%This program calculates the input and output impedance of the Buck-Boost

%converter.

clc

clear all

syms vg rg d rL L rC C R vC iL rds rD vD io

%Converter Dynamical equations

%M1: diL/dt for closed MOSFET.

%M2: dvC/dt for closed MOSFET.

%M3: current of input DC source for closed MOSFET.

%M4: output voltage of converter for closed MOSFET.

%M5: diL/dt for open MOSFET.

%M6: dvC/dt for open MOSFET.

%M7: current of input DC source for open MOSFET.

%M8: output voltage of converter for open MOSFET.

M1=(-(rg+rds+rL)\*iL+vg)/L;

M2=(R/(R+rC)\*io-vC/(R+rC))/C;

M3=iL;

M4=R\*rC/(R+rC)\*io+R/(R+rC)\*vC;

M5=(-(rL+rD+rC\*R/(R+rC))\*iL-R/(R+rC)\*vC-R\*rC/(R+rC)\*io-vD)/L;

M6=(R/(R+rC)\*iL-1/(R+rC)\*vC+R/(R+rC)\*io)/C;

M7=0;

M8=rC\*R/(rC+R)\*iL+R/(R+rC)\*vC+R\*rC/(R+rC)\*io+vD;

%Averaged Equations

diL\_dt\_ave=simplify(M1\*d+M5\*(1-d));

dvC\_dt\_ave=simplify(M2\*d+M6\*(1-d));

ig\_ave=simplify(M3\*d+M7\*(1-d));

vo\_ave=simplify(M4\*d+M8\*(1-d));

%DC Operating Point

DC=solve(diL\_dt\_ave==0,dvC\_dt\_ave==0,iL,vC);

IL=DC.iL;

VC=DC.vC;

%Linearization

A11=simplify(subs(diff(diL\_dt\_ave,iL),[iL vC io],[IL VC 0]));

A12=simplify(subs(diff(diL\_dt\_ave,vC),[iL vC io],[IL VC 0]));

A21=simplify(subs(diff(dvC\_dt\_ave,iL),[iL vC io],[IL VC 0]));

A22=simplify(subs(diff(dvC\_dt\_ave,vC),[iL vC io],[IL VC 0]));

AA=[A11 A12;A21 A22];

B11=simplify(subs(diff(diL\_dt\_ave,io),[iL vC io],[IL VC 0]));

B12=simplify(subs(diff(diL\_dt\_ave,vg),[iL vC io],[IL VC 0]));

B13=simplify(subs(diff(diL\_dt\_ave,d),[iL vC io],[IL VC 0]));

B21=simplify(subs(diff(dvC\_dt\_ave,io),[iL vC io],[IL VC 0]));

B22=simplify(subs(diff(dvC\_dt\_ave,vg),[iL vC io],[IL VC 0]));

B23=simplify(subs(diff(dvC\_dt\_ave,d),[iL vC io],[IL VC 0]));

BB=[B11 B12 B13;B21 B22 B23];

C11=simplify(subs(diff(ig\_ave,iL),[iL vC io],[IL VC 0]));

C12=simplify(subs(diff(ig\_ave,vC),[iL vC io],[IL VC 0]));

C21=simplify(subs(diff(vo\_ave,iL),[iL vC io],[IL VC 0]));

C22=simplify(subs(diff(vo\_ave,vC),[iL vC io],[IL VC 0]));

CC=[C11 C12; C21 C22];

D11=simplify(subs(diff(ig\_ave,io),[iL vC io],[IL VC 0 ]));

D12=simplify(subs(diff(ig\_ave,vg),[iL vC io],[IL VC 0]));

D13=simplify(subs(diff(ig\_ave,d),[iL vC io],[IL VC 0]));

D21=simplify(subs(diff(vo\_ave,io),[iL vC io],[IL VC 0 ]));

D22=simplify(subs(diff(vo\_ave,vg),[iL vC io],[IL VC 0]));

D23=simplify(subs(diff(vo\_ave,d),[iL vC io],[IL VC 0]));

DD=[D11 D12 D13;D21 D22 D23];

%Components Values

%Variables have underline are used to store the numeric values of components

%Variables without underline are symbolic variables.

%for example:

%L: symbolic vvariable shows the inductor inductance

%L\_: numeric variable shows the inductor inductance value.

