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```
clc;clear;close all;
tic
```

User Input

```
DistLoadFlowSolution=powerflow;
% Function Input
User.Function='ObjfuncPoweRnLSF';
User.NumbVar=4;
% User.Lb=[-20,-10,-5,-1];
% User.Ub=[20,10,5,1];

Standard = true;
Bus_Data = 'Enugu ';
bn=33;

User.MaxIter=10;
User.Lb=[150 1];
User.Ub=[1500 bn];

% User.Lb=[0 0 0];
% User.Ub=[2.0  2  2];
% Cuckoo Input
User.NumNest=25;
%Levy Flight Input
User.beta=3/2;
pa=0.25;
```

Initializing the Cuckoo Algorithm

```
SampleNest.CPnLoc=[];
SampleNest.PLosVolt=[];
Nest=repmat(SampleNest,User.NumNest,1);
```

```
for i=1:User.NumNest
%     Nest(i).Position=round(User.Lb+(User.Ub-
User.Lb).*rand(size(User.Lb)));
    Nest(i).CPnLoc=round(User.Lb+(User.Ub-
User.Lb).*rand(size(User.Lb)));


 DistLoadFlowCPSolution=powerflowCP(Nest(i).CPnLoc(1,1),Nest(i).CPnLoc(1,2));

       Nest(i).CostPLos=[DistLoadFlowCPSolution.PtLosskW];
       Nest(i).CostPbrLos=[DistLoadFlowCPSolution.Pbrloss];
       Nest(i).CostVact=[DistLoadFlowCPSolution.Vactual];
       Nest(i).CostVolt=[DistLoadFlowCPSolution.VmagPU];
       Nest(i).CostVSI=[DistLoadFlowCPSolution.VSI];
       Nest(i).CostMinVolt=[DistLoadFlowCPSolution.minVSI];
       Nest(i).CostLSF=[DistLoadFlowCPSolution.LSF];

       Nest(i).CostVDI=[DistLoadFlowCPSolution.VDI];
       Nest(i).CostVDIsum=[DistLoadFlowCPSolution.VDIsum];

       Nest(i).CostVangle=[DistLoadFlowCPSolution.Vangle];
       Nest(i).CostQtLos=[DistLoadFlowCPSolution.QtLosskVAr];
       Nest(i).CostQbrLos=[DistLoadFlowCPSolution.Qbrloss];
       Nest(i).CostSLos=[DistLoadFlowCPSolution.SLosskVA];
end
```

Geting Current best Solution 1

```
fitness=10^10*ones(User.NumNest,1);
% function
%
 [BestNest.Cost,Bestnest,Nest.Position,fitness]=get_best_nest(Nest.Position,Nest.P
for j=1:User.NumNest

    Nest(j).PLosVolt=feval(User.Function,...
            Nest(j).CostPLos,Nest(j).CostLSF);

%     Nest(j).PLosVolt=feval(User.Function,...
%             Nest(j).CostPLos,Nest(j).CostMinVolt,Nest(j).CostQtLos);
    if Nest(j).PLosVolt<=fitness(j)
        fitness(j)=Nest(j).PLosVolt;
        Nest(j).CPnLoc=Nest(j).CPnLoc;
    end
end

% Find the current best
[BestNest.PLosVolt,K]=min(fitness) ;
BestNest.CPnLoc=Nest(K).CPnLoc;
        BestNest.CostPLos       =    Nest(K).CostPLos;
        BestNest.CostPbrLos     =    Nest(K).CostPbrLos;
        BestNest.CostVact       =    Nest(K).CostVact;
        BestNest.CostVolt       =    Nest(K).CostVolt;
        BestNest.CostVSI        =    Nest(K).CostVSI;
```

```
        BestNest.CostLSF         =    Nest(K).CostLSF;

        BestNest.CostVDI         =    Nest(K).CostVDI;
        BestNest.CostVDIsum         =    Nest(K).CostVDIsum;

        BestNest.CostMinVolt     =    Nest(K).CostMinVolt;
        BestNest.CostVangle      =    Nest(K).CostVangle;
        BestNest.CostQtLos       =    Nest(K).CostQtLos;
        BestNest.CostQbrLos      =    Nest(K).CostQbrLos;
        BestNest.CostSLos        =    Nest(K).CostSLos;
%end of get_best_nest

New_Nest=Nest; % Just preallocting New_Nest
```

Starting the iteration

```
for iter =1:User.MaxIter
```

Generate new solutions (but keep the current best)

```
%fuction
 New_Nest.Postion=get_cuckoos(Nest.Position,Bestnest.Position,User.Lb,User.Ub);
% Note arg1 is calling in the number os nest (i.e
 Nest.Postion=User.NumNest)
sigma=(gamma(1+User.beta)*sin(pi*User.beta/2)/
(gamma((1+User.beta)/2)*User.beta*2^((User.beta-1)/2)))^(1/User.beta);
for j=1:User.NumNest

