Scilab Textbook Companion for Microwave Devices And Circuits by S. Y. Liao[1]

Created by
Tariq Siddiqui
B.Tech (pursuing)
Electronics Engineering
M. N. N. I. T., Allahabad
College Teacher
Prof. Rajeev Gupta, MNNIT Allahabad
Cross-Checked by
Santosh Kumar, IITB

July 17, 2017

---

[1] Funded by a grant from the National Mission on Education through ICT, http://spoken-tutorial.org/NMEICT-Intro. This Textbook Companion and Scilab codes written in it can be downloaded from the "Textbook Companion Project" section at the website http://scilab.in

Book Description

Title: Microwave Devices And Circuits

Author: S. Y. Liao

Publisher: Pearson Education

Edition: 3

Year: 2003

ISBN: 978-81-7758-353-3

Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

Contents

List of Scilab Codes

Chapter 2

Electromagnetic plane waves

Scilab code Exa 2.6.5 `Calculation of a Gold Film Coating`

```

//chapter_no.-2,  page_no.-69
//Example No.-2-6-5

clc;

//(a) Program_to_find_gold-film_surface_resistance


t=80*(10^(-10));//Film_Thickness
o=4.1*(10^7);     //Bulk_conductivity
p=570*(10^(-10));    //Electron_mean_free_path
of=[(3*t*o)/(4*p)]*[0.4228 + log(p/t)];//the_gold-film_conductivity_is_of=[3*t*o/4*p]*[0.4228 + ln(p/t)]

Rs=1/(t*of);//the_gold_film_surface_resistance_is_given_by__Rs=1/(t*of) in_Ohms_per_square
disp(Rs,'the_gold_film_surface_resistance_in_Ohms_per_square_is
```

```
');




//(b) Program_to_find_the_microwave_attenuation

Attenuation=40-20*log10(Rs)        //Microwave_attenuation

disp(Attenuation,'Microwave__Attenuation_is_in_db_is:');


//(c)Light_transmittance_T

disp('From figure No.2-6-5 of Light transmittance T and light attenuation loss L versus wavelength with film thickness t as parameter for gold film , we find that for given gold film of thickness 80 angstrom ,the LIGHT TRANSMITTANCE T is estimated to be 75%');



//(d)light_reflection_loss_R

disp('From_the_same_figure_the_LIGHT_REFLECTION_LOSS_R_is_about_25%');
```

Scilab code Exa 2.6.6 `Computation of a Copper Film Coating`

```

//chapter_no.-1,  page_no.-74
```

```
//Example No.-2-6-6
clc;

//(a) Program to find copper-film surface resistance


t=60*(10^(-10));//Film Thickness
o=5.8*(10^7);     //Bulk conductivity
p=420*(10^(-10));    //Electron mean free path
of=[(3*t*o)/(4*p)]*[0.4228 + log(p/t)];////the copper-film conductivity is  of=[3*t*o/4*p]*[0.4228 + ln(p/t)]



Rs=1/(t*of);//the copper film surface resistance is given by  Rs=1/(t*of) in Ohms per square
disp(Rs,'the copper film surface resistance in Ohms per square is');


//(b) Program to find the microwave attenuation

Attenuation=40-20*log10(Rs)        //Microwave attenuation

disp(Attenuation,'Microwave  Attenuation  in db is:');

//(c)Light transmittance T

disp('From figure No.2-6-11 of Light transmittance T and light attenuation loss L versus wavelength with film thickness t as parameter for copper film, we find that for given copper film of thickness 60 angstrom ,the LIGHT TRANSMITTANCE T
```

```
    is estimated to be 82%');

//(d)light_reflection_loss_R

disp('From the same figure the LIGHT REFLECTION LOSS
    R is about 18% ');
```

Chapter 3

Electromagnetic plane waves

Scilab code Exa 3.1.1 `Line characteristic impedance and phase constant`

```

//chapter no.-3,  page no.-84
//Example no.3-1-1

clc;


//(a)Calculate the line Characteristic Impedance


R=2;
L=8*(10^-9);
C=.23*(10^-12);
f=1*(10^9);
G=.5*(10^-3);
w=2*%pi*f;

Z0=sqrt((R+(%i*w*L))/(G+(%i*w*C)));
x=real(Z0);
y=imag(Z0);
o=atand(y,x);
```

```
disp(o,'the_phase_of_Z0_is =');
M=abs(Z0);//magintue_of_Z0
disp(M,'the_magnitude_of_Z0_is =');
disp(Z0,'the_line_characteristic_impedance is =');



//(b)Calculate_the_propagation_constant

r=sqrt((R+(%i*w*L))*(G+(%i*w*C)));
x=real(r);
y=imag(r);
o=atand(y,x);
disp(o,'the_phase_of_r_is =');
M=abs(r);//magintue_of_r
disp(M,'the_magnitude_of_r_is =');
disp(r,'the_propagation_constant is =');
```

