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```
% ------------------------------------------------------------------
% Optimal location of Distributed Generator on IEEE Standard Radial
% Distribution Network
% Using Particle Swarm Optimiation Algorithm by Joel Olayemi
% Programmed by Joel Olayemi at Dextan Solutions
% email: dextansolutions@gmail.com
% Phone: 2349034859219
% Programming dates: May 2019 to June 2019

clc;
clear;
close all;

tic
DistLoadFlowSolution=powerflow;
```

Problem Definition

```
User.Function ='obj_Dg_LRI_n_VPII';
User.NumVar=3;
bn=33;
User.Lb=[1000 1];
User.Ub=[5000  bn];
varsize=size(User.Lb);

Standard = true;
Bus_Data = 'Ayepe ';
```

Parameter of PSO

```
kappa = 1;
phi1 = 2.05;
phi2 = 2.05;
phi = phi1 + phi2;
chi = 2*kappa/abs(2-phi-sqrt(phi^2-4*phi));

User.MaxIt=10;
User.nPop=50;
User.w=chi;       %Inatial Coeficient
```

```
User.c1=chi*phi1;      %Personal Coeficient
User.c2=chi*phi2;      %Social Coeficient
wdamp=1;
MaxVelocity = 0.2*(User.Ub-User.Lb);
MinVelocity = -MaxVelocity;
```

Initialization

```
empty_particle.DGnLoc = [];
empty_particle.Velocity = [];
empty_particle.CostPLosVolt = [];
empty_particle.Best.DGnLoc = [];
empty_particle.Best.CostPLosVolt = [];

%Creat Population Array
particle=repmat(empty_particle,User.nPop,1);

%Initialize Global Best
GlobalBest.CostPLosVolt=inf;
%Initialize the Population Member
for i=1:User.nPop

    %Generate Random Solutions
    particle(i).DGnLoc=round(User.Lb+(User.Ub-
User.Lb).*rand(size(User.Lb)));



 DistLoadFlowDGSolution=powerflowDG(particle(i).DGnLoc(1,1),particle(i).DGnLoc(1,2

       particle(i).CostPLos=[DistLoadFlowDGSolution.PtLosskW];
       particle(i).CostPbrLos=[DistLoadFlowDGSolution.Pbrloss];
       particle(i).CostVact=[DistLoadFlowDGSolution.Vactual];
       particle(i).CostVolt=[DistLoadFlowDGSolution.VmagPU];
       particle(i).CostVSI=[DistLoadFlowDGSolution.VSI];
       particle(i).CostMinVolt=[DistLoadFlowDGSolution.minVSI];
       particle(i).CostVangle=[DistLoadFlowDGSolution.Vangle];

       particle(i).CostVSF=[DistLoadFlowDGSolution.VSF];
       particle(i).CostVSFsum=[DistLoadFlowDGSolution.VSFsum];
       particle(i).CostVDI=[DistLoadFlowDGSolution.VDI];
       particle(i).CostVDIsum=[DistLoadFlowDGSolution.VDIsum];

       particle(i).CostQtLos=[DistLoadFlowDGSolution.QtLosskVAr];
       particle(i).CostQbrLos=[DistLoadFlowDGSolution.Qbrloss];
       particle(i).CostSLos=[DistLoadFlowDGSolution.SLosskVA];

        %Initialize Velocity
        particle(i).Velocity=zeros(varsize);

        %Evalute Cost Function
       particle(i).CostPLosVolt=feval(User.Function,...
           DistLoadFlowSolution.PtLosskW,particle(i).CostPLos,...
```

```
            DistLoadFlowSolution.QtLosskVAr,particle(i).CostQtLos,...
            particle(i).CostVSFsum,particle(i).CostVDIsum);

        %Update Personnal Best
        particle(i).Best.DGnLoc=particle(i).DGnLoc;
        particle(i).Best.CostPLosVolt=particle(i).CostPLosVolt;