    % implementing Levy Flight for each nest
    s=Nest(j).CPnLoc;

     % Levy flights by Mantegna's algorithm
    u=randn(size(s))*sigma;
    v=randn(size(s));
    step=u./abs(v).^(1/User.beta);

    stepsize=0.01*step.*(s-BestNest.CPnLoc);

     s=s+stepsize.*randn(size(s));
```

Application of simple constraints 1

function s=simplebounds(s,Lb,Ub) Apply the lower bound

```
     ns_tmp=s;
     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 th is new move
    s=ns_tmp;
    % end of simplebounds

 New_Nest(j).CPnLoc=round(s);        % Calling simplebounds


New_DistLoadFlowCPSolution=powerflowCP(New_Nest(j).CPnLoc(1,1),New_Nest(j).CPnLoc

      New_Nest(j).CostPLos=[New_DistLoadFlowCPSolution.PtLosskW];
      New_Nest(j).CostPbrLos=[New_DistLoadFlowCPSolution.Pbrloss];
      New_Nest(j).CostVact=[New_DistLoadFlowCPSolution.Vactual];
      New_Nest(j).CostVolt=[New_DistLoadFlowCPSolution.VmagPU];
      New_Nest(j).CostVSI=[New_DistLoadFlowCPSolution.VSI];
      New_Nest(j).CostMinVolt=[New_DistLoadFlowCPSolution.minVSI];
      New_Nest(j).CostLSF=[New_DistLoadFlowCPSolution.LSF];

      New_Nest(j).CostVDI=[New_DistLoadFlowCPSolution.VDI];
      New_Nest(j).CostVDIsum=[New_DistLoadFlowCPSolution.VDIsum];

      New_Nest(j).CostVangle=[New_DistLoadFlowCPSolution.Vangle];
      New_Nest(j).CostQtLos=[New_DistLoadFlowCPSolution.QtLosskVAr];
      New_Nest(j).CostQbrLos=[New_DistLoadFlowCPSolution.Qbrloss];
      New_Nest(j).CostSLos=[New_DistLoadFlowCPSolution.SLosskVA];

end
```

end of get_cuckoos

Geting Current best Solution 2

calling get_best_nest again... but using New_Nest.Position as input 2nd arguement

```
for j=1:User.NumNest
%      Nest(j).Cost=feval(User.Function,New_Nest(j).Position);

 Nest(j).PLosVolt=feval(User.Function,...
            New_Nest(j).CostPLos,New_Nest(j).CostLSF);
%       Nest(j).PLosVolt=feval(User.Function,...
%
 New_Nest(j).CostPLos,New_Nest(j).CostMinVolt,New_Nest(j).CostQtLos);

    if Nest(j).PLosVolt<=fitness(j)
        fitness(j)=Nest(j).PLosVolt;
%         Nest(j).CPnLoc=New_Nest(j).CPnLoc;
          Nest(j)=New_Nest(j);
    end
end

% Find the current best
[~,K]=min(fitness) ;
BestNest.CPnLoc=Nest(K).CPnLoc;
```

```
BestNest.CostPLos       =    Nest(K).CostPLos;
        BestNest.CostPbrLos     =    Nest(K).CostPbrLos;
        BestNest.CostVact       =    Nest(K).CostVact;
        BestNest.CostVolt       =    Nest(K).CostVolt;
        BestNest.CostVSI        =    Nest(K).CostVSI;
        BestNest.CostMinVolt    =    Nest(K).CostMinVolt;
        BestNest.CostLSF        =    Nest(K).CostLSF;

         BestNest.CostVDI        =    Nest(K).CostVDI;
         BestNest.CostVDIsum        =    Nest(K).CostVDIsum;

        BestNest.CostVangle     =    Nest(K).CostVangle;
        BestNest.CostQtLos      =    Nest(K).CostQtLos;
        BestNest.CostQbrLos     =    Nest(K).CostQbrLos;
        BestNest.CostSLos       =    Nest(K).CostSLos;
% End of calling get_best_nest again... but using new_nest as input
 arguement
```

function new_nest=empty_nests(nest,Lb,Ub,pa) ;

```
%.............. Discovery and randomization...............

%............ A fraction of worse nests are discovered with a
 probability pa..............

% Discovered or not -- a status vector
% Converting structure field position to array matrix of NumNest by
% NumbVar
arrayNestCPnLoc=cell2mat({Nest.CPnLoc}.');
K=rand(size(arrayNestCPnLoc))>pa;

% In the real world, if a cuckoo's egg is very similar to a host's
 eggs, then
% this cuckoo's egg is less likely to be discovered, thus the fitness
 should
% be related to the difference in solutions.  Therefore, it is a good
 idea
% to do a random walk in a biased way with some random step sizes.
```

New solution by biased/selective random walks

