III	100

Sl. No	Name	Cap
37	Narasimhana Palli SS-I	100
38	Narasimhana Palli SS-II	100
39	Kamamolooru SS-II	63
40	Obana Palli SS-I	100
41	New Node Created	
42	Tene Banda SS-II	100
43	Tene Banda SS-III	63
44	Kothur SS	100
45	Obana Palli SS-III	100
46	P.Kothur SS-III	63
47	P.Kothur SS-II	63

Figure 3: Pantram Palli Feeder after rearrange as per Standered Test System

Table I. Line data of PantramPalli Feeder

Branch No	From Node	To Node	Distance Between Nodes(KM)	R (Ohm/KM)	X (Ohm/KM)	R (OHMS)	X (OHMS)
1	1	2	0.83	0.55	0.351	0.4565	0.2913
2	2	3	1.25	0.55	0.351	0.6875	0.4388
3	3	4	0.8	0.55	0.351	0.4400	0.2808
4	4	5	0.87	0.55	0.351	0.4785	0.3054
5	5	6	0.56	0.55	0.351	0.3080	0.1966
6	6	7	0.67	0.55	0.351	0.3685	0.2352
7	7	8	0.15	0.55	0.351	0.0825	0.0527
8	8	9	0.14	0.55	0.351	0.0770	0.0491
9	9	10	0.36	0.55	0.351	0.1980	0.1264
10	10	11	0.51	0.55	0.351	0.2805	0.1790
11	11	12	0.3	0.55	0.351	0.1650	0.1053
12	12	13	0.36	0.55	0.351	0.1980	0.1264
13	13	14	0.38	0.55	0.351	0.2090	0.1334
14	14	15	0.28	0.55	0.351	0.1540	0.0983
15	15	16	0.66	0.55	0.351	0.3630	0.2317
16	16	17	0.79	0.55	0.351	0.4345	0.2773
17	17	18	0.07	0.55	0.351	0.0385	0.0246
18	18	19	0.41	0.55	0.351	0.2255	0.1439
19	19	20	0.53	0.55	0.351	0.2915	0.1860
20	20	21	0.14	0.55	0.351	0.0770	0.0491
21	21	22	0.13	0.55	0.351	0.0715	0.0456
22	2	40	0.35	0.55	0.351	0.1925	0.1229
23	40	41	1.5	0.55	0.351	0.8250	0.5265
24	41	42	0.14	0.55	0.351	0.0770	0.0491
25	42	43	0.22	0.55	0.351	0.1210	0.0772
26	41	44	0.73	0.55	0.351	0.4015	0.2562
27	40	45	0.59	0.55	0.351	0.3245	0.2071
28	45	46	0.35	0.55	0.351	0.1925	0.1229
29	46	47	0.28	0.55	0.351	0.1540	0.0983
30	4	23	0.79	0.55	0.351	0.4345	0.2773
31	5	24	0.14	0.55	0.351	0.0770	0.0491
32	24	25	0.8	0.55	0.351	0.4400	0.2808
33	9	26	0.72	0.55	0.351	0.3960	0.2527
34	11	27	0.15	0.55	0.351	0.0825	0.0527
35	27	28	0.44	0.55	0.351	0.2420	0.1544
36	14	29	1.1	0.55	0.351	0.6050	0.3861
37	29	30	0.5	0.55	0.351	0.2750	0.1755
38	30	31	1.23	0.55	0.351	0.6765	0.4317
39	15	32	0.56	0.55	0.351	0.3080	0.1966
40	32	33	0.79	0.55	0.351	0.4345	0.2773
41	17	34	0.57	0.55	0.351	0.3135	0.2001
42	34	35	0.29	0.55	0.351	0.1595	0.1018
43	35	36	0.81	0.55	0.351	0.4455	0.2843
44	18	37	0.07	0.55	0.351	0.0385	0.0246
45	37	38	0.29	0.55	0.351	0.1595	0.1018
46	21	39	0.9	0.55	0.351	0.4950	0.3159

Table II Load data for the feeder (unity D.F &0.8P.F)

