Design of Distribution Network with the Integration of Diesel Generator and PV cells using Matlab

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1. Introduction

The electrical maintenance section of the NIT Kurukshetra is planning for to install a new power distribution system in the campus. The source of the power will be the UHBVN substation near the Kirmach Road. It is connected to the substation at NIT Kurukshetra.

2. Abstract

The electric distribution system can be the most stressed part of a power system. Firstly, the electric load is stochastic in nature and fluctuates throughout the day. Secondly, the distribution system previously had one directional power flow but now Distributed Generation (DGs) is being integrated and results in bi-directional power flow. In the context of these challenges, this paper presents a combined-model which handles the uncertain load variations and optimal placement and sizing of DG into the distribution system. Distribution system reconfiguration is one of the major approaches to reduce the losses in the distribution system. With the integration of Distributed Generation (DG) in the distribution system, there can be further improvement in voltage profile and further loss reduction in the reconfigured system. The main contribution of this paper is: (i). Proposing novel and modified novel power loss sensitivity methods for finding optimal locations for placement of multiple DGs, (ii) obtaining the sizes of distributed sources for reduced losses and better voltage profile, and (iii) Study of variation of multiple DG sizes taking the effect of reconfiguration of the distribution system, (iv) Study of the impact of DG sizes taking into consideration the power factor. The proposed method has been implemented and tested on IEEE 33 bus distribution system.

3 .Objective

- To minimize the system losses and maintain the voltage at a specific level by installing a **Diesel Generator set** and **Rooftop Solar Plant.**
- **Techniques:** Load flow analysis of RDS by Backward/Forward (BW/FW) Sweep.
- **TO FIND**:

  1.) Active Power

2.) Reactive Power
3.) Voltage and Current Profile
4.) Losses and Operational generation dispatch.

3. Single Line Diagram of IEEE Radial Distribution System (RDS)

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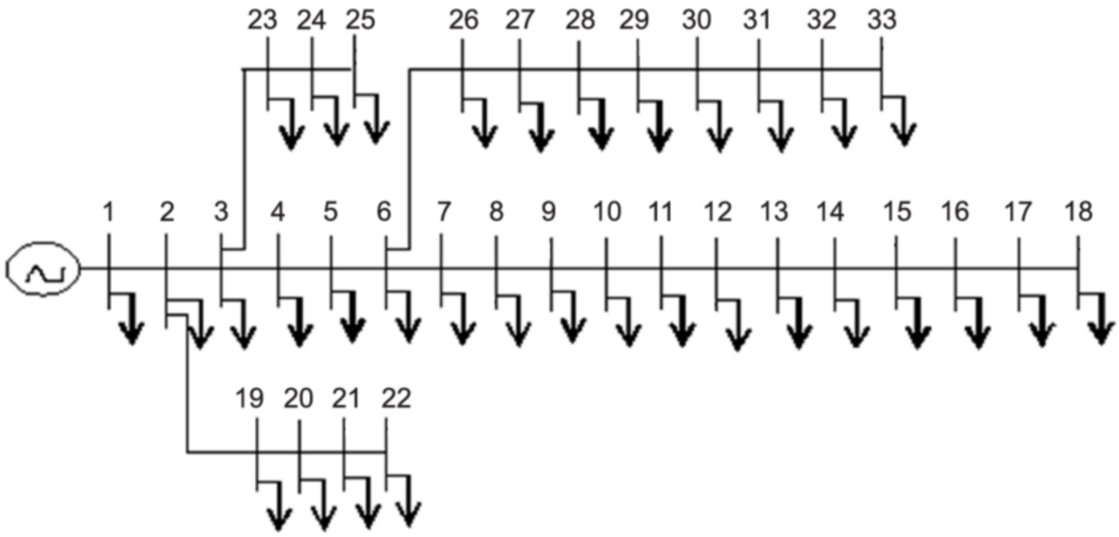
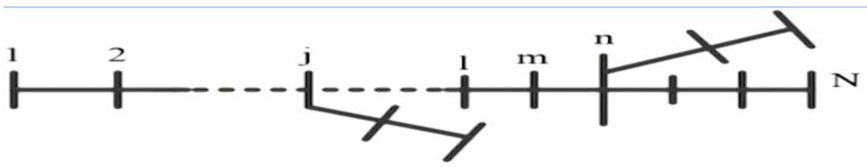


4. Method use to Solve the Problem

- Design presents Backward/Forward (BW/FW) Sweep algorithm for load flow analysis of radial distribution network.
- In ***backward sweep***, Kirchhoff's Current Law and Kirchhoff's voltage Law are used to compute the bus voltage from the farthest Node.
- In ***forward Sweep***, downstream bus voltage is updated starting from source Node.
- The procedure stops after the mismatch of calculated, and the specified voltage at the substation is less than convergence tolerance.
- Line losses are calculated afterwards using updated bus voltage.
- Using this method load flow solution for a distribution network can be obtained without solving any set of simultaneous equations.