```
NumbaofNest=size(arrayNestCPnLoc,1);          %NumbaofNest =
 User.NumNest
nestn1=arrayNestCPnLoc(randperm(NumbaofNest),:);
nestn2=arrayNestCPnLoc(randperm(NumbaofNest),:);
Nstepsize=rand*(nestn1-nestn2);
new_arrayNestCPnLoc=arrayNestCPnLoc+Nstepsize.*K;

for j=1:size(new_arrayNestCPnLoc,1)
     Ns=new_arrayNestCPnLoc(j,:);
```

```
    %Application of simple constraints 2
    % Apply the lower bound
    Nns_tmp=Ns;
    nI=Nns_tmp<User.Lb;
    Nns_tmp(nI)=User.Lb(nI);

    % Apply the upper bounds
    nJ=Nns_tmp>User.Ub;
    Nns_tmp(nJ)=User.Ub(nJ);
    % Update this new move
    Ns=Nns_tmp;
    % end of simplebounds
    New_Nest(j).CPnLoc=round(Ns);


 New_DistLoadFlowCPSolution=powerflowCP(New_Nest(j).CPnLoc(1,1),New_Nest(j).CPnLoc

      New_Nest(j).CostPLos=[New_DistLoadFlowCPSolution.PtLosskW];
      New_Nest(j).CostPbrLos=[New_DistLoadFlowCPSolution.Pbrloss];
      New_Nest(j).CostVact=[New_DistLoadFlowCPSolution.Vactual];
      New_Nest(j).CostVolt=[New_DistLoadFlowCPSolution.VmagPU];
      New_Nest(j).CostVSI=[New_DistLoadFlowCPSolution.VSI];
      New_Nest(j).CostMinVolt=[New_DistLoadFlowCPSolution.minVSI];
      New_Nest(j).CostLSF=[New_DistLoadFlowCPSolution.LSF];

      New_Nest(j).CostVDI=[New_DistLoadFlowCPSolution.VDI];
      New_Nest(j).CostVDIsum=[New_DistLoadFlowCPSolution.VDIsum];

      New_Nest(j).CostVangle=[New_DistLoadFlowCPSolution.Vangle];
      New_Nest(j).CostQtLos=[New_DistLoadFlowCPSolution.QtLosskVAr];
      New_Nest(j).CostQbrLos=[New_DistLoadFlowCPSolution.Qbrloss];
      New_Nest(j).CostSLos=[New_DistLoadFlowCPSolution.SLosskVA];
end
```

Geting Current best Solution 3

calling get_best_nest again... but using New_Nest.Position as input 2nd arguement

```
for j=1:User.NumNest
%     New_Nest(j).Cost=feval(User.Function,New_Nest(j).Position);

 New_Nest(j).PLosVolt=feval(User.Function,...
            New_Nest(j).CostPLos,New_Nest(j).CostLSF);

%     New_Nest(j).PLosVolt=feval(User.Function,...
%
 New_Nest(j).CostPLos,New_Nest(j).CostMinVolt,New_Nest(j).CostQtLos);

    if New_Nest(j).PLosVolt<=fitness(j)
        fitness(j)=New_Nest(j).PLosVolt;
%         Nest(j).CPnLoc=New_Nest(j).CPnLoc;
        Nest(j)=New_Nest(j);
    end
```

```
end

% Find the current best
[New_BestNest.PLosVolt,K]=min(fitness) ;
New_BestNest.CPnLoc=Nest(K).CPnLoc;

        New_BestNest.CostPLos       =    Nest(K).CostPLos;
        New_BestNest.CostPbrLos     =    Nest(K).CostPbrLos;
        New_BestNest.CostVact       =    Nest(K).CostVact;
        New_BestNest.CostVolt       =    Nest(K).CostVolt;
        New_BestNest.CostVSI        =    Nest(K).CostVSI;
        New_BestNest.CostLSF        =    Nest(K).CostLSF;

         New_BestNest.CostVDI        =    Nest(K).CostVDI;
         New_BestNest.CostVDIsum        =    Nest(K).CostVDIsum;

        New_BestNest.CostMinVolt    =    Nest(K).CostMinVolt;
        New_BestNest.CostVangle     =    Nest(K).CostVangle;
        New_BestNest.CostQtLos      =    Nest(K).CostQtLos;
        New_BestNest.CostQbrLos     =    Nest(K).CostQbrLos;
        New_BestNest.CostSLos       =    Nest(K).CostSLos;
% End of calling get_best_nest again... but using new_nest as input
 arguement
    if New_BestNest.PLosVolt<BestNest.PLosVolt
%         BestNest.PLosVolt=New_BestNest.PLosVolt;
%         BestNest.CPnLoc =New_BestNest.CPnLoc;
        BestNest = New_BestNest;
    end


    BestCost(iter)=BestNest.PLosVolt;
    TlineLossPaIter(iter)= BestNest.CostPLos;
    VDIpaIter(iter)= BestNest.CostVDIsum;
    % Show Iteration Information
    disp(['Iteration ' num2str(iter) ': Best Cost = '
 num2str(BestCost(iter))]);
```

Iteration 1: Best Cost = 131.7106

Iteration 2: Best Cost = 131.7106

Iteration 3: Best Cost = 131.7106

Iteration 4: Best Cost = 131.7106

Iteration 5: Best Cost = 129.4268

Iteration 6: Best Cost = 129.1867

Iteration 7: Best Cost = 129.1867

Iteration 8: Best Cost = 128.9504

Iteration 9: Best Cost = 128.9504

Iteration 10: Best Cost = 128.9504