        %Update Global Best
        if particle(i).Best.CostPLosVolt < GlobalBest.CostPLosVolt
            GlobalBest=particle(i).Best;
        end

end

BestCosts=zeros(User.MaxIt,1);
```

Main Loop of PSO

```
for It=1:User.MaxIt

    for i=1:User.nPop

        %Update Velocity
         particle(i).Velocity=User.w*particle(i).Velocity...
             +User.c1*rand(varsize).*(particle(i).Best.DGnLoc-
particle(i).DGnLoc)...
             +User.c2*rand(varsize).*(GlobalBest.DGnLoc-
particle(i).DGnLoc);

          % Apply the lower bound
             ns_tmpV=particle(i).Velocity;
             IV=ns_tmpV<MinVelocity;
             ns_tmpV(IV)=MinVelocity(IV);
             % Apply the upper bounds
             JV=ns_tmpV>MaxVelocity;
             ns_tmpV(JV)=MaxVelocity(JV);
             % Update this new move
             particle(i).Velocity=ns_tmpV;

         %Update Position
         particle(i).DGnLoc=round(particle(i).DGnLoc +
 particle(i).Velocity);


             % Apply the lower bound
             ns_tmp=particle(i).DGnLoc;
             I=ns_tmp<User.Lb;
             ns_tmp(I)=User.Lb(I);
             % Apply the upper bounds
             J=ns_tmp>User.Ub;
             ns_tmp(J)=User.Ub(J);
             % Update this new move
             particle(i).DGnLoc=ns_tmp;
```

```
DistLoadFlowDGSolution=powerflowDG(particle(i).DGnLoc(1,1),particle(i).DGnLoc(1,2

      particle(i).CostPLos=[DistLoadFlowDGSolution.PtLosskW];
      particle(i).CostPbrLos=[DistLoadFlowDGSolution.Pbrloss];
      particle(i).CostVact=[DistLoadFlowDGSolution.Vactual];
      particle(i).CostVolt=[DistLoadFlowDGSolution.VmagPU];
      particle(i).CostVSI=[DistLoadFlowDGSolution.VSI];
      particle(i).CostMinVolt=[DistLoadFlowDGSolution.minVSI];
      particle(i).CostVangle=[DistLoadFlowDGSolution.Vangle];

      particle(i).CostVSF=[DistLoadFlowDGSolution.VSF];
      particle(i).CostVSFsum=[DistLoadFlowDGSolution.VSFsum];
      particle(i).CostVDI=[DistLoadFlowDGSolution.VDI];
      particle(i).CostVDIsum=[DistLoadFlowDGSolution.VDIsum];

      particle(i).CostQtLos=[DistLoadFlowDGSolution.QtLosskVAr];
      particle(i).CostQbrLos=[DistLoadFlowDGSolution.Qbrloss];
      particle(i).CostSLos=[DistLoadFlowDGSolution.SLosskVA];

      %Evaluation of Cost/Objective function
      particle(i).CostPLosVolt=feval(User.Function,...
          DistLoadFlowSolution.PtLosskW,particle(i).CostPLos,...
           DistLoadFlowSolution.QtLosskVAr,particle(i).CostQtLos,...
           particle(i).CostVSFsum,particle(i).CostVDIsum);

       %Update Peronal Best
       if particle(i).CostPLosVolt < particle(i).Best.CostPLosVolt
           particle(i).Best.DGnLoc=particle(i).DGnLoc;
           particle(i).Best.CostPLosVolt=particle(i).CostPLosVolt;

         particle(i).Best.CostPlos= particle(i).CostPLos;
         particle(i).Best.CostPbrLos= particle(i).CostPbrLos;
         particle(i).Best.CostVact= particle(i).CostVact;
         particle(i).Best.CostVolt= particle(i).CostVolt;
         particle(i).Best.CostVSI= particle(i).CostVSI;
         particle(i).Best.CostMinVolt= particle(i).CostMinVolt;
         particle(i).Best.CostVangle= particle(i).CostVangle;

         particle(i).Best.CostVSF=[DistLoadFlowDGSolution.VSF];
      particle(i).Best.CostVSFsum=[DistLoadFlowDGSolution.VSFsum];
      particle(i).Best.CostVDI=[DistLoadFlowDGSolution.VDI];
      particle(i).Best.CostVDIsum=[DistLoadFlowDGSolution.VDIsum];

         particle(i).Best.CostQtLos= particle(i).CostQtLos;
         particle(i).Best.CostQbrLos= particle(i).CostQbrLos;
         particle(i).Best.CostSLos= particle(i).CostSLos;