5. Backward and Forward Sweep Algorithm



Total numbers of nodes = N

STEP 1: Initialization of Voltages—

$$V_i = V_s \angle 0° \quad \text{for i=2,3, 4....... N}$$

STEP 2: Iteration count initialization k=1.

STEP 3: Load Current Computation—

$$\boldsymbol{I_i} = \left(\frac{\boldsymbol{P_i + Q_i}}{\boldsymbol{V_i^{k+1}}}\right)^* \quad \text{for i=2,3, 4....... N}$$

STEP 4: BACKWARD SWEEP—

$$\boldsymbol{I_{mn}} = \boldsymbol{I_{n}^{k}}{}_{+}\boldsymbol{\Sigma}(\boldsymbol{all\ current\ of\ branches\ emanted\ from\ bus\ N})$$

STEP 5: FORWARD SWEEP: - $\boldsymbol{V_n^k} = \boldsymbol{V_m^k} - \boldsymbol{z_{mn} I_{mn}^k}$ for n=2,3, 4....... N

STEP 6: $\boldsymbol{e_j^k} = \left|\boldsymbol{v_j} - \boldsymbol{v_j^{k-1}}\right|$ for j=2,3, 4....... N

STEP 7: $\boldsymbol{e_{m_x}^k} = \boldsymbol{max}(\boldsymbol{e_2^k}, \boldsymbol{e_3^k}, \boldsymbol{e_4^k} \ldots \boldsymbol{e_N^k})$

STEP 8: IF $\boldsymbol{e_{max}} \leq \boldsymbol{\varepsilon}$ {Tolerance} PRINT RESULT.

ELSE update iteration count k=k+1 & go to STEP 3.

EQUIPMENT REQUIRED:

.MATLAB

. POWERPOINT

.MS WORD

6. RESULT

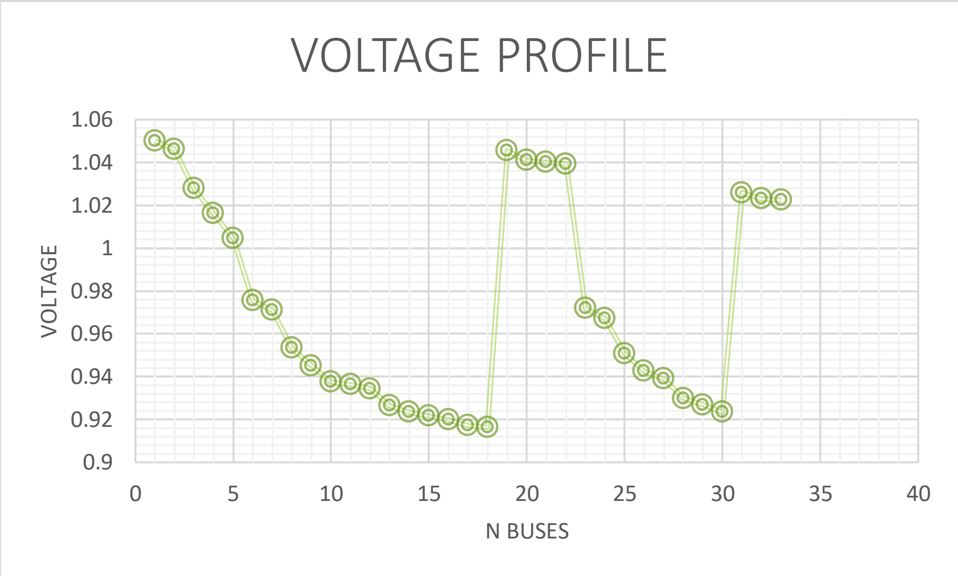
TABLE SHOWING LOSS,VOLTAGE AT EACH NODE

Vb	Plosskw	Qlosskw	voltage	P	Q	R	X
1.0500 + 0.0000i	15.4913	8.0145	1.05	0	0	0.0762	0.0394
1.0461 + 0.0003i	65.956	33.5934	1.0461	0.001	0.0006	0.4074	0.2075
1.0278 + 0.0022i	36.4933	18.5856	1.0278	0.0009	0.0004	0.3025	0.154
1.0161 + 0.0036i	34.9569	17.8041	1.0161	0.0012	0.0008	0.315	0.1604
1.0045 + 0.0051i	72.1653	62.2965	1.0045	0.0006	0.0003	0.6769	0.5843