Bus No	P KW	Q KVAR	Bus No	P KW	Q KVAR
1	0	0	25	89.15	85.92
2	0	0	26	67.51	47.12
3	44.26	39.47	27	44.39	33.29
4	111.90	114.16	28	113.77	116.06
5	0	0	29	82.06	79.09
6	88.77	85.57	30	57.44	40.09
7	38.42	25.82	31	97.35	99.32
8	78.70	73.68	32	102.58	104.65
9	67.51	47.12	33	70.12	48.95
10	7.46	3.82	34	56.70	39.57
11	47.74	35.81	35	70.87	72.30
12	50.36	35.15	36	52.22	36.45
13	51.10	39.66	37	80.94	82.58
14	0	0	38	54.46	38.01
15	58.19	40.62	39	43.64	32.73
16	54.83	38.27	40	61.92	41.61
17	0	0	41	0	0
18	80.94	82.58	42	66.02	46.08
19	54.46	38.01	43	49.24	47.46
20	33.57	21.68	44	76.84	74.06
21	38.05	25.57	45	42.90	27.71
22	42.12	42.44	46	41.03	28.64
23	44.76	35.91	47	37.67	26.30
24	89.52	91.33			

IX. Results:

(a)Load Flow Results

By considering Diversity Factor and Power Factor the load data of PantramPalli feeder is tabulated in Table II. The load flow calculations are performed to get the voltages at each node & the total power losses. The voltage profiles, the power losses are obtained by solving the simple algebraic equations which are section IV.

Table III Voltage profiles

Bus No	Power Summation Method	BIBC & BCBV	Bus No	Power Summation Method	BIBC & BCBV
1	1.0000	1.0000	25	0.9354	0.9352
2	0.9839	0.9838	26	0.9157	0.9153
3	0.9629	0.9626	27	0.9061	0.9055
4	0.9496	0.9494	28	0.9057	0.9051
5	0.9363	0.9360	29	0.8959	0.8939
6	0.9285	0.9282	30	0.8957	0.8933
7	0.9197	0.9193	31	0.8953	0.8923
8	0.9177	0.9173	32	0.8937	0.8933
9	0.9160	0.9156	33	0.8931	0.8929
10	0.9119	0.9115	34	0.8870	0.8860
11	0.9062	0.9057	35	0.8866	0.8857
12	0.9033	0.9028	36	0.8858	0.8854
13	0.8999	0.8995	37	0.8869	0.8865
14	0.8965	0.8961	38	0.8865	0.8864
15	0.8945	0.8941	39	0.8848	0.8848
16	0.8911	0.8906	40	0.9834	0.9829
17	0.8873	0.8868	41	0.9827	0.9808
18	0.8870	0.8866	42	0.9826	0.9807

19	0.8864	0.8859	43	0.9824	0.9806
20	0.8857	0.8852	44	0.9825	0.9804
21	0.8856	0.8851	45	0.9829	0.9824
22	0.8855	0.8851	46	0.9827	0.9822
23	0.9475	0.9491	47	0.9826	0.9821
24	0.9361	0.9358			

The load flow calculations are done by using two methods, one by Power summation method and another by BIBC & BCBV method. Where the voltage results are tabulated in Table III. The voltages magnitudes at nodes are equal in both the methods. The real and reactive power losses for both the methods are tabulated in Table IV. The losses are similar for both the methods.

The nodes which are close to the source are having the higher voltage magnitude is the nodes that are far-away from the source are of lower voltage magnitude (due to higher drop in voltage).The radial diagram of 47-node PantramPalli feeder shown in Figure 2 or 3 is having 9-laterals to the main feeder. The first lateral (40, 41, 42, and 43) and the second lateral (45, 46, and 47) are close to the source, so the voltage magnitudes at each node are higher (Table 5.44). Whereas the third lateral (29, 30, 31) are having lower voltage magnitudes (<0.95 p.u), as they are far away from the source. Similarly the remaining laterals are having lower voltage magnitudes as they are far away from the source. From Table III, it can be found that the following nodes are sensitive as the voltages are less than 0.95 pu.