L\_=20e-6;

rL\_=.01;

C\_=80e-6;

rC\_=.05;

rds\_=.04;

rD\_=.01;

VD\_=.7;

D\_=.4;

VG\_=24;

rg\_=.1;

R\_=5;

AA\_=eval(subs(AA,[vg rg rds rD vD rL L rC C R d io],[VG\_ rg\_ rds\_ rD\_ VD\_ rL\_ L\_ rC\_ C\_ R\_ D\_ 0]));

BB\_=eval(subs(BB,[vg rg rds rD vD rL L rC C R d io],[VG\_ rg\_ rds\_ rD\_ VD\_ rL\_ L\_ rC\_ C\_ R\_ D\_ 0]));

CC\_=eval(subs(CC,[vg rg rds rD vD rL L rC C R d io],[VG\_ rg\_ rds\_ rD\_ VD\_ rL\_ L\_ rC\_ C\_ R\_ D\_ 0]));

DD\_=eval(subs(DD,[vg rg rds rD vD rL L rC C R d io],[VG\_ rg\_ rds\_ rD\_ VD\_ rL\_ L\_ rC\_ C\_ R\_ D\_ 0]));

sys=ss(AA\_,BB\_,CC\_,DD\_);

sys.stateName={'iL','vC'};

sys.inputname={'io','vg','d'};

sys.outputname={'ig','vo'};

ig\_io=sys(1,1);

ig\_vg=sys(1,2);

ig\_d=sys(1,3);

vo\_io=sys(2,1);

vo\_vg=sys(2,2);

vo\_d=sys(2,3);

Zin=1/ig\_vg; %input impedance

Zout=vo\_io; %output impedance

%Draws the bode diagram of input/output impedance

figure(1)

bode(Zin), grid minor

figure(2)

bode(Zout), grid minor

%Display the DC operating point of converter

disp('steady state operating point of converter')

disp('IL')

disp(eval(subs(IL,[vg rg rds rD vD rL L rC C R d io],[VG\_ rg\_ rds\_ rD\_ VD\_ rL\_ L\_ rC\_ C\_ R\_ D\_ 0])));

disp('VC')

disp(eval(subs(VC,[vg rg rds rD vD rL L rC C R d io],[VG\_ rg\_ rds\_ rD\_ VD\_ rL\_ L\_ rC\_ C\_ R\_ D\_ 0])));

%This program calculates the input and output impedance of the Boost

%converter.

clc

clear all

syms vg rg d rL L rC C R vC iL rds rD vD io

%Converter Dynamical equations

%M1: diL/dt for closed MOSFET.

%M2: dvC/dt for closed MOSFET.

%M3: current of input DC source for closed MOSFET.

%M4: output voltage of converter for closed MOSFET.

%M5: diL/dt for open MOSFET.

%M6: dvC/dt for open MOSFET.

%M7: current of input DC source for open MOSFET.

%M8: output voltage of converter for open MOSFET.

M1=(-(rg+rL+rds)\*iL+vg)/L;

M2=(-vC/(R+rC)+R/(R+rC)\*io)/C;

M3=iL;

M4=R/(R+rC)\*vC+R\*rC/(R+rC)\*io;

M5=(-(rg+rL+rD+R\*rC/(R+rC))\*iL-R/(R+rC)\*vC-R\*rC/(R+rC)\*io+vg-vD)/L;

M6=((R/(R+rC))\*iL-vC/(R+rC)+R/(R+rC)\*io)/C;

M7=iL;

M8=R\*rC/(R+rC)\*iL-R/(R+rC)\*vC+R\*rC/(R+rC)\*io;

%Averaged Equations

diL\_dt\_ave=simplify(M1\*d+M5\*(1-d));

dvC\_dt\_ave=simplify(M2\*d+M6\*(1-d));

ig\_ave=simplify(M3\*d+M7\*(1-d));

vo\_ave=simplify(M4\*d+M8\*(1-d));

%DC Operating Point

DC=solve(diL\_dt\_ave==0,dvC\_dt\_ave==0,iL,vC);

IL=DC.iL;

VC=DC.vC;

%Linearization

A11=simplify(subs(diff(diL\_dt\_ave,iL),[iL vC io],[IL VC 0]));

A12=simplify(subs(diff(diL\_dt\_ave,vC),[iL vC io],[IL VC 0]));

A21=simplify(subs(diff(dvC\_dt\_ave,iL),[iL vC io],[IL VC 0]));

A22=simplify(subs(diff(dvC\_dt\_ave,vC),[iL vC io],[IL VC 0]));