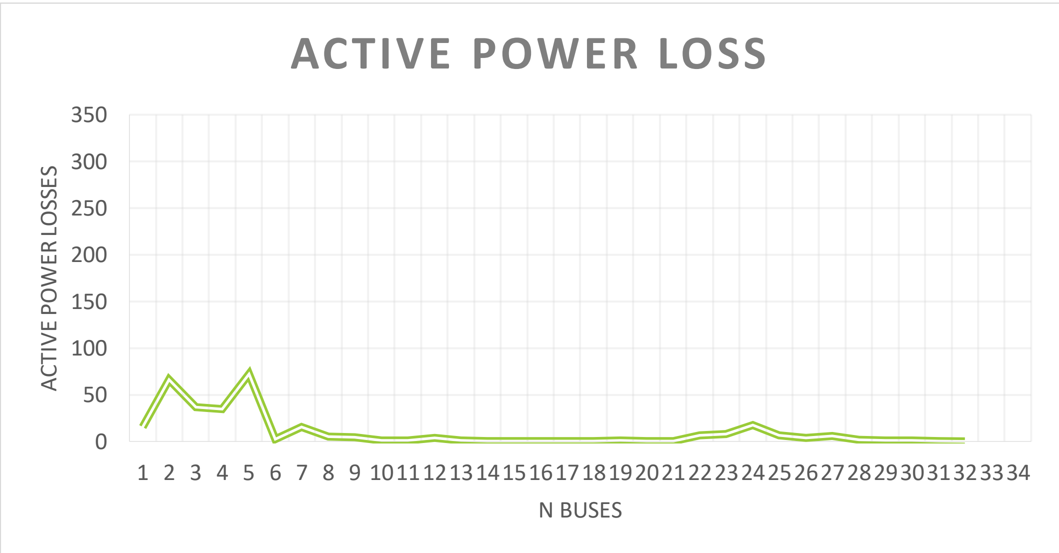
0.9755 + 0.0017i	2.4799	8.1975	0.9755	0.0006	0.0002	0.1547	0.5114
0.9710 - 0.0034i	15.1775	10.9534	0.971	0.002	0.001	1.4144	1.0207
0.9533 - 0.0070i	5.4681	3.9285	0.9533	0.002	0.001	0.8512	0.6116
0.9450 - 0.0087i	4.6426	3.3034	0.9451	0.0006	0.0002	0.8595	0.6116
0.9374 - 0.0102i	0.725	0.2397	0.9375	0.0006	0.0002	0.1625	0.0537
0.9363 - 0.0101i	1.1545	0.3818	0.9363	0.0004	0.0003	0.3094	0.1023
0.9343 - 0.0099i	3.4968	2.7512	0.9344	0.0006	0.0003	1.2132	0.9545
0.9263 - 0.0120i	0.9568	1.2595	0.9264	0.0006	0.0003	0.4476	0.5892
0.9233 - 0.0137i	0.4691	0.4175	0.9234	0.0012	0.0008	0.4884	0.4347
0.9215 - 0.0145i	0.37	0.2702	0.9216	0.0006	0.0001	0.6168	0.4504
0.9197 - 0.0150i	0.3309	0.4417	0.9198	0.0006	0.0002	1.0653	1.4223
0.9170 - 0.0167i	0.0699	0.0548	0.9172	0.0006	0.0002	0.605	0.4744
0.9163 - 0.0169i	0.1939	0.1851	0.9164	0.0009	0.0004	0.1355	0.1293
1.0455 + 0.0001i	1.0032	0.904	1.0455	0.0009	0.0004	1.2431	1.1202
1.0410 - 0.0014i	0.1215	0.1419	1.041	0.0009	0.0004	0.3384	0.3954
1.0401 - 0.0018i	0.0526	0.0696	1.0401	0.0009	0.0004	0.5859	0.7746
1.0393 - 0.0023i	6.4865	3.304	1.0393	0.0009	0.0004	0.1678	0.0855
0.9719 + 0.0025i	8.1483	4.1487	0.9719	0.0009	0.0005	0.2349	0.1196
0.9671 + 0.0037i	17.2816	15.2369	0.9671	0.0042	0.002	0.8752	0.7717
0.9500+0.00521	6.1693	5.3745	0.9508	0.0042	0.002	0.6646	0.579
0.9426 + 0.0075i	3.4502	1.7574	0.9426	0.0006	0.0003	0.4194	0.2136
0.9390 + 0.0098i	5.8462	5.7778	0.939	0.0006	0.0003	0.8053	0.7959
0.9298 + 0.0127i	1.6568	1.9311	0.9299	0.0006	0.0002	0.2566	0.2991
0.9267 + 0.0136i	1.322	2.0555	0.9268	0.0012	0.0007	0.2818	0.4382
0.9233 + 0.0145i	0.7843	0.5359	0.9234	0.002	0.006	0.3729	0.2548
1.0258 + 0.0019i	0.6561	0.5181	1.0258	0.0015	0.0007	0.7421	0.586
1.0230 + 0.0014i	0.0368	0.0288	1.023	0.0021	0.001	0.7405	0.5794
1.0224 + 0.0014i			1.0224	0.0006	0.0004		
TOTAL	313.6132	214.4626		0.0371	0.023	17.83	15.5247