            %Update Global Best
           if particle(i).Best.CostPLosVolt < GlobalBest.CostPLosVolt
               GlobalBest=particle(i).Best;
           end
       end
```

```
    end

    %Store the Best Cost Value
        BestCosts(It)=GlobalBest.CostPLosVolt;
        %Display Iteration Informatio
         disp(['Iteration', num2str(It)...
            ,' Best Cost = ',num2str(BestCosts(It))])
        %Damping inerial coeficient
%         User.w=User.w*wdamp;
end
```

```
Iteration1 Best Cost = -6.9467
Iteration2 Best Cost = -6.9592
Iteration3 Best Cost = -6.9592
Iteration4 Best Cost = -6.9592
Iteration5 Best Cost = -6.9592
Iteration6 Best Cost = -6.9592
Iteration7 Best Cost = -6.9592
Iteration8 Best Cost = -6.9592
Iteration9 Best Cost = -6.9592
Iteration10 Best Cost = -6.9592
```

Results

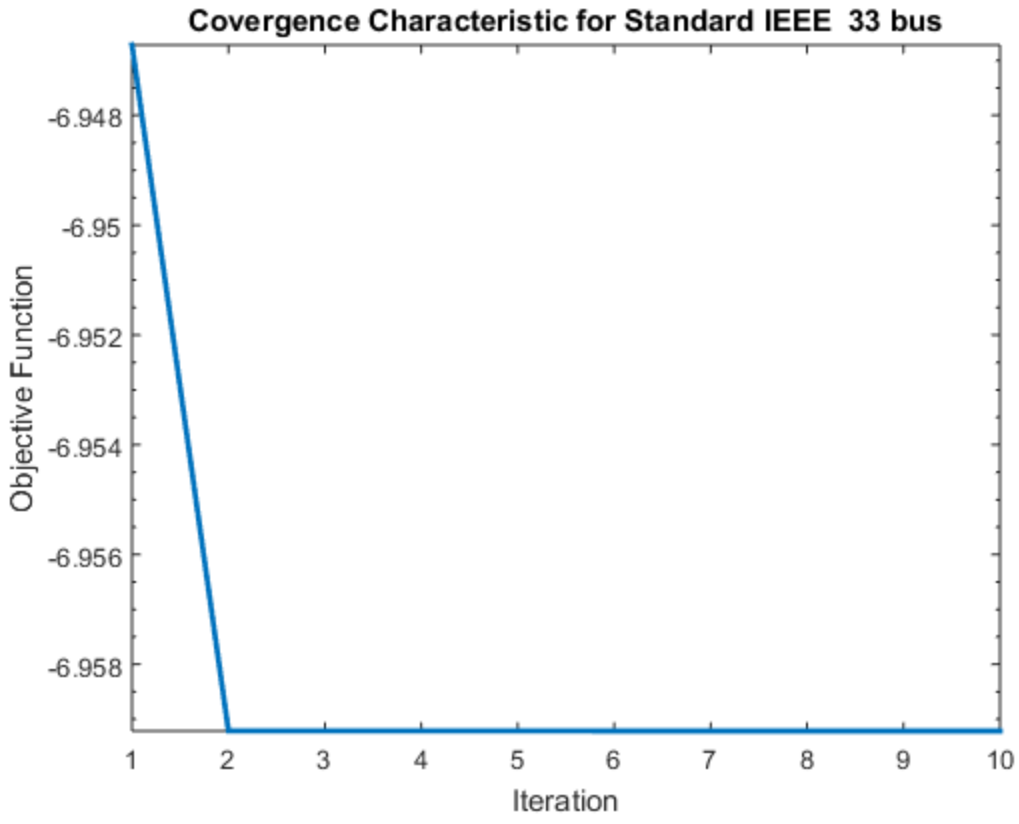
```
figure(1);
% plot(BestFireFlyCost,'LineWidth',2);
semilogy(BestCosts,'LineWidth',2);
xlabel('Iteration');
ylabel('Objective Function');
% This part save the figure in png format into a folder already
 created called "Report"
if Standard
    title(['Covergence Characteristic for Standard IEEE  ',
 num2str(bn), ' bus'])
    saveas(gcf,['Report/
Covergence_Characteristic_for_IEEE_Standard_bus_',num2str(bn),'.png'])
else
     title(['Covergence Characteristic for ',Bus_Data, num2str(bn), '
 bus'])
    saveas(gcf,['Report/
Covergence_Characteristic_for_',Bus_Data,num2str(bn),'_bus','.png'])
end
%
%---------------------------------------------------------------------
figure(2)
x=1:bn;
Vpdg=GlobalBest.CostVolt;
VpBase=DistLoadFlowSolution.VmagPU;
plot(x,Vpdg,'g-o',x,VpBase,'r-*');
xlim([1 bn]);

