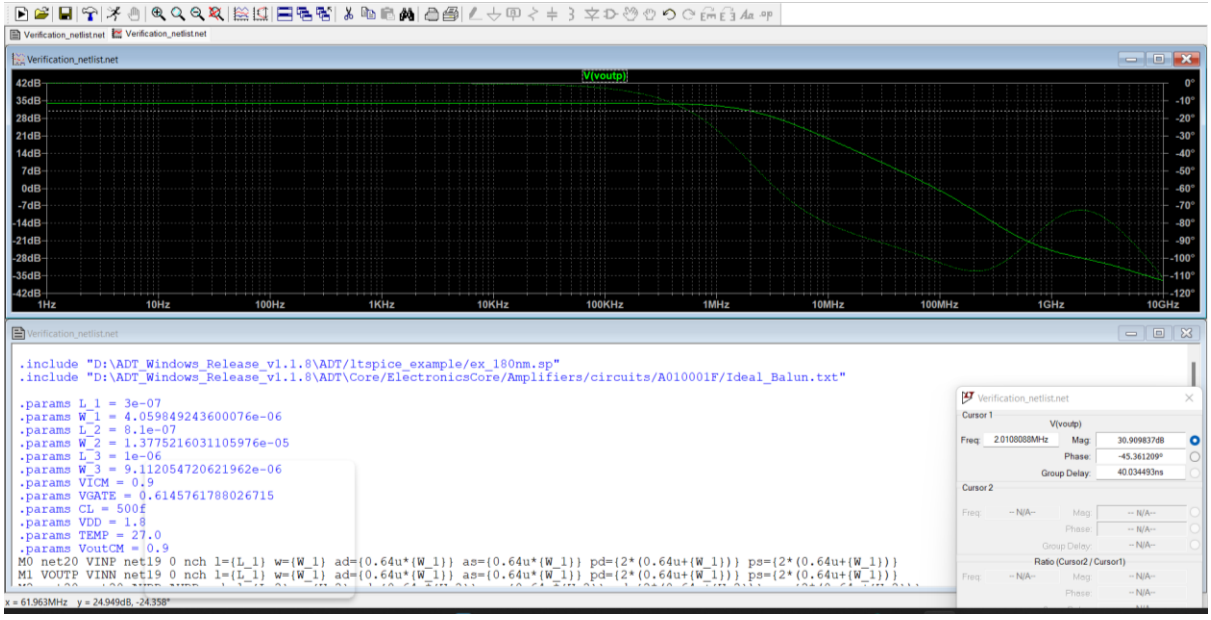
PART 1

Question1:

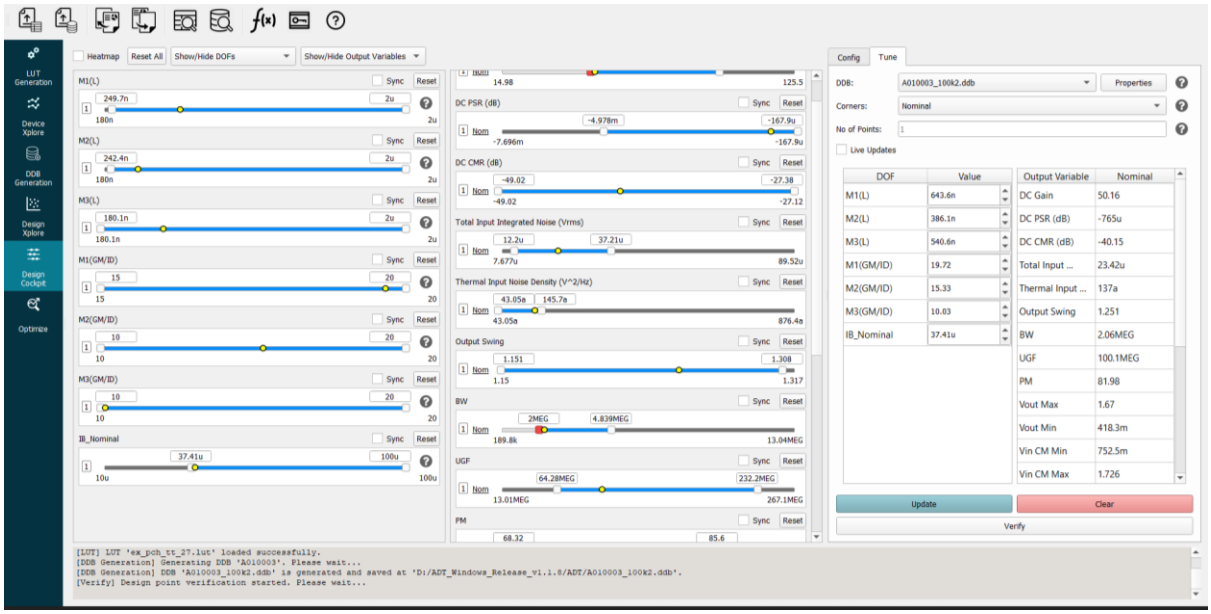
Question2:

Verifying Results

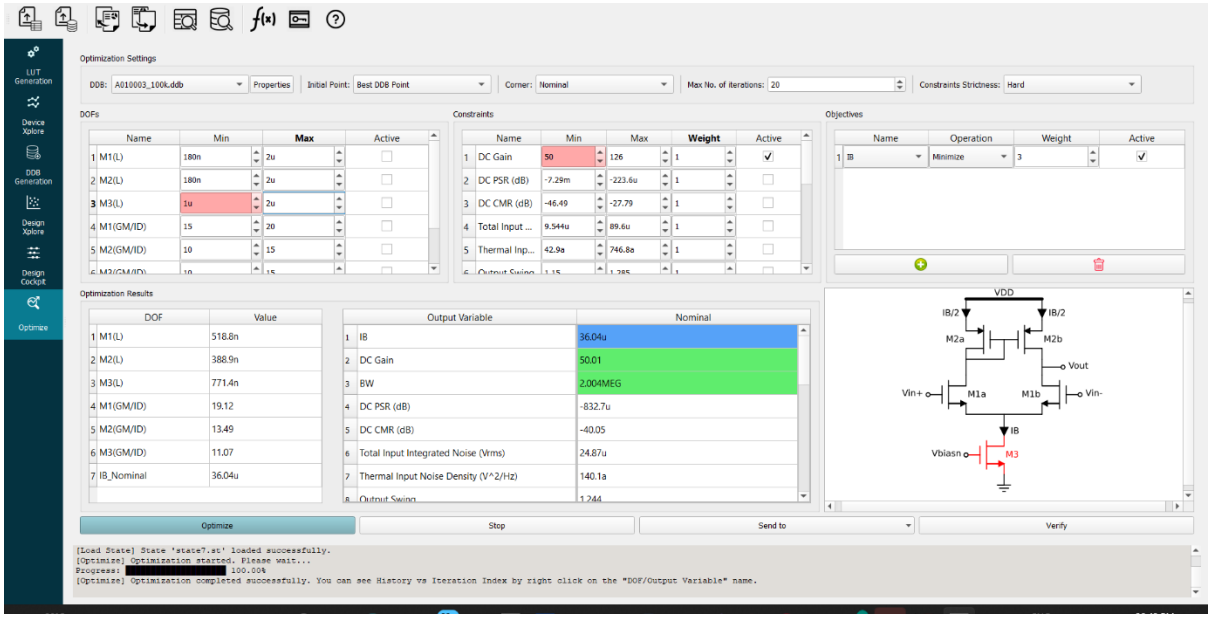
GBW=100Mega , Avdc=34db



Question3:



Question4:



Question5:

Figure 1 Results .

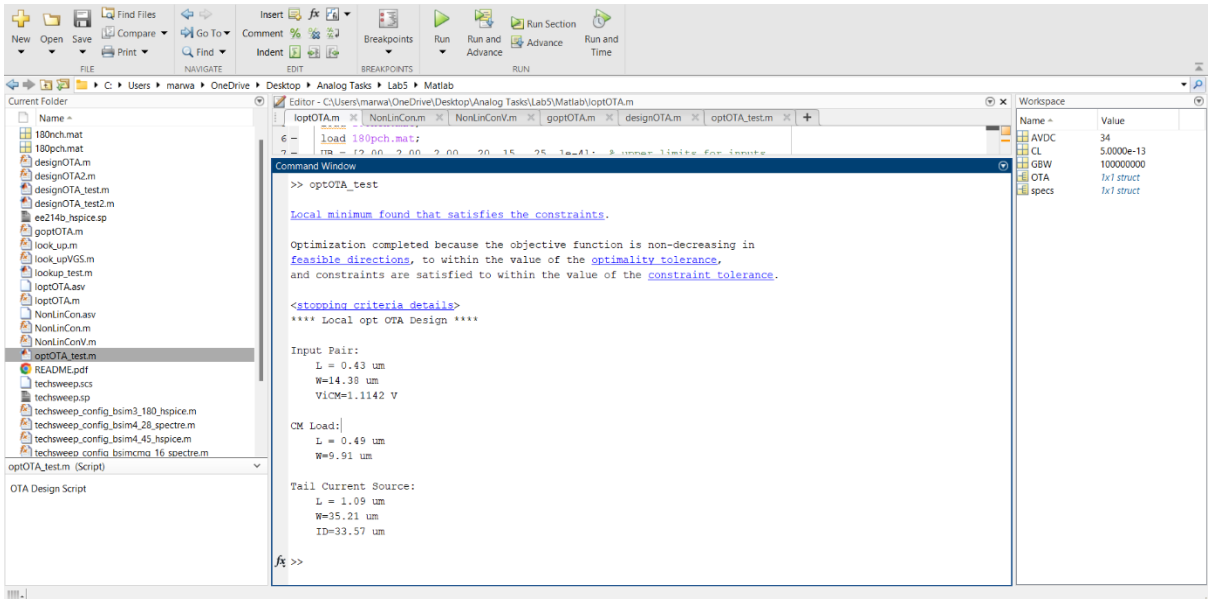


Figure 2 lopt function .