The nodes that required for compensation are Nodes: 5,4,7,6,11,10,17,16,14,13,12,15,23,8,9, 32,36,39,25,33,19,20,29,31,35,38,28,26,34,18,24,37,21,30,27,22Voltages can be improved by placing capacitor at single node or by placing capacitor at multiple nodes. By using Particle Swarm Optimization Technique. The capacitors are placed at multiple nodes and the voltage profiles are shown in figure 4 & 5. Compensated Nodes by using PSO are tabulated in Table IV

Table III Losses by BIBC & BCBV Method and Power Summation Method

Power Summation Method Losses			BIBC & BCBV Method Losses		
TLP =	261.0808	KW	TLP =	261.7033	KW
TLQ =	166.6277	KVAR	TLQ =	167.0251	KVAR
TL =	427.7086	KW	TL =	428.7283	KW

By placing the 2.2MVAR capacitor bank at 5th node the voltage profiles are shown in Figure IV and V. The status of networks before and after compensation for single placement of 2.2MVAR capacitor at node 5 and multiple placement of capacitor using PSO at nodes 22nd, 29th and 8th are shown in Table V. From Table V, it can be found that after placing 2.2MVAR at node 5, there are still some sensitive nodes which are required for compensation and it can be found that, the same 2.2MVAR is distributed at 3 nodes and are placed using Particle Swarm Optimization Technique. There is no node have low voltage (<0.95 p.u) profile. From table its is noted that the power losses are also still reduced for single and multiple placement.

Hence it is shows the multiple placement is proffered. The real time losses are shown in Table VI. These losses are compared with losses obtained by using BIBC & BCBV and power summation method are tabulated in table VII, Energy losses are computed using BIBC & BCBV and Power summation method and also real time energy losses from substation are calculated. It is observed that the computed energy losses closely match ing the calculated energy (real time data) losses. The voltage profile for single and multiple placement using PSO

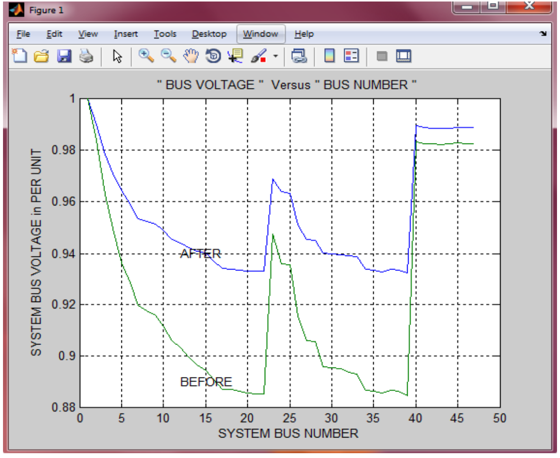


Figure 4. Voltage profiles

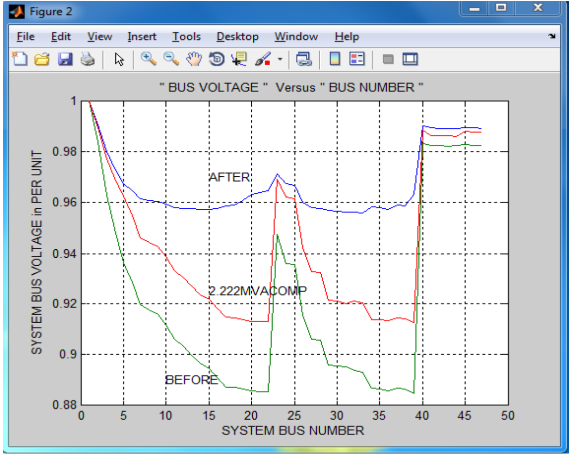


Figure 5. Voltage profiles

Table IV Injected Reactive Power using PSO at different nodes

Nodes Compensated=22,8& 29		
Best Node 22	Global Best Particle=	1176 KVAR
Best Node8	Global Best Particle=	=-919 KVAR
Best Node 29	Global Best Particle=	=-201 KVAR