legend('Voltage With DG','Voltage With No DG','Location','northeast')
```

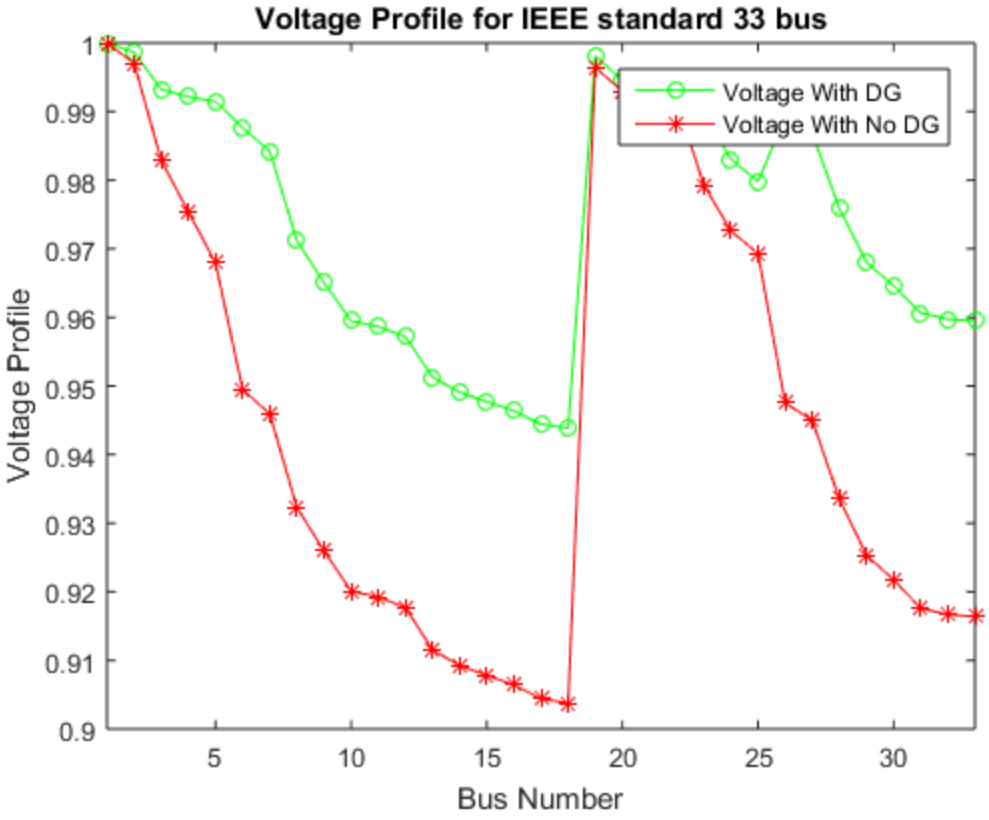
```
xlabel('Bus Number')
ylabel('Voltage Profile')
if Standard
    title(['Voltage Profile for IEEE standard ', num2str(bn), ' bus'])
    saveas(gcf,['Report/Voltage_Profile_for_IEEE
 standard_',num2str(bn),'_bus','.png'])
else
    title(['Voltage Profile for ',Bus_Data, num2str(bn), ' bus'])
    saveas(gcf,['Report/
Voltage_Profile_for_',Bus_Data,num2str(bn),'_bus','.png'])
end
hold on