```
end
% iteration ends
```

Result Display

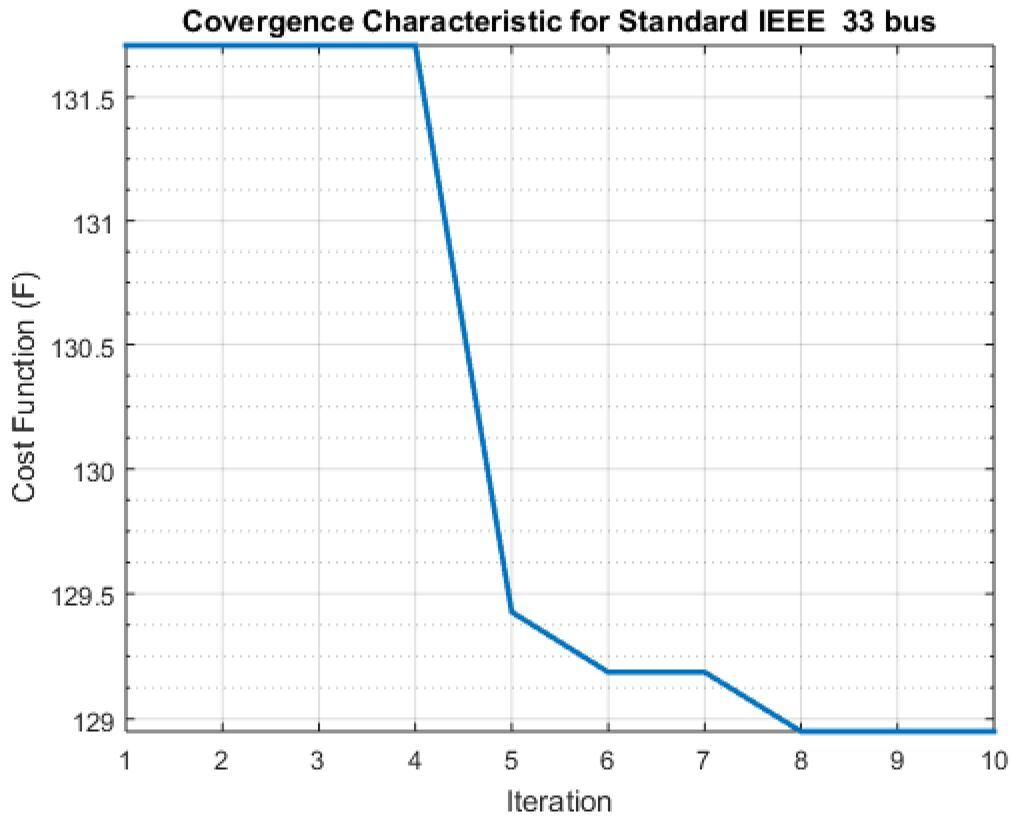
```
figure (1);
%plot(BestCost,'LineWidth',2);
semilogy(BestCost,'LineWidth',2);
xlabel('Iteration');
ylabel('Cost Function (F)');
grid on;
% This part save the figure in png format into a folder already
 created called "Report"
if Standard
    title(['Covergence Characteristic for Standard IEEE  ',
 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);
% %plot(BestCost,'LineWidth',2);
% semilogy(abs(BestCost),'LineWidth',2);
% xlabel('Iteration');
% ylabel('Best Cost');
% grid on;

figure(2)
x=1:bn;
VpCP=BestNest.CostVolt;
VpBase=DistLoadFlowSolution.VmagPU;
plot(x,VpCP,'g-o',x,VpBase,'r-*');
xlim([1 bn]);