AA=[A11 A12;A21 A22];

B11=simplify(subs(diff(diL\_dt\_ave,io),[iL vC io],[IL VC 0]));

B12=simplify(subs(diff(diL\_dt\_ave,vg),[iL vC io],[IL VC 0]));

B13=simplify(subs(diff(diL\_dt\_ave,d),[iL vC io],[IL VC 0]));

B21=simplify(subs(diff(dvC\_dt\_ave,io),[iL vC io],[IL VC 0]));

B22=simplify(subs(diff(dvC\_dt\_ave,vg),[iL vC io],[IL VC 0]));

B23=simplify(subs(diff(dvC\_dt\_ave,d),[iL vC io],[IL VC 0]));

BB=[B11 B12 B13;B21 B22 B23];

C11=simplify(subs(diff(ig\_ave,iL),[iL vC io],[IL VC 0]));

C12=simplify(subs(diff(ig\_ave,vC),[iL vC io],[IL VC 0]));

C21=simplify(subs(diff(vo\_ave,iL),[iL vC io],[IL VC 0]));

C22=simplify(subs(diff(vo\_ave,vC),[iL vC io],[IL VC 0]));

CC=[C11 C12; C21 C22];

D11=simplify(subs(diff(ig\_ave,io),[iL vC io],[IL VC 0 ]));

D12=simplify(subs(diff(ig\_ave,vg),[iL vC io],[IL VC 0]));

D13=simplify(subs(diff(ig\_ave,d),[iL vC io],[IL VC 0]));

D21=simplify(subs(diff(vo\_ave,io),[iL vC io],[IL VC 0 ]));

D22=simplify(subs(diff(vo\_ave,vg),[iL vC io],[IL VC 0]));

D23=simplify(subs(diff(vo\_ave,d),[iL vC io],[IL VC 0]));

DD=[D11 D12 D13;D21 D22 D23];

%Components Values

%Variables have underline are used to store the numeric values of components

%Variables without underline are symbolic variables.

%for example:

%L: symbolic vvariable shows the inductor inductance

%L\_: numeric variable shows the inductor inductance value.

L\_=120e-6;

rL\_=.01;

C\_=100e-6;

rC\_=.05;

rds\_=.04;

rD\_=.01;

VD\_=.7;

D\_=.6;

VG\_=12;

rg\_=.1;

R\_=50;

AA\_=eval(subs(AA,[vg rg rds rD vD rL L rC C R d io],[VG\_ rg\_ rds\_ rD\_ VD\_ rL\_ L\_ rC\_ C\_ R\_ D\_ 0]));

BB\_=eval(subs(BB,[vg rg rds rD vD rL L rC C R d io],[VG\_ rg\_ rds\_ rD\_ VD\_ rL\_ L\_ rC\_ C\_ R\_ D\_ 0]));

CC\_=eval(subs(CC,[vg rg rds rD vD rL L rC C R d io],[VG\_ rg\_ rds\_ rD\_ VD\_ rL\_ L\_ rC\_ C\_ R\_ D\_ 0]));

DD\_=eval(subs(DD,[vg rg rds rD vD rL L rC C R d io],[VG\_ rg\_ rds\_ rD\_ VD\_ rL\_ L\_ rC\_ C\_ R\_ D\_ 0]));

sys=ss(AA\_,BB\_,CC\_,DD\_);

sys.stateName={'iL','vC'};

sys.inputname={'io','vg','d'};

sys.outputname={'ig','vo'};

ig\_io=sys(1,1);

ig\_vg=sys(1,2);

ig\_d=sys(1,3);

vo\_io=sys(2,1);

vo\_vg=sys(2,2);

vo\_d=sys(2,3);

Zin=1/ig\_vg; %input impedance

Zout=vo\_io; %output impedance

%Draws the bode diagram of input/output impedance

figure(1)

bode(Zin), grid minor

figure(2)

bode(Zout), grid minor

%Display the DC operating point of converter

disp('steady state operating point of converter')

disp('IL')

disp(eval(subs(IL,[vg rg rds rD vD rL L rC C R d io],[VG\_ rg\_ rds\_ rD\_ VD\_ rL\_ L\_ rC\_ C\_ R\_ D\_ 0])));

disp('VC')

disp(eval(subs(VC,[vg rg rds rD vD rL L rC C R d io],[VG\_ rg\_ rds\_ rD\_ VD\_ rL\_ L\_ rC\_ C\_ R\_ D\_ 0])));