Table V Status of Networks before and After Compensation

Single Placement Of Capacitor	Multiple Placement Of Capacitor
Status Of Network Before Compensation	Status Of Network Before Compensation
Base_Reactive_Loss = 166.6277kvar	Base_Reactive_Loss = 166.6277kvar
Base_Real_Loss= 261.0808kw	Base_Real_Loss= 261.0808kw
Before_Min_V=0.8848	Before_Min_V=0.8848
Rank= 5,4,7,6,11,10,17,16,14,13,12,15,23,8, 9,32,3639,25,33,19,20,29,31,35,38,28,26,34, 18,24,37,21,30,27,22	Rank= ,4,7,6,11,10,17,16,14,13,12,15,23,8, 9,32,36,39,25,33,19,20,29,31,35,38,28,26, 34,18,24,37,21,30,27,22
Status Of Network After Compensation	Status Of Network After Compensation
Comp_Reactive_Loss=114.8005 Kvar	Comp_Reactive_Loss=93.1050 Kvar
Comp_Real_Loss=179.8725 Kw	Comp_Real_Loss=175.8725 Kw
After_Min_V=0.9128	After_Min_V=0.9559
Rank=7,8,9,10,11,12,13,14,15,16,17,18,19, 20,21,22,26,27,28,29,30,31,32,33,34,35,36, 37,38,39	Rank=0

Table VI. Technical Losses from Substation

Units Sent Out From The 11k.V. System					**472000**	Units	
Average Demand					793.01075	KVA	*
Peak Demand During The Month (290amp)					**5525.2421**	KVA	
Load Factor Of The Month					0.1435251		
DISTRIBUTION Tr. IN THE 11kV SYSTEM							
No. DTRS		**Rating**		**Total**			
`31		100	KVA	3100			
10		63	KVA	630			
Total KVA				3730			
IRON LOSSES WHEN THE DEMAND IS EQUAL TO TOTAL TRANSFORMER CAPACITY							
100	KVA	31	No.S	450	Watts	13950	
63	KVA	10	No.S	350	Watts	3500	
		Total Iron Losses				17450	
COPPER LOSSES WHEN THE DEMAND IS EQUAL TO TOTAL TRANSFORMER CAPACITY							
100	KVA	31	No.S	2000	Watts	62000	
63	KVA	10	No.S	1320	Watts	13200	
		Total Copper Losses				75200	
11kv Line Losses As Per PPL Statement					332749	**Watts**	
Maximum Demand During The Month					5525.2421	KVA	
Total Transformer Capacity					3730	KVA	
Ratio Of Maximum Demand To The Tr Capacity					1.4812981		
Tr. Cu Losses(Corrected To Demand)					165007.16	Watts	
Line Cu Losses(Corrected To Demand)					730132.56	Watts	
LEAST LOSS FACTOR							
Llf=0.8x(Lf*Lf)+0.2(Lf)					0.0574771		
Corrected Tr. Cu Losses(Actual Loading Condition)=						9484.139	Watts
Corrected Line Cu Losses(Actual Loading Condition)=						41965.93	Watts
Units Handled During The Month=						472000	Units
Units Billed During The Month=						204000	Units
Actual Losses In 11kv Line,Tr =						268000	Units
Total Tr.Losses=Iron Losses+Copper Losses=						182457.16	Watts
Total Tr.Losses For One Month=Total Tr Lossesx24x31days=						135748.13	Kwh
%Of Transformer Losses=						28.76	%
Total11kv Line Losses=						41965.93	Watts
11kv Line Losses For One Month=Total 11kv Lossesx24x31days=						31222.65	Kwh
%Of 11kv Line Losses=						6.61	%
Total Loss=Tr. Loss+11kv Line Loss=						**35.38**	**%**

Table VII. Losses comparison between Load Flow Methods and PPL Sheet

PANTRAMPALLI					
Power Summation Method Losses			**BIBC & BCBV Method Losses**		
TLP =	261.0808	KW	TLP =	261.7033	KW
TLQ =	166.6277	KVAR	TLQ =	167.0251	KVAR
TL =	427.7086	KW	TL =	428.7283	KW
Energy Loss =(TLP*24*31)=	194244	Units	**Energy Loss =(TLP*24*31)**	194707	Units
= 41.15	%		=	41.25	%
Energy Loss as per PPL Sheet=		35.38% of 472000	166993.6	Units	
		=	35.38	%	