7 GRAPHICAL REPRESENTAION OF DIFFERENT PARAMETERS

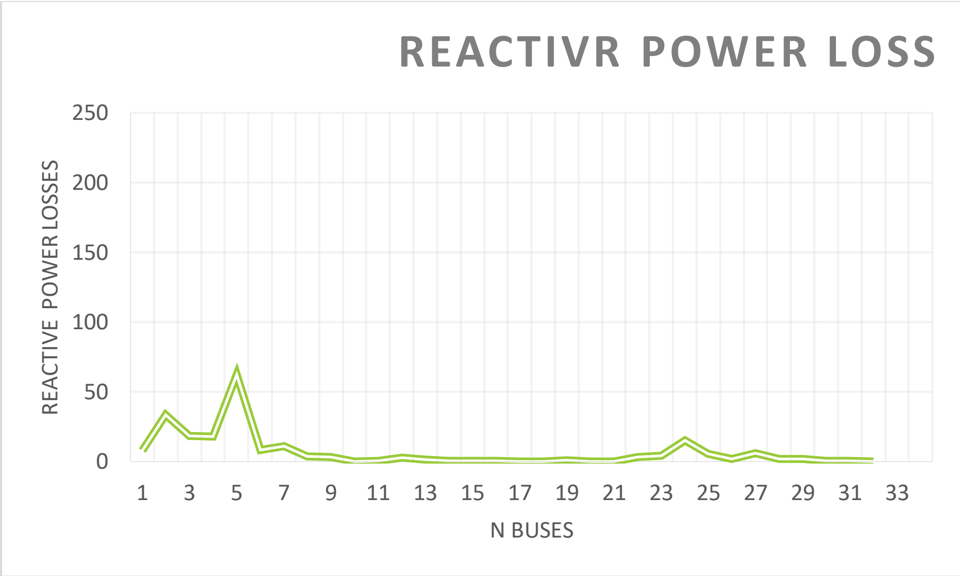
A . VOLTAGE GRAPH



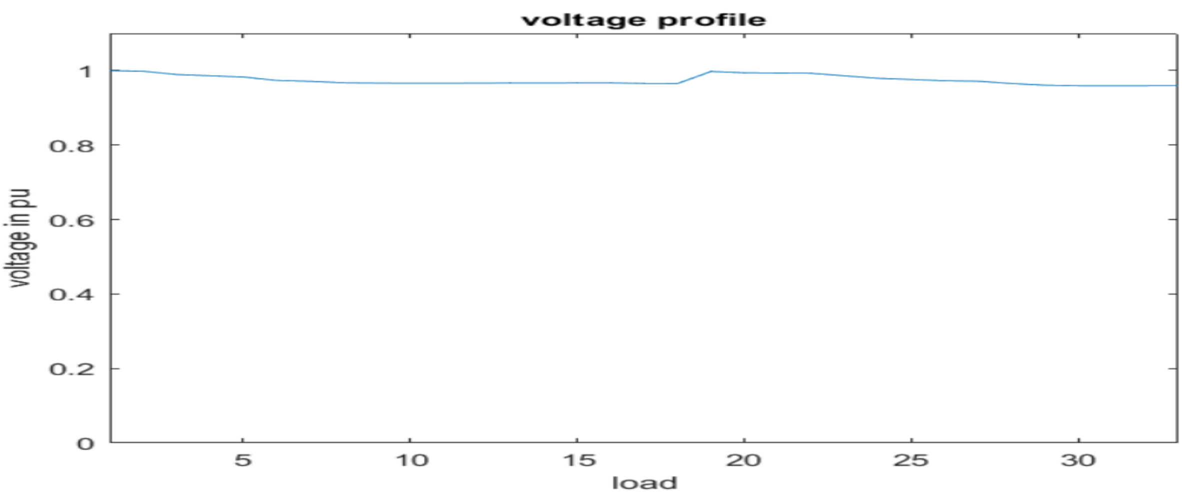
B .ACTIVE POWER LOSS



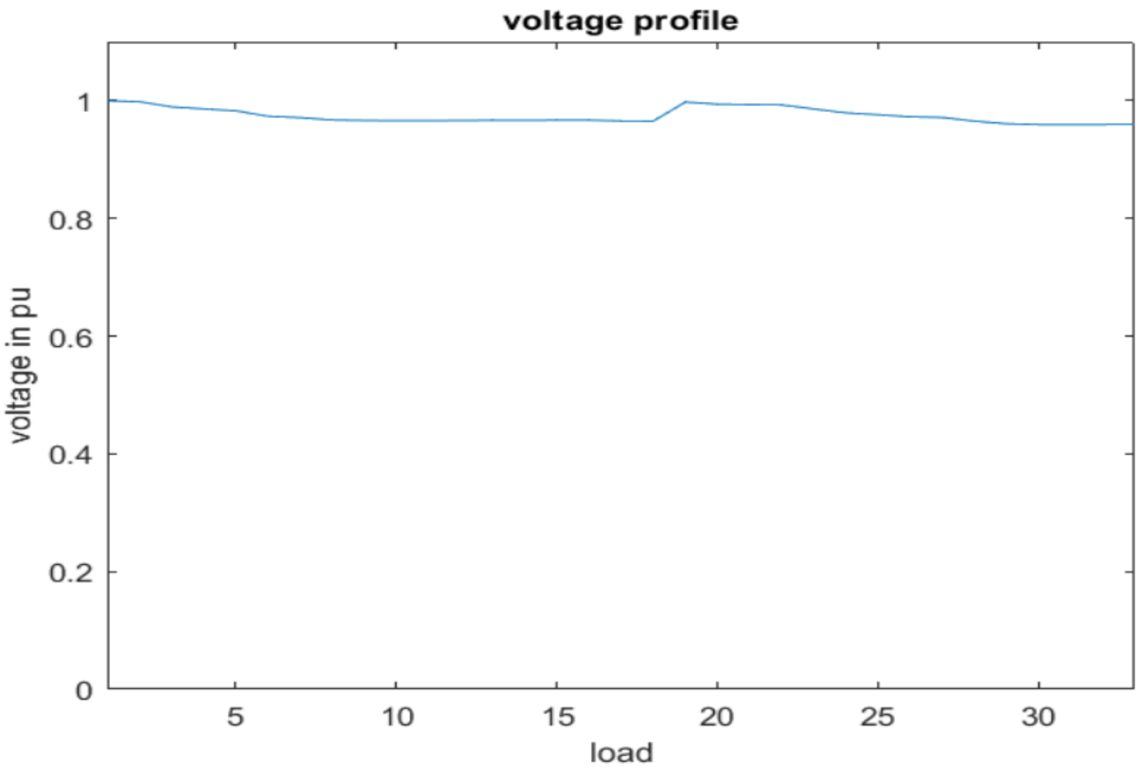
C .REACTIVE POWER LOSS



. VOLTAGE WITH PV CELLS ONLY

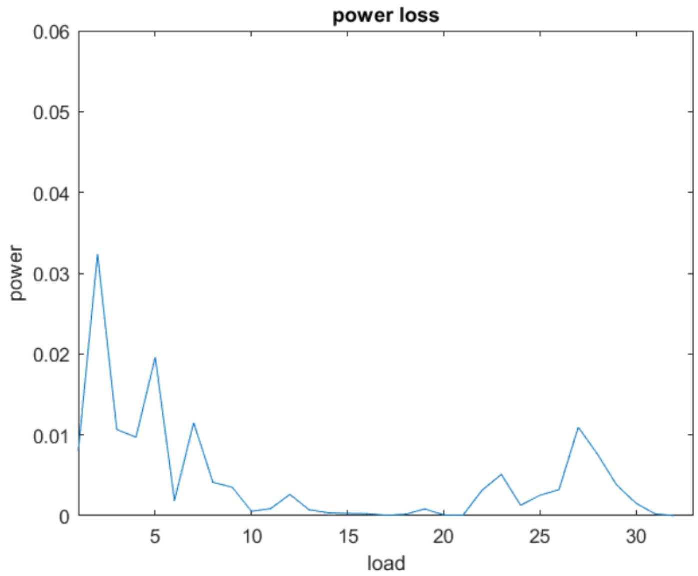


VOLTAGE BOTH PV AND DG GENERATOR

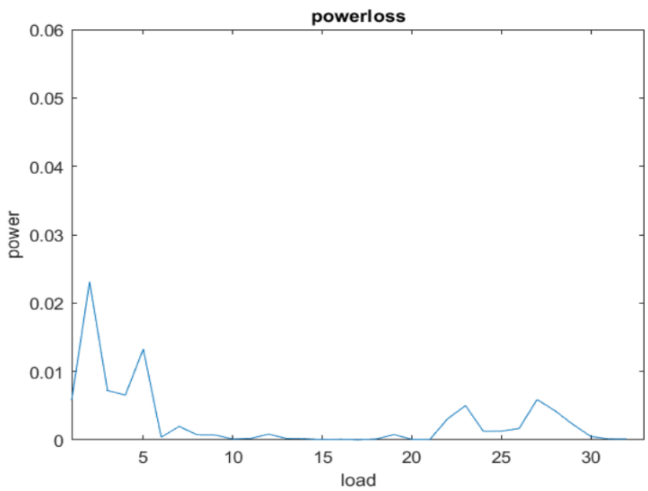


POWER LOSSES GRAPH :

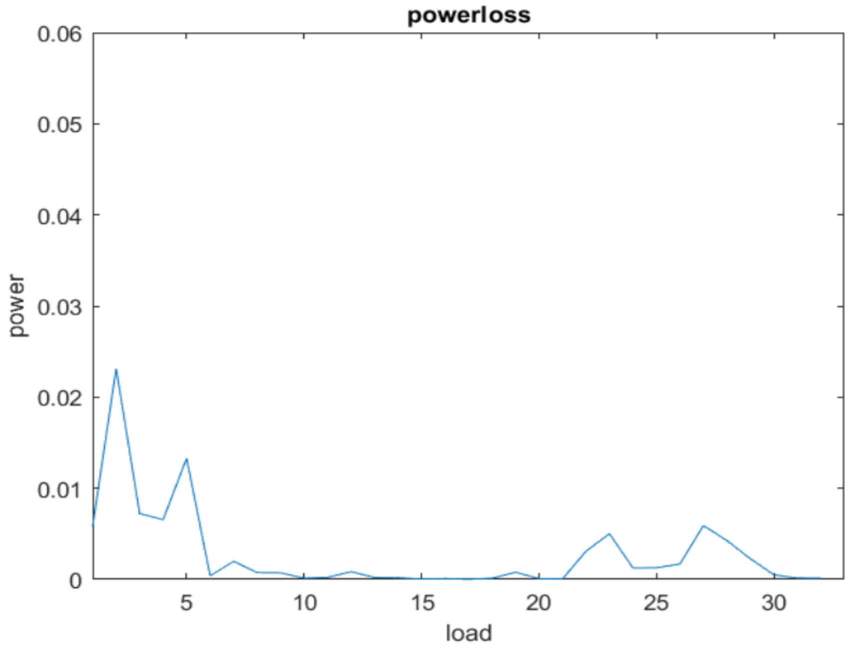
.POWER LOSS WITH DIESEL GENERATOR ONLY



- ***POWER LOSS WITH PV CELL ONLY***



- ***POWER LOSS WITH DIESEL GENERATOR AND PV CELL BOTH***



. ***Results and Discussions*** : Before reconfiguration of the 33 bus distribution system, the base case losses are 202.665kw and 135.133kVAr. Using the Novel method, DG with optimal size will be placed at each and every node and then the bus at which total power loss is minimum will be considered as the optimal location. It is observed from the figure that the optimal location for placement of a single diesel generator is bus 6. After placing the DG of size 2000 kW at bus 6, the real and reactive power losses are reduced by 48.649% and 44.684% from its base case respectively. The minimum voltage has been increased from 0.91309p.u to 0.9498p.u. For locating the distributed PV cell plant , nodes having large voltage drop are required to have a large capacity of PV cells. After placing the PV cells of size 1000 kW at different nodes ,the minimum voltage has been increased from 0.913p.u to 0.963p.u. After placing both PV cells and diesel generators of size 1000 kW and 2000kW =3000kW ,the minimum voltage has been increased from 0.913p.u to 0.983p.u.