figure(3)
xv=1:bn-1;
VSIdg=GlobalBest.CostVSI;
VsiBase=DistLoadFlowSolution.VSI;
plot(xv,VSIdg,'g-o',xv,VsiBase,'r-*');
xlim([1 bn-1]);
legend('VSI With DG','VSI With No DG','Location','northeast')
xlabel('Branch Number')
ylabel('Voltage Stability Index')

if Standard
    title(['Voltage Stability Index for IEEE standard ',
 num2str(bn), ' bus'])
    saveas(gcf,['Report/Voltage_Stability_Index_for_IEEE
 standard_',num2str(bn),'_bus','.png'])
else
    title(['Voltage Stability Index for ',Bus_Data, num2str(bn), '
 bus'])
    saveas(gcf,['Report/
Voltage_Stability_Index_for_',Bus_Data,num2str(bn),'_bus','.png'])
end
hold on

figure(4)
PtLossBase=DistLoadFlowSolution.PtLosskW;
PtLossDG=GlobalBest.CostPlos;
pp=[PtLossBase;PtLossDG];
bar(pp,'DisplayName','1=Before DG placement  2=After DG placement');
ylabel('Power Loss (kW)','FontSize',11);
legend('show');
PercentRedu=((PtLossBase-PtLossDG)/PtLossBase)*100;
if Standard
    title(['Total Power Loss for IEEE standard ', num2str(bn), '
 bus'])
    saveas(gcf,['Report/Total_Power_Loss_for_IEEE
 standard_',num2str(bn),'_bus','.png'])
else
    title(['Total Power Loss for ',Bus_Data, num2str(bn), ' bus'])
    saveas(gcf,['Report/
Total_Power_Loss_for_',Bus_Data,num2str(bn),'_bus','.png'])
```

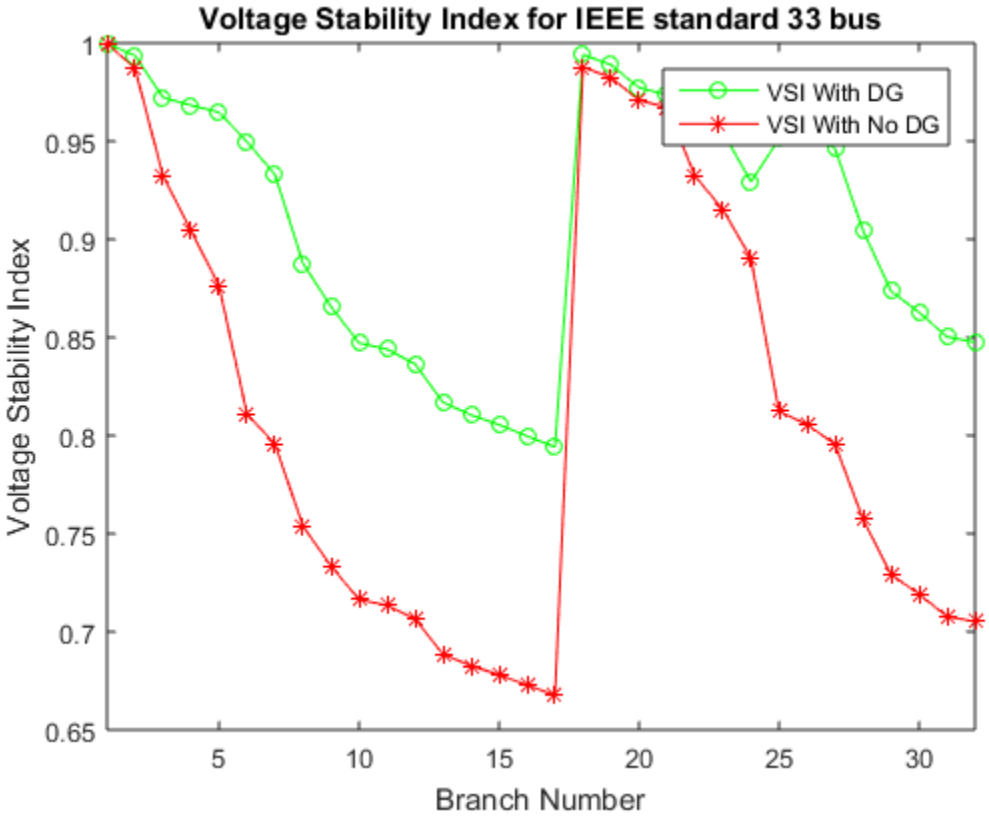
```
end