legend('Voltage With Capacitor','Voltage With No
 Capacitor','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
```

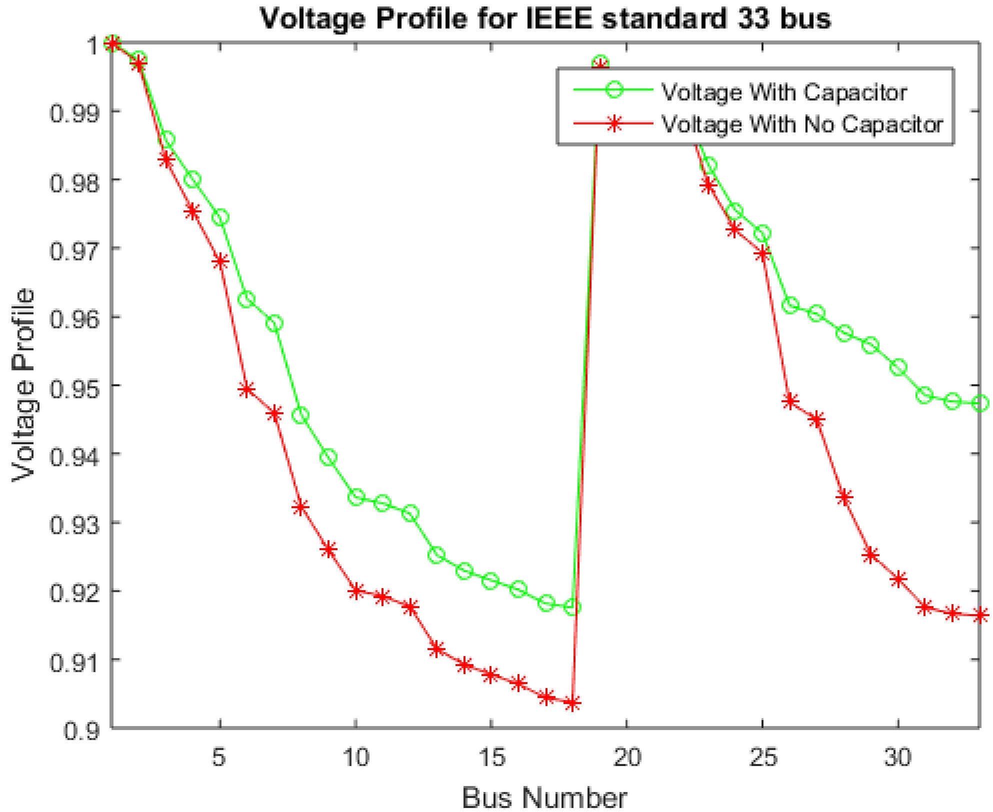
```
hold on

figure(3)
xv=1:bn-1;
VSIcp=BestNest.CostVSI;
VsiBase=DistLoadFlowSolution.VSI;
plot(xv,VSIcp,'g-o',xv,VsiBase,'r-*');
xlim([1 bn-1]);
legend('VSI With Capacitor','VSI With No
 Capacitor','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;
PtLossCP=BestNest.CostPLos;
pp=[PtLossBase;PtLossCP];
bar(pp,'DisplayName','1=Before Capacitor placement  2=After Capacitor
 placement');
ylabel('Power Loss (kW)','FontSize',11);
legend('show');
PercentRedu=((PtLossBase-PtLossCP)/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)
xv=1:bn-1;
LSFcp=BestNest.CostLSF;
LsfBase=DistLoadFlowSolution.LSF;
plot(xv,LSFcp,'g-o',xv,LsfBase,'r-*');
xlim([1 bn-1]);
legend('LSF With Capacitor','LSF With No
 Capacitor','Location','northeast')
```

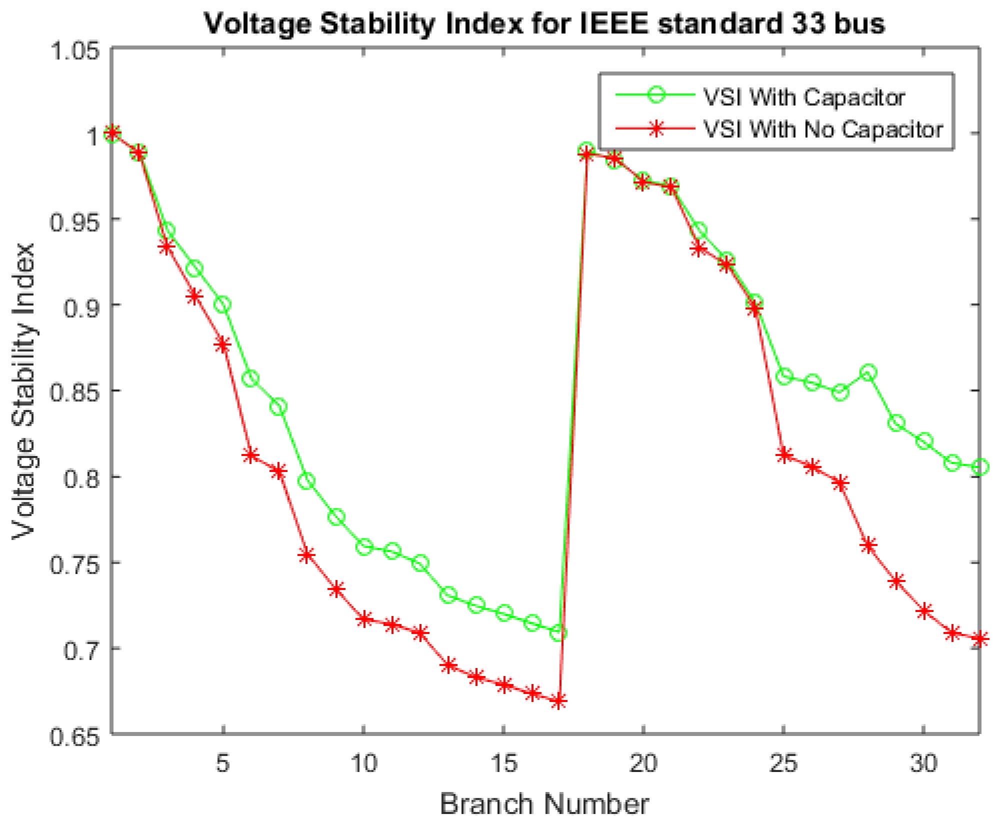
```
xlabel('Branch Number')
ylabel('Loss Sensitivity Factor')