(b) Reliability indices evaluation
Interruption Data

Table VIII Details of Distribution System

Load Points	**No of Customers**	**Total Connected Load(KW)**	**Average Connected load(KW)**	**Load Points**	**No of Customers**	**Total Connected Load(KW)**	**Average Connected load(KW)**
1	0	0.00	0	25	18	89.15	4.9528
2	0	0.00	0.0000	26	13	67.51	5.1931
3	9	44.76	4.9733	27	21	44.39	2.1138
4	18	111.90	6.2167	28	26	113.77	4.3758
5	0	0.00	0.0000	29	18	82.06	4.5589
6	22	88.77	4.0350	30	12	57.44	4.7867
7	8	38.42	4.8025	31	24	97.35	4.0563
8	14	78.70	5.6214	32	24	102.58	4.2742
9	11	67.51	6.1373	33	22	70.12	3.1873
10	1	7.46	7.4600	34	19	56.70	2.9842
11	10	47.74	4.7740	35	12	70.87	5.9058
12	10	50.36	5.0360	36	11	52.22	4.7473
13	11	51.10	4.6455	37	14	80.94	5.7814
14	0	0.00	0.0000	38	12	54.46	4.5383
15	15	58.19	3.8793	39	13	43.64	3.3569
16	8	54.83	6.8538	40	11	61.92	5.6291
17	0	0.00	0.0000	41	0	0.00	0.0000
18	14	80.94	5.7814	42	15	66.02	4.4013
19	12	54.46	4.5383	43	13	49.24	3.7877
20	7	33.57	4.7957	44	18	76.84	4.2689
21	8	38.05	4.7563	45	7	42.90	6.1286
22	13	48.12	3.7015	46	6	41.03	6.8383
23	10	44.76	4.4760	47	5	37.67	7.5340
24	15	89.52	5.9680				

Table IX Interruption effect in a calendar year (without isolator)

Interruption Case	**Load Point Affected**	**Duration (hrs)**	**Cause of Interruption**
1	18,19,20,21 22,27,28	8	DTR failure and for replacement
2	12,13,14,15 16,17,18,19,20, 21,22,29,30 31,32,33,27, 28,34,35,36	24	Line Failure Due to Heavy Wind and Gail
3	28	4	DTR failure and for replacement
4	25	2	DTR failure and for replacement
5	40,45,46,47 44,42,43	6	Line Fault Due to 11KV Insulator damage

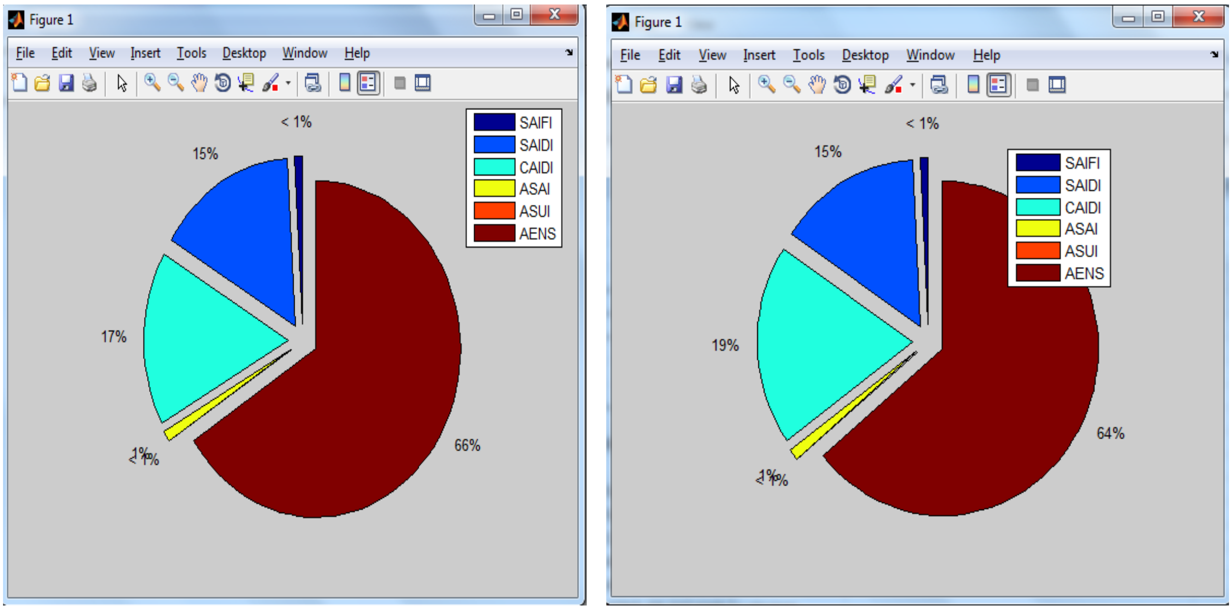
Table X. Distribution System reliability Indices