CONCLUSION: This thesis work focused on efficient reconfiguration of the distribution network while optimising the size, location and optimum operating power factor of DGs. Artificial Bee Colony (ABC) algorithm was used as the optimization algorithm for fulfilling the objectives of the project. An interactive computer program was developed in MATLAB . The program takes a variety of inputs from the user and takes those inputs as parameters for the optimization process. The program optimises the configuration of branches, sizes, locations and operating power factor of DGs in such a way that the program suggests a design that would give the best voltage profile and least power loss.

.Instruction on How to RUN the Code

- **STEP:1** Save the codes.

- **STEP:2** Click on the run button.
- **STEP:3** Click on the command window. You can see the output of the code.

STEP:4 For diesel generator- put power source (-ve power load) at node 6. Save the code again and run it

7. MATLAB CODE

.BUS DATA FILE CODE

```
1.    100   60    0
2.    90    40    0
3.    120   80    0
4.    60    30    0
5.    60    20    0
6.    200   100   0
7.    200   100   0
8.    60    20    0
9.    60    20    0
10.   45    30    0
11.   60    35    0
12.   60    35    0
13.   120   80    0
14.   60    10    0
15.   60    20    0
16.   60    20    0
17.   90    40    0
18.   90    40    0
19.   90    40    0
20.   90    40    0
21.   90    40    0
22.   90    50    0
23.   420   200   0
24.   420   200   0
25.   60    25    0
26.   60    25    0
27.   60    20    0
28.   120   70    0
29.   200   600   0
30.   150   70    0
31.   210   100   0
32.   60    40    0
```

.LINE DATA FILE CODE:

```
•   1    1    2    0.0922   0.0477
•   2    2    3    0.4930   0.2511
•   3    3    4    0.3660   0.1864
•   4    4    5    0.3811   0.1941
•   4    5    6    0.8190   0.7070
•   6    6    7    0.1872   0.6188
•   7    7    8    1.7114   1.2351
•   8    8    9    1.0300   0.7400
•   9    9    10   1.0400   0.7400
•   10   10   11   0.1966   0.0650
•   11   11   12   0.3744   0.1238
```

- 12 12 13 1.4680 1.1550
- 13 13 14 0.5416 0.7129
- 14 14 15 0.5910 0.5260
- 15 15 16 0.7463 0.5450
- 16 16 17 1.2890 1.7210
- 17 17 18 0.7320 0.5740
- 18 2 19 0.1640 0.1565
- 19 19 20 1.5042 1.3554
- 20 20 21 0.4095 0.4784
- 21 21 22 0.7089 0.9373
- 22 6 23 0.2030 0.1034
- 23 23 24 0.2842 0.1447
- 24 24 25 1.0590 0.9337
- 25 25 26 0.8042 0.7006
- 26 26 27 0.5075 0.2585
- 27 27 28 0.9744 0.9630
- 28 28 29 0.3105 0.3619
- 29 29 30 0.3410 0.5302
- 30 3 31 0.4512 0.3083
- 31 31 32 0.8980 0.7091
- 32 32 33 0.8960 0.7011

.LOAD FLOW_ FBS FILE CODE: (MAIN CODE)

```
• clc;
• clear all;
• format short;
• tic
• m=load('loaddata33bus.m');
• l=load('linedata33bus.m');

• br=length(l);
• no=length(m);
• MVAb=100;
• KVb=11;
• Zb=(KVb^2)/MVAb;
• % Per unit Values
• for i=1:br
• R(i,1)=(l(i,4))/Zb;
• X(i,1)=(l(i,5))/Zb;
• end
• for i=1:no
• P(i,1)=((m(i,2))/(1000*MVAb));
• Q(i,1)=((m(i,3))/(1000*MVAb));
• end
• R
• X
• P
• Q
```

- C=zeros(br,no);
- for i=1:br
- a=l(i,2);
- b=l(i,3);
- for j=1:no
    - if a==j
        - C(i,j)=-1;
    - end
    - if b==j
        - C(i,j)=1;
    - end
- end
- end
- C
- e=1;
- for i=1:no
- d=0;
- for j=1:br
    - if C(j,i)==-1
        - d=1;
    - end
- end
- if d==0
    - endnode(e,1)=i;
    - e=e+1;
- end
- end
- endnode
- h=length(endnode);
- for j=1:h
- e=2;
- f=endnode(j,1);
- for s=1:no
- if (f~=1)
    - k=1;
    - for i=1:br
        - if ((C(i,f)==1)&&(k==1))
        - f=i;
        - k=2;
        - end
    - end
    - k=1;
    - for i=1:no
        - if ((C(f,i)==-1)&&(k==1));
        - f=i;
        - g(j,e)=i;
        - e=e+1;
        - k=3;
        - end
    - end
- end
- end