if Standard
    title(['Loss Sensitivity Factor for IEEE standard ',
 num2str(bn), ' bus'])
    saveas(gcf,['Report/Loss_Sensitivity_Factor_for_IEEE
 standard_',num2str(bn),'_bus','.png'])
else
    title(['Loss Sensitivity Factor for ',Bus_Data, num2str(bn), '
 bus'])
    saveas(gcf,['Report/
Loss_Sensitivity_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 Capacitor placement is ',
 num2str(PtLossCP)])
disp('*****************************************************************')
disp(['The Percentage reduction after Capacitor placement is ',
 num2str(PercentRedu)])

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

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

figure (6);
%plot(BestCost,'LineWidth',2);
semilogy(TlineLossPaIter,'LineWidth',2);
xlabel('Iteration');
ylabel('Total Line Loss');
grid on;
% This part save the figure in png format into a folder already
 created called "Report"
if Standard
    title(['Total Line Loss for Standard IEEE  ', num2str(bn), '
 bus'])
    saveas(gcf,['Report/
Total_Line_Loss_for_IEEE_Standard_bus_',num2str(bn),'.png'])
else
     title(['Total Line Loss for ',Bus_Data, num2str(bn), ' bus'])
    saveas(gcf,['Report/
Total_Line_Loss_for_',Bus_Data,num2str(bn),'_bus','.png'])
end

figure (7);
%plot(BestCost,'LineWidth',2);
```

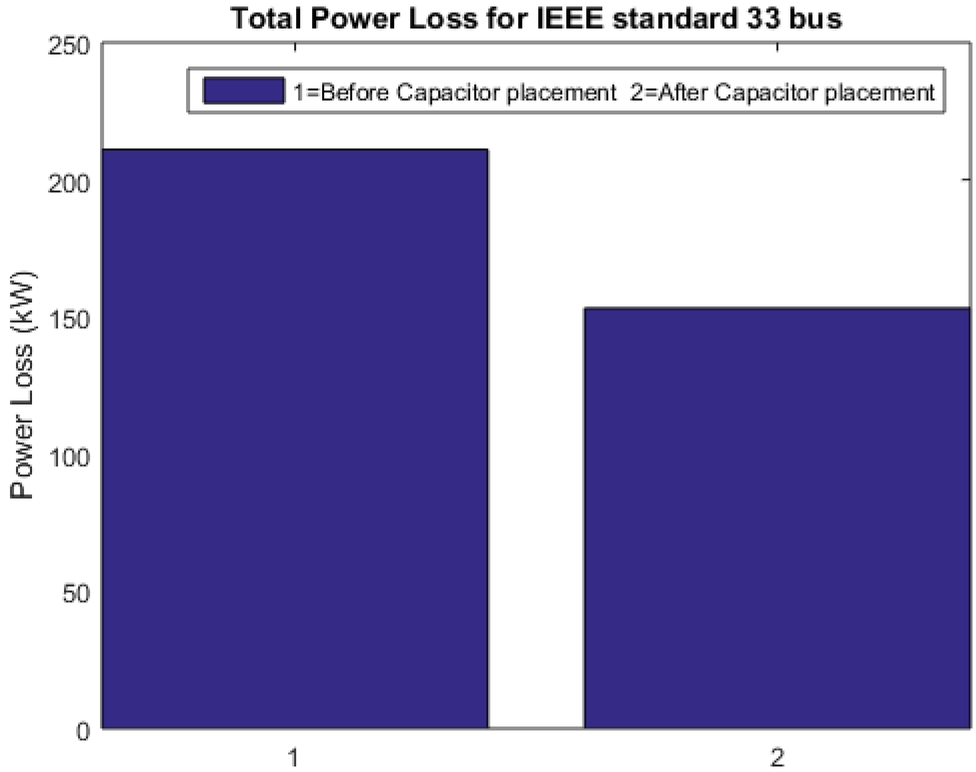
```
semilogy(VDIpaIter,'LineWidth',2);
xlabel('Iteration');
ylabel('Total Voltage Deviation');
grid on;
% This part save the figure in png format into a folder already
 created called "Report"
if Standard
    title(['Total Voltge Deviation for Standard IEEE  ',
 num2str(bn), ' bus'])
    saveas(gcf,['Report/
Total_Voltage_Deviation_for_IEEE_Standard_bus_',num2str(bn),'.png'])
else
     title(['Total Voltge Deviation for ',Bus_Data, num2str(bn), '
 bus'])
    saveas(gcf,['Report/
Total_Voltage_Deviation_for_',Bus_Data,num2str(bn),'_bus','.png'])
end
toc
```