Distribution System Reliability Indices
SAIFI=0.922 interruptions/customer
SAIDI=15.065 hrs/customer
CAIDI=15.065 hrs/customer interruption
ASAI=0.998280
ASUI=0.001720
AENS=64.372 KWh/customer

The details of the distribution system are shown in Table VII. There are 5 interruption cases during the year 2011-2012 (Table IX). When the feeder was not provided with isolators, 37 load points got affected during the 5 interruptions. The Distribution System Reliability Indices are calculated by section V and are tabulated in Table X and the percentage of indices is represented in pie chart as shown in Figure VI (a).When the feeder is provided with isolator at 20th ode, the load point 18 will only be affected and the load points affected are reduced from 37 to 31 (Table XI) during 5 interruption cases. Distribution Reliability Indices are shown in Table XII. The percentage of indices is represented in pie chart as shown in Figure VI (b). When the feeder is not provided with isolator the Average Energy Not Supplied (AENS) is 64.372 KWh/Customer. When the feeder is provided with isolator at 18th node the Average Energy Not Supplied (AENS) is reduced to 59.537 KWh/Customer.

Table XI: Interruption effect in a calendar year (with isolator at 20th node)

Interruption Case	**Load Point Affected**	**Duration (hrs)**	**Cause of Interruption**
1	18	8	DTR failure and for replacement
2	12 13,14, 15,16,17, 19,20,21 22,29,30 31,32,33 27,28,34 35,36, 18	24	Line Failure Due to Heavy Wind and Gail
3	28	4	DTR failure and for replacement
4	25	2	DTR failure and for replacement
5	40	6	Line Fault Due to 11KV Insulator damage
	45,46,47	6	
	44,42,43	6	



(a) (b)

Figure VI Indices in Pie chart with and with out isolator

Table XII. Distribution System Reliability Indices (with isolator)

Distribution System Reliability Indices
SAIFI=0.764 interruptions/customer
SAIDI=13.800 hrs/customer
CAIDI=13.800 hrs/customer interruption
ASAI=0.998425
ASUI=0.001575
AENS=59.537 KWh/customer

X. CONCLUSIONS

Load is not constant throughout the day; it varies from time to time. By considering the terms Diversity factor and Power Factor single conditions are considered for framing load data for performing load flow analysis. The conditions are namely unity DF and poor PF. During the peak demand covered over a month, by considering terms Load Factor (LF) and Loss Load factor (LLF) real time losses of feeder from substation are calculated for comparison with load flow losses. In this Paper distribution load flow analysis was done by using forward sweep through BIBC & BCBV technique. By considering Load Factor (LF) and Loss Load Factor (LLF), real time losses of feeder from substation are calculated. The losses obtained by using load flow methods and are verified by comparing them with real time losses of feeder from substation. Nodes having voltages less than 0.95 p.u are stored in a rank vector. Those nodes are suggested for capacitor placement. Capacitor can be placed with highest capacity at single node or distributing the same capacity at multiple nodes using PSO technique. Distribution System reliability Indices are calculated for before and after placement of isolator. Average Energy Not Supplied (AENS) for rural feeder is less when compared with rural feeder. Summing up, it is observed that the distribution reliability of rural feeder is improved by placing capacitors at appropriate nodes and isolators in the feeder.

REFERENCES

[1] K.Prakash, M.Sydulu, "Partical Swarm Optimization Based Capacitor Placement on Radial Distribution System",Power Engineering Society, IEEE General Meeting - PES , pp. 1-5, 2007

[2] A.A.A. Esmin and G. Lambert-Torres, "A Particle Swarm Optimization Applied to Loss Power Minimization", IEEE Transactions on Power Systems, USA, vol. 20, no. 2, pp. 859-866, 2005.