figure(5)
x=1:bn;
VDIdg=GlobalBest.CostVDI;
VDIBase=DistLoadFlowSolution.VDI;
plot(x,VDIdg,'g-o',x,VDIBase,'r-*');
xlim([1 bn]);
legend('Voltage Deviation Index With DG','Voltage Deviation Index With
 No DG','Location','northeast')
xlabel('Bus Number')
ylabel('Voltage Deviation Index')

if Standard
    title(['Voltage Deviation Index for IEEE standard ',
 num2str(bn), ' bus'])
    saveas(gcf,['Report/Voltage_Deviation_Index_for_IEEE
 standard_',num2str(bn),'_bus','.png'])
else
    title(['Voltage Deviation Index for ',Bus_Data, num2str(bn), '
 bus'])
    saveas(gcf,['Report/
Voltage_Deviation_Index_for_',Bus_Data,num2str(bn),'_bus','.png'])
end
hold on

figure(6)
xv=1:bn-1;
VSFdg=GlobalBest.CostVSF;
VsFBase=DistLoadFlowSolution.VSF;
plot(xv,VSFdg,'g-o',xv,VsFBase,'r-*');
xlim([1 bn-1]);
legend('VSF With DG','VSF With No DG','Location','northeast')

xlabel('Branch Number')
ylabel('Voltage Stability Factor')

if Standard
    title(['Voltage Stability Factor for IEEE standard ',
 num2str(bn), ' bus'])
    saveas(gcf,['Report/Voltage_Stability_Factor_for_IEEE
 standard_',num2str(bn),'_bus','.png'])
else
    title(['Voltage Stability Factor for ',Bus_Data, num2str(bn), '
 bus'])
    saveas(gcf,['Report/
Voltage_Stability_Factor_for_',Bus_Data,num2str(bn),'_bus','.png'])
end
hold on

disp(['The Total Power loss for base case is ', num2str(PtLossBase)])
disp('************************************************************')
disp(['The Total Power loss for after DG placement is ',
 num2str(PtLossDG)])
```

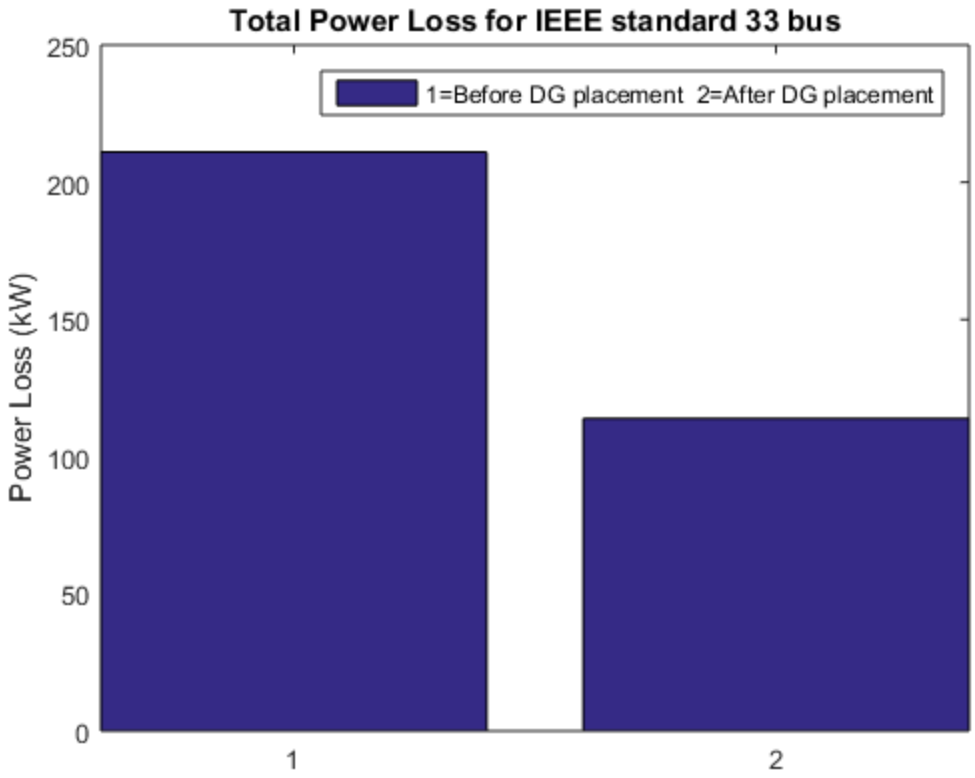
```
disp('*****************************************************************')
disp(['The Percentage reduction after DG placement is ',
 num2str(PercentRedu)])