```
The Total Power loss for base case is 210.9876
****************************************************************
The Total Power loss for after Capacitor placement is 153.1905
****************************************************************
The Percentage reduction after Capacitor placement is 27.3936
Elapsed time is 122.577547 seconds.
```

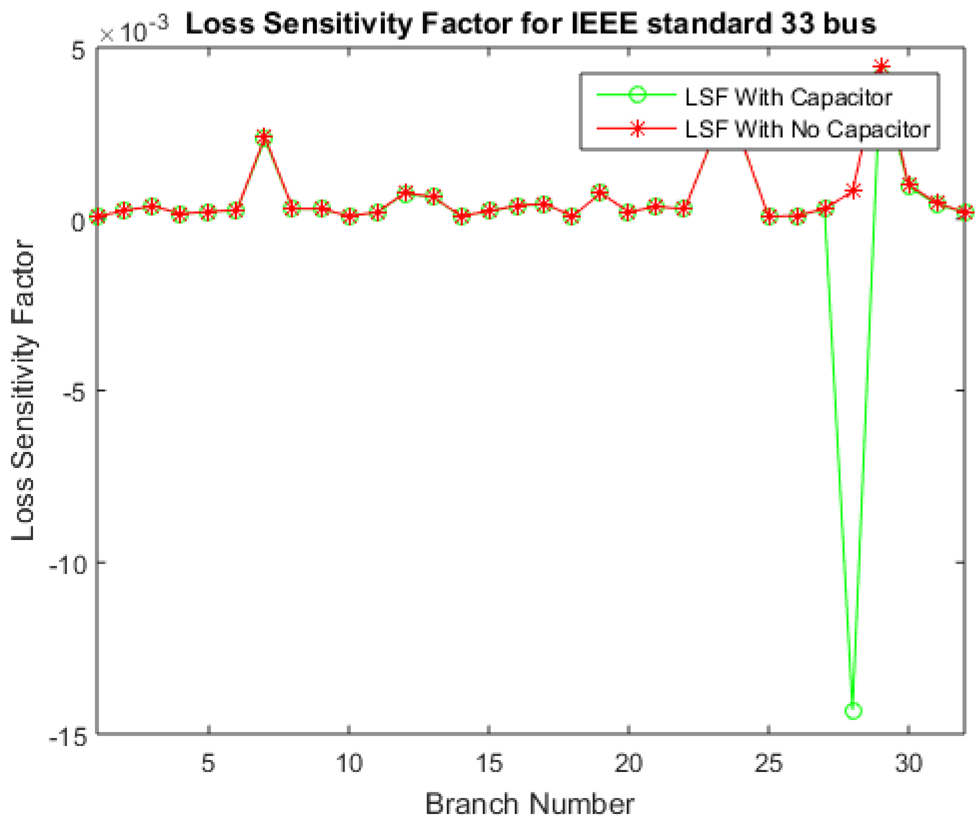



Voltage Profile for IEEE standard 33 bus
Voltage With Capacitor
Voltage With No Capacitor
Voltage Profile
Bus Number
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0.9
5
10
15
20
25
30

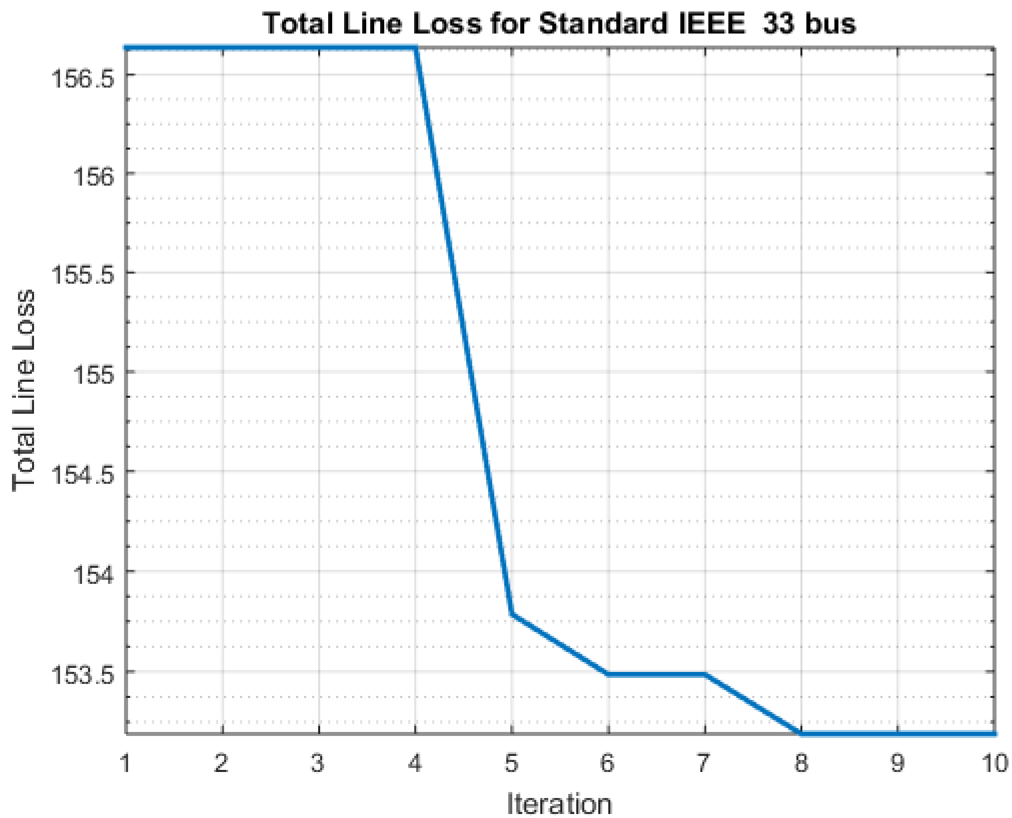

Voltage Stability Index for IEEE standard 33 bus
VSI With Capacitor
VSI With No Capacitor
Voltage Stability Index
Branch Number