[3] S.Gosh and D.Das, "Method for load-flow solution of radial distribution networks", IEE Proc.-Gener. Transm.Distrib... Vol. 146, No. 6, November 1999.

[4] N. Balijepalli, S. S. Venkatah, and R. D. Christie, "Modeling and analysis of distribution reliability indices", IEEE Trans. Power Del., vol.19, no. 4, pp. 1950–1955, Oct. 2004.

[5] J. H. Teng andW. M. Lin, "Current-based power flow solutions for distribution systems," in Proc. IEEE Int. Conf. Power Syst. Technol., Beijing, China, 1994, pp. 414–418.

[6] T. S. Chen, M. S. Chen, T. Inoue, and E. A. Chebli, "Three-phase cogenerator and transformer models for distribution system analysis," IEEE Trans. Power Delivery, vol. 6, pp. 1671–1681.2, Oct. 1991.

[7] T.-H. Chen, M.-S. Chen, K.-J. Hwang, P. Kotas, and E. A. Chebli, "Distribution system power flow analysis—A rigid approach," IEEE Trans. Power Delivery, vol. 6, pp. 1146–1152, July 1991.

[8] K. A. Birt, J. J. Graffy, J. D. McDonald, and A. H. El-Abiad, "Three phase load flow program," IEEE Trans. Power Apparat. Syst., vol. PAS.95, pp. 59–65, Jan./Feb. 1976.

[9] Smarajit Ghosh , Karma Sonam Sherpa" An Efficient Method for Load Flow Solution of Radial Distribution Networks", International Journal of Electrical and Electronics Engineering,Vol.2.pp 636-647, September 2008.

[10] D. Shirmohammadi, H. W. Hong, A. Semlyen, and G. X. Luo, "A compensation- based power flow method for weakly meshed distribution and transmission networks," IEEE Trans. Power Syst., vol. 3, pp. 753– 762, May 1988.

[11] G. X. Luo and A. Semlyen, "Efficient load flow for large weakly meshed networks," IEEE Trans. Power Syst., vol. 5, pp. 1309–1316, Nov. 1990.

[12] C. S. Cheng and D. Shirmohammadi, "A three-phase power flow method for real-time distribution system analysis," IEEE Trans. Power Syst., vol. 10, pp. 671–679, May 1995.

[13] R. D. Zimmerman and H. D. Chiang, "Fast decoupled power flow for unbalanced radial distribution systems," IEEE Trans. Power Syst., vol. 10, pp. 2045–2052, Nov. 1995.

[14] W. M. Kersting and L. Willis, "Radial Distribution Test Systems, IEEE Trans. Power Syst.", vol. 6, IEEE Distribution PlanningWorking Group Rep., Aug. 1991.

[15] M. E Baran and F. F. Wu, "Optimal Sizing of Capacitors Placed on a Radial Distribution System", IEEE Trans. Power Delivery, vol. no.1, pp. 1105-1117, Jan. 1989.

[16] M. E. Baran and F. F. Wu, "Optimal Capacitor Placement on radial distribution system," IEEE Trans. Power Delivery, vol. 4, no.1, pp. 725734, Jan. 1989.

[17] M. H. Haque, "Capacitor placement in radial distribution systems for loss reduction," IEE Proc-Gener, Transm, Distrib, vol, 146, No.5, Sep. 1999.

[18] R.Billinton and J. E. Billinton, "Distribution system reliability indices," IEEE Trans. Power Del., vol. 4, no. 1, pp.561–586, Jan. 1989.

[19] IEEE Standards, "IEEE Guide for Electric Power Distribution Reliability Indices", IEEE Power Engineering Society.

[20] Robert J.Rusch and David L.Metz, " Customer Oriented Reliability Indices and Data Collection", Stanley Consultants, Muscatine,IA 52761.

[21] Roy Billinton and Ronald N.Allan, A Text Book on "Reliability Evaluation of Power Systems" 2nd Edition, Plenum Press, New York and London.

[22] S. Ghosh and D. Das, "Method for load-flow solution of radial distribution Networks", IEEE Proceedings on Generation, Transmission & Distribution, Vol.146, No. 6, pp. 641-648, 1999

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