% if Standard
% save(['DGWorkSpaceIEEEStandard_',num2str(bn),'_bus','.mat'])
% else
%     save(['DGWorkSpace_',Bus_Data,num2str(bn),'_bus','.mat'])
% end

toc

if Standard
    save(['DGWorkSpaceIEEEStandard_',num2str(bn),'_bus','.mat'])

else
    save(['DGWorkSpace_',Bus_Data,num2str(bn),'_bus','.mat'])
end
```

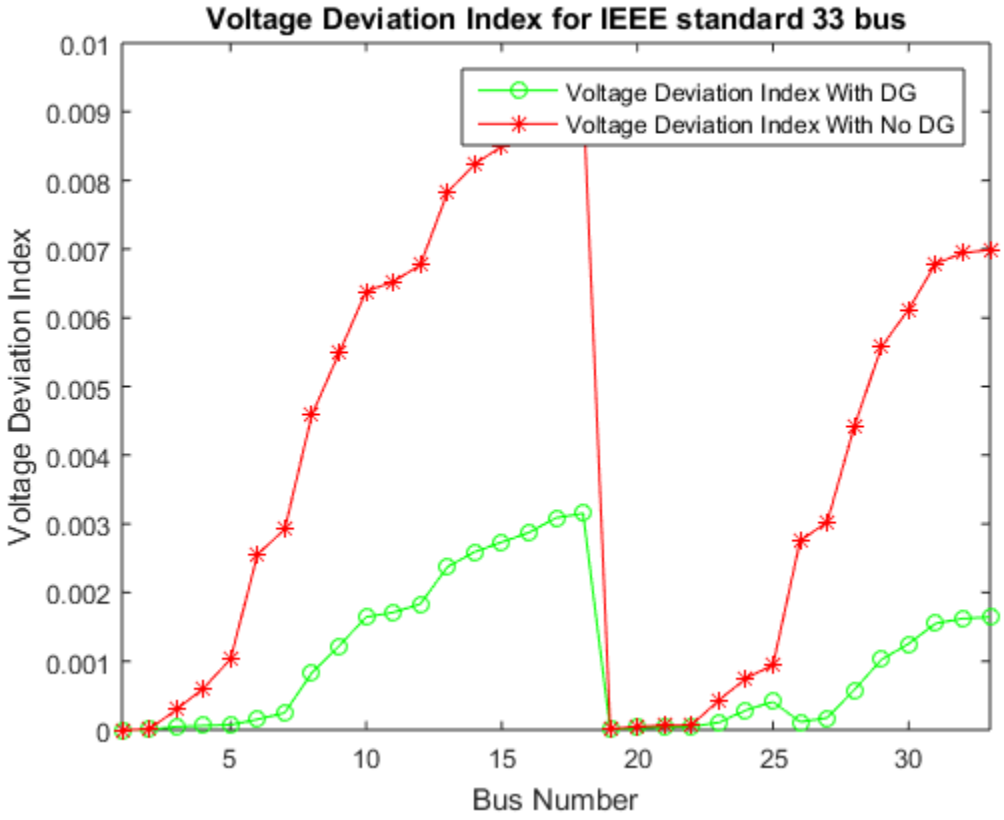
```
The Total Power loss for base case is 210.9876
*****************************************************************
The Total Power loss for after DG placement is 113.8422
*****************************************************************
The Percentage reduction after DG placement is 46.0432
Elapsed time is 101.005290 seconds.
```

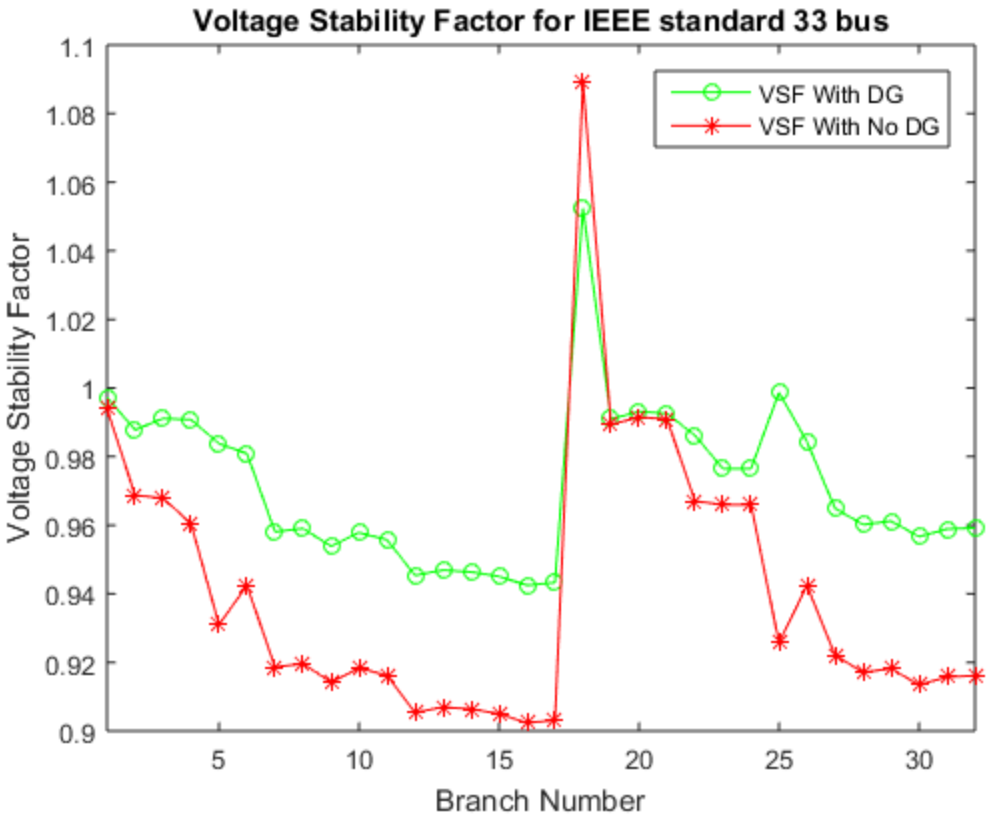



Voltage Profile for IEEE standard 33 bus
Voltage With DG
Voltage With No DG
Voltage Profile
Bus Number
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0.9
5
10
15
20
25
30


Voltage Stability Index for IEEE standard 33 bus
VSI With DG
VSI With No DG
Voltage Stability Index
Branch Number
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
5
10
15
20
25
30


Total Power Loss for IEEE standard 33 bus
1=Before DG placement 2=After DG placement
Power Loss (kW)
250
200
150
100
50
0
1
2


Voltage Deviation Index for IEEE standard 33 bus
Voltage Deviation Index With DG
Voltage Deviation Index With No DG
Voltage Deviation Index
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
5
10
15
20
25
30
Bus Number



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