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
5
10
15
20
25
30

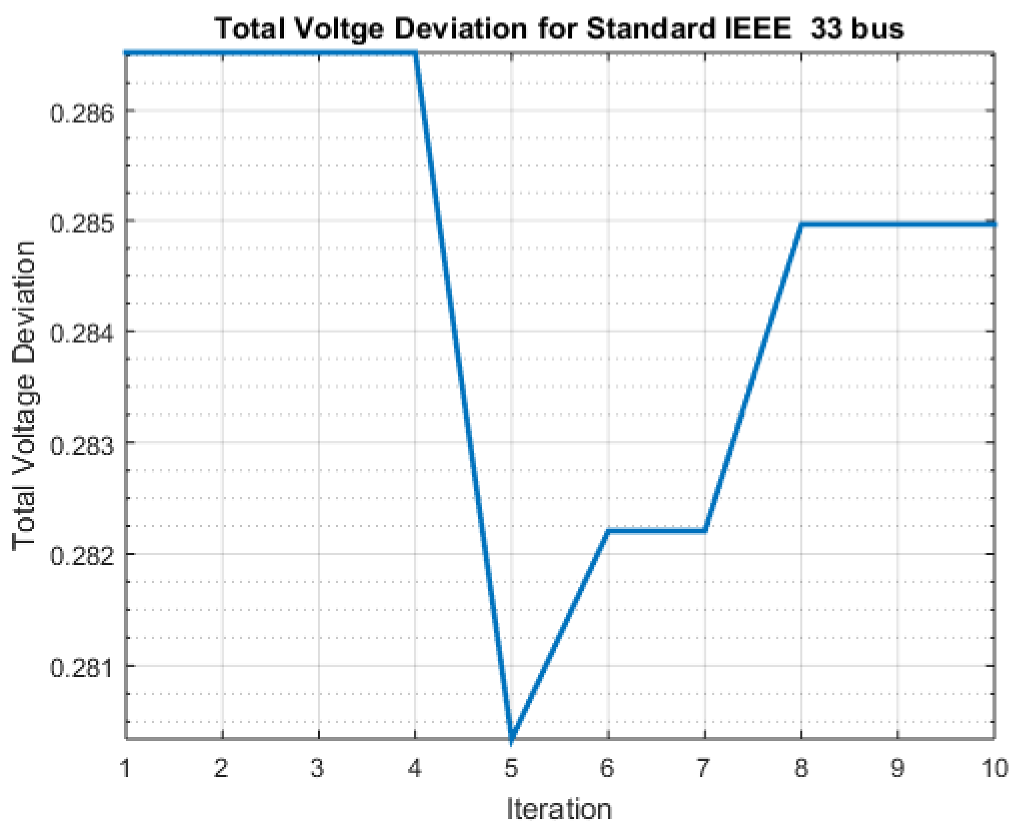


Total Power Loss for IEEE standard 33 bus
1=Before Capacitor placement 2=After Capacitor placement
Power Loss (kW)
250
200
150
100
50
0
1
2



Loss Sensitivity Factor for IEEE standard 33 bus
×10^-3
LSF With Capacitor
LSF With No Capacitor
Loss Sensitivity Factor
5
0
-5
-10
-15
5
10
15
20
25
30
Branch Number


Total Line Loss for Standard IEEE 33 bus
Total Line Loss
156.5
156
155.5
155
154.5
154
153.5
1
2
3
4
5
6
7
8
9
10
Iteration


Total Voltge Deviation for Standard IEEE 33 bus
Total Voltage Deviation
0.286
0.285
0.284
0.283
0.282
0.281
1
2
3
4
5
6
7
8
9
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Iteration

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