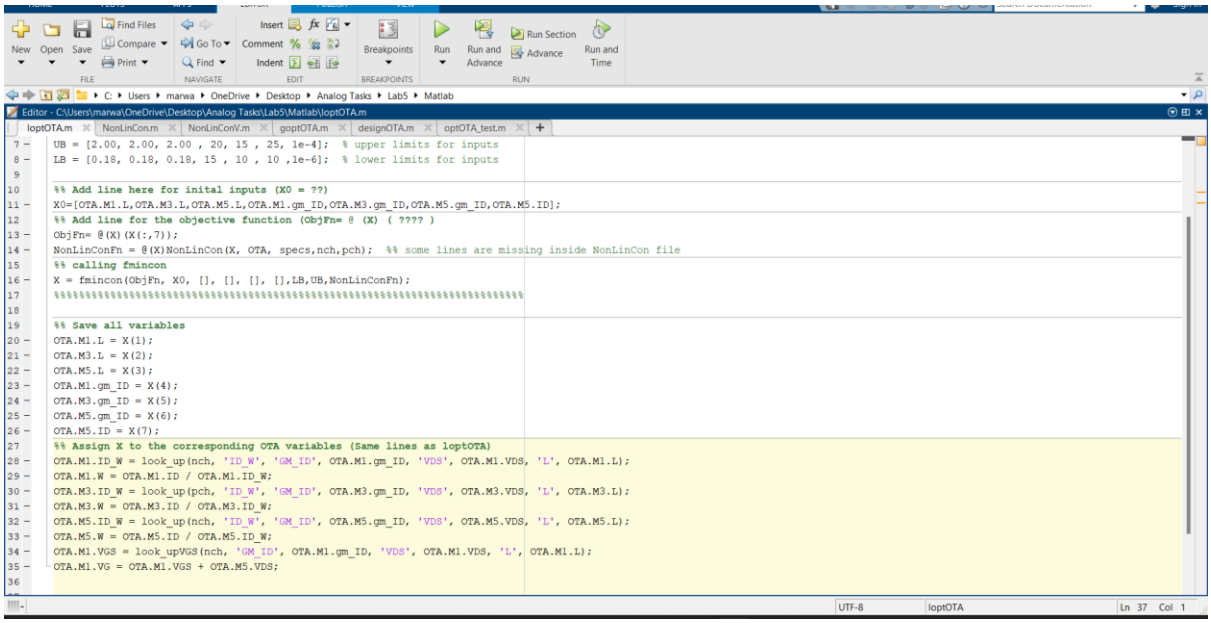
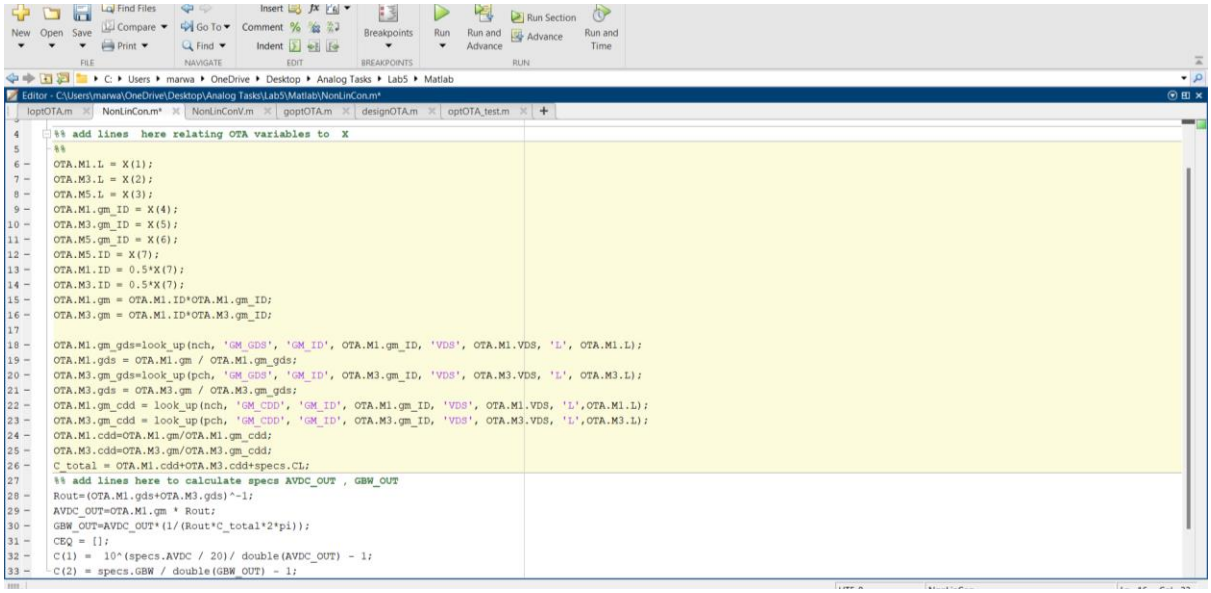


Figure 3 Nonlincon function .