- end
- for i=1:h
- g(i,1)=endnode(i,1);
- end
- g;
- w=length(g(1,:))
- for i=1:h
- j=1;
- for k=1:no
    - for t=1:w
        - if g(i,t)==k
        - g(i,t)=g(i,j);
        - g(i,j)=k;
        - j=j+1;
        - end
    - end
- end
- end
- g;
- for k=1:br
- e=1;
- for i=1:h
    - for j=1:w-1
        - if (g(i,j)==k)
        - if g(i,j+1)~=0
            - adjb(k,e)=g(i,j+1);
            - e=e+1;
        - else
            - adjb(k,1)=0;
        - end
        - end
    - end
- end
- end
- adjb;
- for i=1:br-1
- for j=h:-1:1
    - for k=j:-1:2
        - if adjb(i,j)==adjb(i,k-1)
        - adjb(i,j)=0;
        - end
    - end
- end
- end
- adjb;
- x=length(adjb(:,1));
- ab=length(adjb(1,:));
- for i=1:x
- for j=1:ab
    - if adjb(i,j)==0 && j~=ab
        - if adjb(i,j+1)~=0

        - adjb(i,j)=adjb(i,j+1);
        - adjb(i,j+1)=0;
        - end
    - end
    - if adjb(i,j)~=0
        - adjb(i,j)=adjb(i,j)-1;
    - end
- end
- end
- adjb;
- for i=1:x-1
- for j=1:ab
    - adjcb(i,j)=adjb(i+1,j);
- end
- end
- b=length(adjcb);

- % voltage current program

- for i=1:no
- vb(i,1)=1.05;
- end
- for s=1:10
- for i=1:no
- nlc(i,1)=conj(complex(P(i,1),Q(i,1)))/(vb(i,1));
- end
- nlc;
- for i=1:br
- Ibr(i,1)=nlc(i+1,1);
- end
- Ibr;
- xy=length(adjcb(1,:));
- for i=br-1:-1:1
- for k=1:xy
    - if adjcb(i,k)~=0
        - u=adjcb(i,k);
        - %Ibr(i,1)=nlc(i+1,1)+Ibr(k,1);
        - Ibr(i,1)=Ibr(i,1)+Ibr(u,1);
    - end
- end
- end
- Ibr;
- for i=2:no
- g=0;
- for a=1:b
        - if xy>1
        - if adjcb(a,2)==i-1
        - u=adjcb(a,1);
        - vb(i,1)=((vb(u,1))-((Ibr(i-1,1))*(complex((R(i-1,1)),X(i-1,1)))));
        - g=1;

- end
- if adjcb(a,3)==i-1
- u=adjcb(a,1);
- vb(i,1)=((vb(u,1))-((Ibr(i-1,1))*(complex((R(i-1,1)),X(i-1,1)))));
- g=1;
- end
- end

- end
- if g==0
  - vb(i,1)=((vb(i-1,1))-((Ibr(i-1,1))*(complex((R(i-1,1)),X(i-1,1)))));
- end

- end
- s=s+1;
- end
- nlc;
- Ibr;
- vb
- vbp=[abs(vb) angle(vb)*180/pi]

- toc;
- for i=1:no
- va(i,2:3)=vbp(i,1:2);
- end
- for i=1:no
- va(i,1)=i;
- end
- va;

- Ibrp=[abs(Ibr) angle(Ibr)*180/pi];
- PL(1,1)=0;
- QL(1,1)=0;

- % losses
- for f=1:br
- Pl(f,1)=(Ibrp(f,1)^2)*R(f,1);
- Ql(f,1)=X(f,1)*(Ibrp(f,1)^2);
- PL(1,1)=PL(1,1)+Pl(f,1);
- QL(1,1)=QL(1,1)+Ql(f,1);
- end

- Plosskw=(Pl)*100000
- Qlosskw=(Ql)*100000
- PL=(PL)*100000
- QL=(QL)*100000

- voltage = vbp(:,1)
- angle = vbp(:,2)*(pi/180)