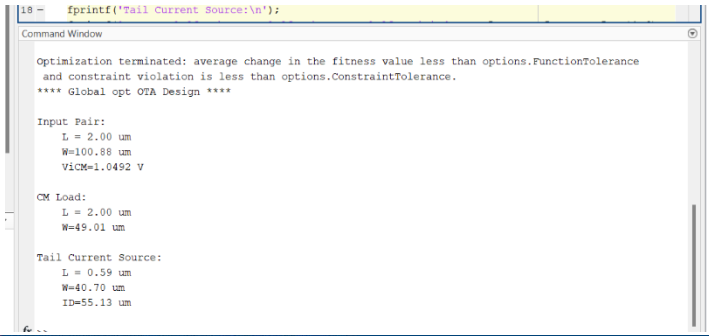


```
%% add lines  here relating OTA variables to  X
%%
OTA.M1.L = X(1);
OTA.M3.L = X(2);
OTA.M5.L = X(3);
OTA.M1.gm_ID = X(4);
OTA.M3.gm_ID = X(5);
OTA.M5.gm_ID = X(6);
OTA.M5.ID = X(7);
OTA.M1.ID = 0.5*X(7);
OTA.M3.ID = 0.5*X(7);
OTA.M1.gm = OTA.M1.ID*OTA.M1.gm_ID;
OTA.M3.gm = OTA.M1.ID*OTA.M3.gm_ID;

OTA.M1.gm_gds=look_up(nch, 'GM_GDS', 'GM_ID', OTA.M1.gm_ID, 'VDS', OTA.M1.VDS, 'L', OTA.M1.L);
OTA.M1.gds = OTA.M1.gm / OTA.M1.gm_gds;
OTA.M3.gm_gds=look_up(pch, 'GM_GDS', 'GM_ID', OTA.M3.gm_ID, 'VDS', OTA.M3.VDS, 'L', OTA.M3.L);
OTA.M3.gds = OTA.M3.gm / OTA.M3.gm_gds;
OTA.M1.gm_cdd = look_up(nch, 'GM_CDD', 'GM_ID', OTA.M1.gm_ID, 'VDS', OTA.M1.VDS, 'L',OTA.M1.L);
OTA.M3.gm_cdd = look_up(pch, 'GM_CDD', 'GM_ID', OTA.M3.gm_ID, 'VDS', OTA.M3.VDS, 'L',OTA.M3.L);
OTA.M1.cdd=OTA.M1.gm/OTA.M1.gm_cdd;
OTA.M3.cdd=OTA.M3.gm/OTA.M3.gm_cdd;
C_total = OTA.M1.cdd+OTA.M3.cdd+specs.CL;
%% add lines here to calculate specs AVDC_OUT , GBW_OUT
Rout=(OTA.M1.gds+OTA.M3.gds)^-1;
AVDC_OUT=OTA.M1.gm * Rout;
GBW_OUT=AVDC_OUT*(1/(Rout*C_total*2*pi));
CEQ = [];
C(1) =  10^(specs.AVDC / 20)/ double(AVDC_OUT) - 1;
C(2) = specs.GBW / double(GBW_OUT) - 1;
```

Question6:

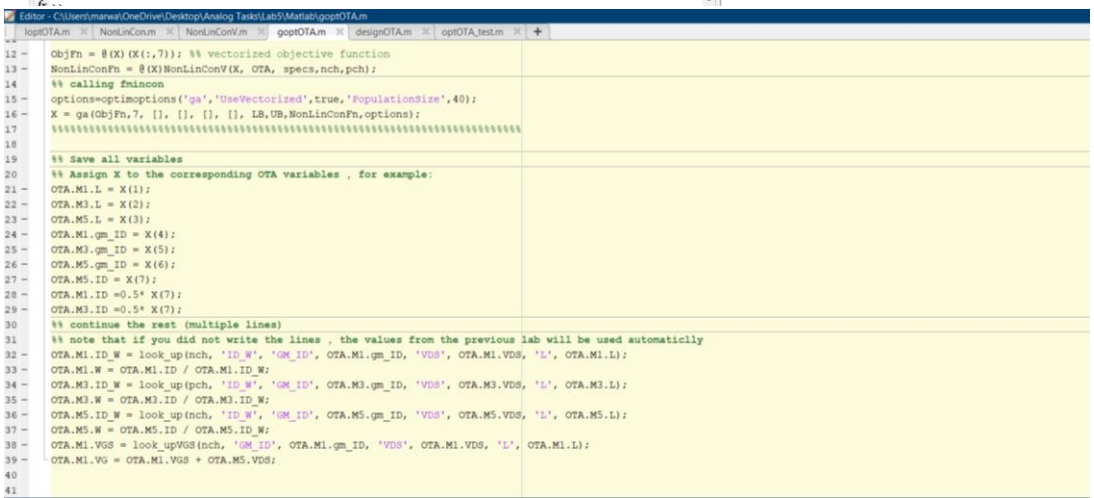
Global Optimizer

Note : This Result isn't Correct but I can't find the bug in my code .



```
fprintf('Tail Current Source:\n');
```

```
Command Window

  Optimization terminated: average change in the fitness value less than options.FunctionTolerance
   and constraint violation is less than options.ConstraintTolerance.
  **** Global opt OTA Design ****

  Input Pair:
      L = 2.00 um
      W=100.88 um
      ViCM=1.0492 V

  CM Load:
      L = 2.00 um
      W=49.01 um

  Tail Current Source:
      L = 0.59 um
      W=40.70 um
      ID=55.13 um
```



```
ObjFn = @(X)(X(:,7)); %% vectorized objective function
NonLinConFn = @(X)NonLinConV(X, OTA, specs,nch,pch);
%% calling fmincon
options=optimoptions('ga','UseVectorized',true,'PopulationSize',40);
X = ga(ObjFn,7, [], [], [], [], LB,UB,NonLinConFn,options);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%% Save all variables
%% Assign X to the corresponding OTA variables , for example:
OTA.M1.L = X(1);
OTA.M3.L = X(2);
OTA.M5.L = X(3);
OTA.M1.gm_ID = X(4);
OTA.M3.gm_ID = X(5);
OTA.M5.gm_ID = X(6);
OTA.M5.ID = X(7);
OTA.M1.ID =0.5* X(7);
OTA.M3.ID =0.5* X(7);
%% continue the rest (multiple lines)
%% note that if you did not write the lines , the values from the previous lab will be used automaticlly
OTA.M1.ID_W = look_up(nch, 'ID_W', 'GM_ID', OTA.M1.gm_ID, 'VDS', OTA.M1.VDS, 'L', OTA.M1.L);
OTA.M1.W = OTA.M1.ID / OTA.M1.ID_W;
OTA.M3.ID_W = look_up(pch, 'ID_W', 'GM_ID', OTA.M3.gm_ID, 'VDS', OTA.M3.VDS, 'L', OTA.M3.L);
OTA.M3.W = OTA.M3.ID / OTA.M3.ID_W;
OTA.M5.ID_W = look_up(nch, 'ID_W', 'GM_ID', OTA.M5.gm_ID, 'VDS', OTA.M5.VDS, 'L', OTA.M5.L);
OTA.M5.W = OTA.M5.ID / OTA.M5.ID_W;
OTA.M1.VGS = look_upVGS(nch, 'GM_ID', OTA.M1.gm_ID, 'VDS', OTA.M1.VDS, 'L', OTA.M1.L);
OTA.M1.VG = OTA.M1.VGS + OTA.M5.VDS;
```

```
OTA.M1.L = X(:,1);
OTA.M3.L = X(:,2);
OTA.M5.L = X(:,3);
OTA.M1.gm_ID = X(:,4);
OTA.M3.gm_ID = X(:,5);
OTA.M5.gm_ID = X(:,6);
OTA.M5.ID = X(:,7);
OTA.M1.ID = 0.5*X(:,7);
OTA.M3.ID = 0.5*X(:,7);
OTA.M1.gm = OTA.M1.ID.*OTA.M1.gm_ID;
OTA.M3.gm = OTA.M3.ID.*OTA.M3.gm_ID;

OTA.M1.gm_gds=look_up(nch, 'GM_GDS', 'GM_ID', OTA.M1.gm_ID, 'VDS', OTA.M1.VDS, 'L', OTA.M1.L);
OTA.M1.gm_gds=diag(OTA.M1.gm_gds);
OTA.M1.gds = OTA.M1.gm ./ OTA.M1.gm_gds;
OTA.M3.gm_gds=look_up(pch, 'GM_GDS', 'GM_ID', OTA.M3.gm_ID, 'VDS', OTA.M3.VDS, 'L', OTA.M3.L);
OTA.M3.gm_gds=diag(OTA.M3.gm_gds);
OTA.M3.gds = OTA.M3.gm ./ OTA.M3.gm_gds;
OTA.M1.gm_cdd = look_up(nch, 'GM_CDD', 'GM_ID', OTA.M1.gm_ID, 'VDS', OTA.M1.VDS, 'L',OTA.M1.L);
OTA.M1.gm_cdd =diag(OTA.M1.gm_cdd);
OTA.M3.gm_cdd = look_up(pch, 'GM_CDD', 'GM_ID', OTA.M3.gm_ID, 'VDS', OTA.M3.VDS, 'L',OTA.M3.L);
OTA.M3.gm_cdd =diag(OTA.M3.gm_cdd);
OTA.M1.cdd=OTA.M1.gm ./ OTA.M1.gm_cdd;
OTA.M3.cdd=OTA.M3.gm ./ OTA.M3.gm_cdd;
C_total = OTA.M1.cdd+OTA.M3.cdd+specs.CL;
%% write ouput specs AVDC_OUT , GBW_OUT equations (include self loading )
Rout=(OTA.M1.gds+OTA.M3.gds).^-1;
AVDC_OUT=OTA.M1.gm .* Rout;
GBW_OUT=OTA.M1.gm ./(2*pi*C_total);
CEQ = [];
```

Question7:

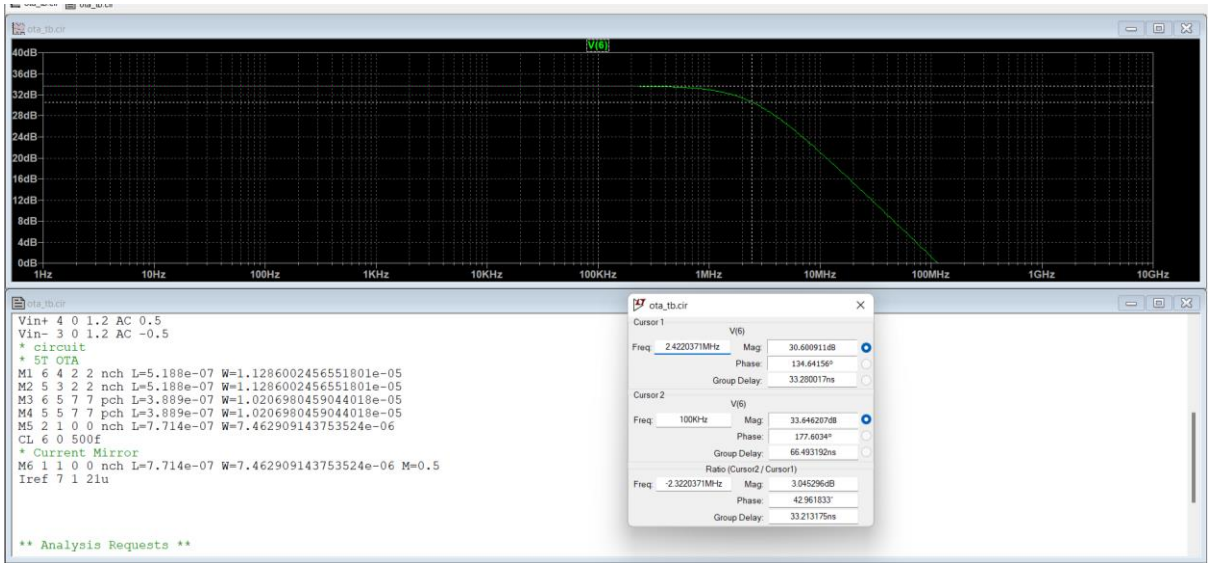
```
% OTA Design Script
% Write the SPECS
clear all;
AVDC = 34; %dB
GBW = 1e8; %Hz
CL = 500e-15; %Farad
specs = struct('AVDC', AVDC,...
'CL', CL,...
'GBW', GBW);

OTA = loptOTA(specs);
% Print the solution
fprintf('**** Local opt OTA Design ****\n\n');
fprintf('Input Pair:\n');
fprintf('    L = %.2f um\n    W=%.2f um\n    ViCM=%.4f V\n\n',OTA.M1.L,OTA.M1.W,OTA.M1.VG);
fprintf('CM Load:\n');
fprintf('    L = %.2f um\n    W=%.2f um\n\n',OTA.M3.L,OTA.M3.W);
fprintf('Tail Current Source:\n');
fprintf('    L = %.2f um\n    W=%.2f um\n    ID=%.2f um \n\n',OTA.M5.L,OTA.M5.W,OTA.M5.ID*1e6);

% Print the solution Global Opt
OTA2 = goptOTA(specs);

fprintf('**** Global opt OTA Design ****\n\n');
fprintf('Input Pair:\n');
fprintf('    L = %.2f um\n    W=%.2f um\n    ViCM=%.4f V\n\n',OTA2.M1.L,OTA2.M1.W,OTA2.M1.VG);
fprintf('CM Load:\n');
fprintf('    L = %.2f um\n    W=%.2f um\n\n',OTA2.M3.L,OTA2.M3.W);
fprintf('Tail Current Source:\n');
fprintf('    L = %.2f um\n    W=%.2f um\n    ID=%.2f um \n\n',OTA2.M5.L,OTA2.M5.W,OTA2.M5.ID*1e6);
```

ADT	Matlab
Input Pair: W= 11.286 u L=518.8n Current Mirror Load : W= 10.2069u L=389n Tail Current Source : W=7.4689u L=771.4n IB=36.04u	Input Pair: W= 14.38u L=0.43u Current Mirror Load : W= 35.21u L=0.49u Tail Current Source : W=9.598u L=1u IB=33.57u

Comment :

The Sizing Difference due to the added constrain in ADT for GBW = 100 mega , where added DCgain constrain and BW Constrain.

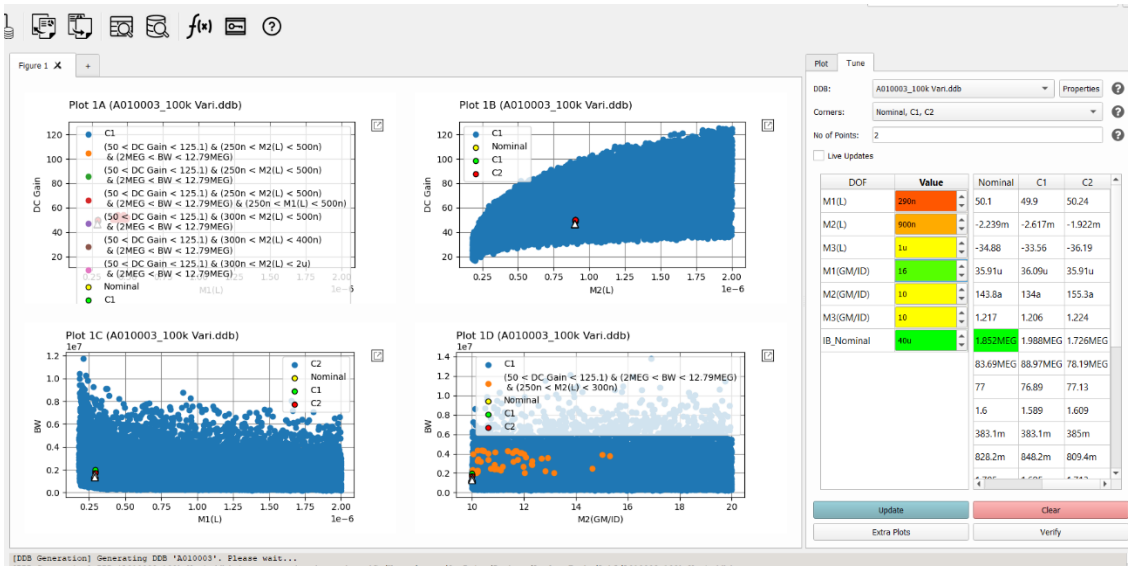
Question8:



PART2:

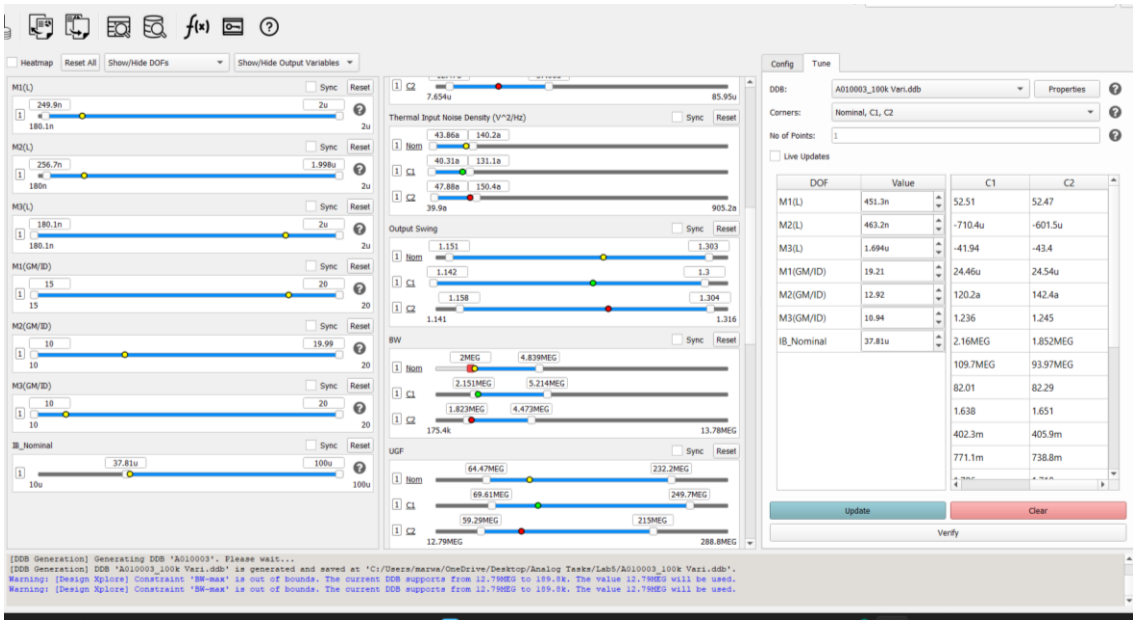
Question 1:

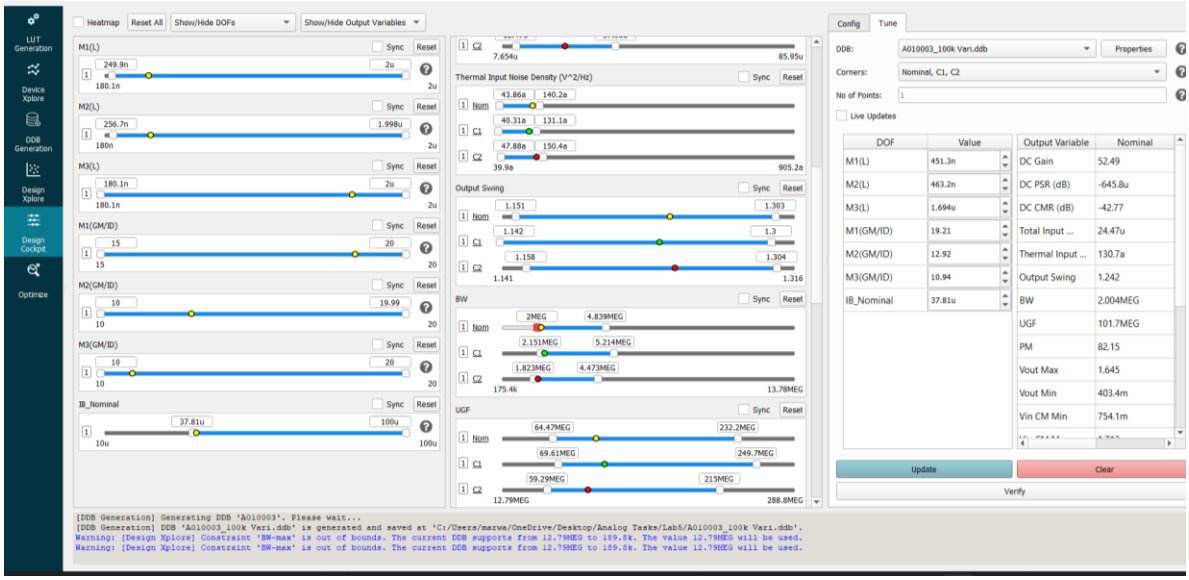
C1 is +10% C2 is -10%



Question 2:

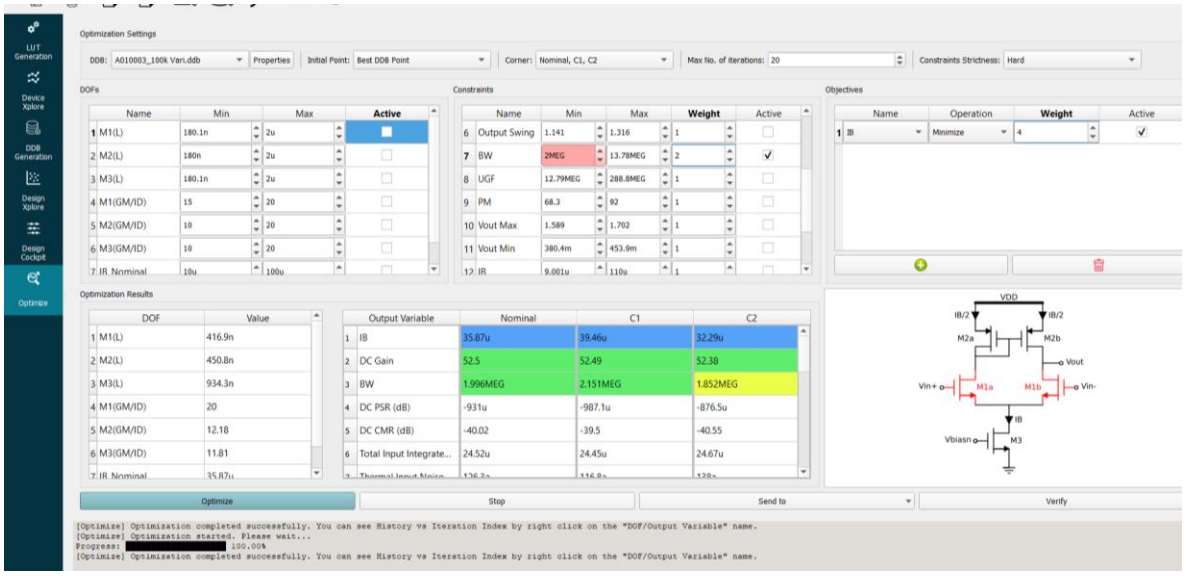
C1 is +10% C2 is -10%





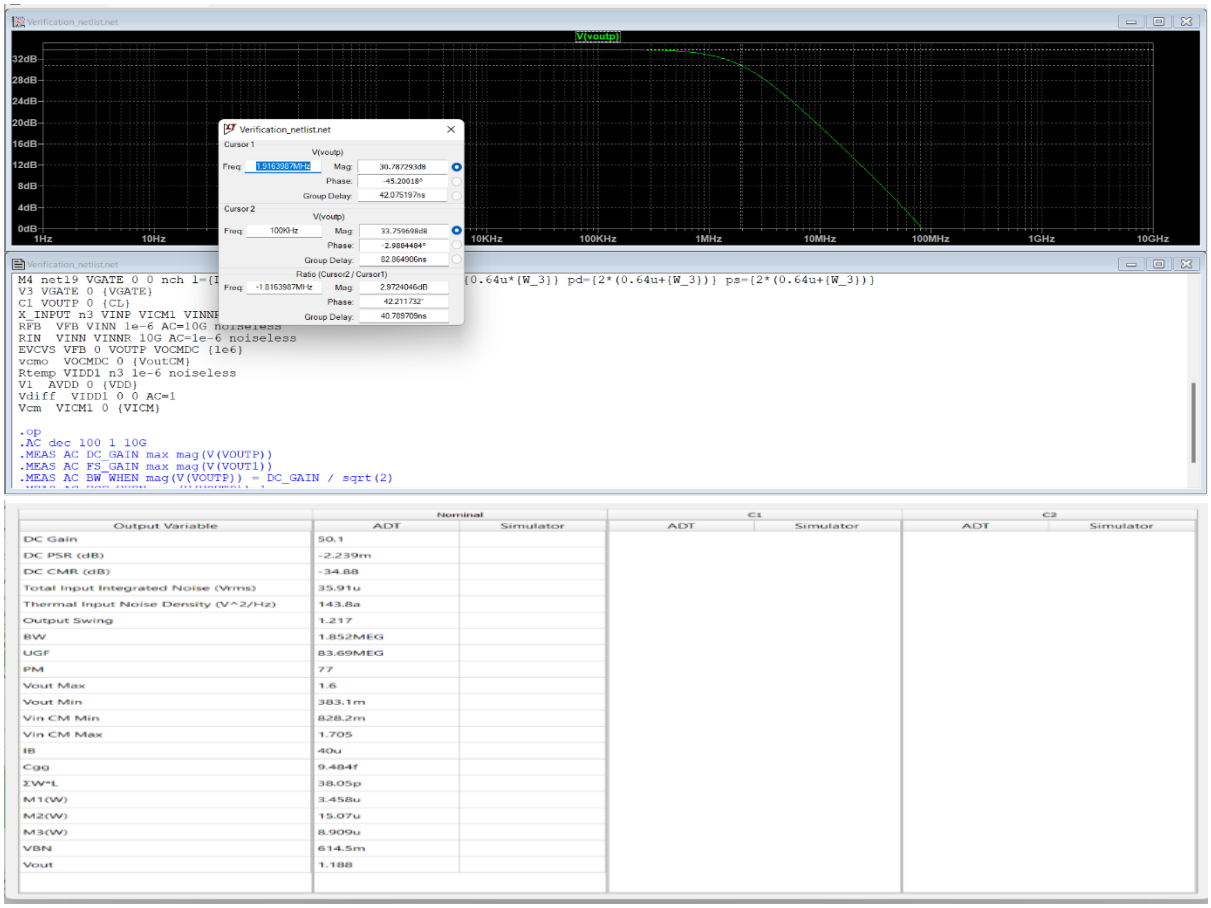
Question 3:

C1 is +10% C2 is -10%



Question 4:

ADT Genrated a netlist for the nomninal Value only



Output Variable	Nominal ADT	Nominal Simulator	C1 ADT	C1 Simulator	C2 ADT	C2 Simulator
DC Gain	50.1					
DC PSR (dB)	-2.239m					
DC CMR (dB)	-34.88					
Total Input Integrated Noise (Vrms)	35.91u					
Thermal Input Noise Density (V^2/Hz)	143.8a					
Output Swing	1.217					
BW	1.852MEG					
UGF	83.69MEG					
PM	77					
Vout Max	1.6					
Vout Min	383.1m					
Vin CM Min	828.2m					
Vin CM Max	1.705					
IB	40u					
Cgg	9.484f					
ΣW*L	38.05p					
M1(W)	3.458u					
M2(W)	15.07u					
M3(W)	8.909u					
VBN	614.5m					
Vout	1.188					