Scilab code Exa 3.2.1 reflection coefficient and transmissioncoefficient

```


//chapter_no.−3,   page_no.−89
//Example_no.3−2−1
clc;


//(a)Calculate_the_reflection_coefficient


Zl=70+(%i*50);
Z0=75+(%i*.01);
r=(Zl-Z0)/(Zl+Z0);
x=real(r);
y=imag(r);
```

```
o=atand(y,x);
disp(o,'the phase of reflection coefficient  is =');
M=abs(r);//magintue of r
disp(M,'the magnitude of reflection coefficient is =');
disp(r,'the reflection coefficient  is =');




//(b)Calculate the transmission coefficient


T=(2*Z1)/(Z1+Z0);
x=real(T);
y=imag(T);
o=atand(y,x);
disp(o,'the phase of transmission coefficient  is =');
M=abs(T);//magintue of T
disp(M,'the magnitude of transmission coefficient is =');
disp(T,'the transmission coefficient  is =');




//(c)Verify the relationship shown in Eq(3-2-21)


T2=T^2;
x=real(T2);
y=imag(T2);
o=atand(y,x);
disp(o,'the phase of T^2 is =');
M=abs(T2);//magintue of T^2
disp(M,'the magnitude of T^2 is =');
disp(T2,'T^2 =');

```

```
p=(Zl/Z0)*(1-(r^2));
x=real(p);
y=imag(p);
o=atand(y,x);
disp(o,'the_phase_of_(Zl/Z0)*(1-(r^2)_is =');
M=abs(T2);//magintue_of_(Zl/Z0)*(1-(r^2)
disp(M,'the_magnitude_of_(Zl/Z0)*(1-(r^2)_is =');
disp(p,'(Zl/Z0)*(1-(r^2)) = ');
disp('since T^2=(Zl/Z0)*(1-(r^2)) hence the_relationship_shown_in_Eq(3-2-21) is verified');




//(d)
   Verify_the_transmission_coefficient_equals_equals_the_algebraic_su
   (2-3-18)


y=r+1;

disp(T,'T =');
disp(y,'r+1 = ');
disp('since T = r+1 hence the_relationship_shown_in_Eq(2-3-18) is verified');
```

Scilab code Exa 3.3.1 Standing Wave Ratio

```

//chapter_no.-3,  page_no.-93
//Example_no.3-3-1
clc;

```

```
//(a)Calculate␣the␣reflection␣coefficient


Zl=73-(%i*42.5);
Z0=50+(%i*.01);
rl=(Zl-Z0)/(Zl+Z0);
x=real(rl);
y=imag(rl);
o=atand(y,x);
disp(o,'the␣phase␣of␣reflection␣coefficient  is =');

M=abs(rl);//magintue␣of␣r
disp(M,'the␣magnitude␣of␣reflection␣coefficient␣is =');
disp(rl,'the␣reflection␣coefficient  is =');



//(b)Calculate␣the␣standing-wave␣ratio


p=(1+M)/(1-M);
disp(p,'the␣standing-wave␣ratio  is =');
```

Scilab code Exa 3.4.1 `Line Impedance`

```


//chapter␣no.-3,  page␣no.-99
//Example␣no.3-4-1

clc;


//(a)Calculate␣the␣input␣impedance
```

```


syms x ;//x is wavelength
Bd=(((2*%pi)/x)*(x/4));
disp(Bd,'from Eq(3-4-26) the line that is 2.25 wavelengths long looks like a quarter-wave line, then Bd= ');

R0=50;//input impedance
Rl=75;//load resistance
Zin=(R0^2)/Rl;
disp(Zin,'From Eq(3-4-26),the input impedance((in ohms) is = ');


//(b) Calculate the magnitude of the instantaneous load voltage


R0=50;//input impedance
Rl=75;//load resistance
rl=(Rl-R0)/(Rl+R0);
disp(rl,'the reflection coefficient is =');



//(b) Calculate the magnitude of the instantaneous load voltage


R0=50;//input impedance
Rl=75;//load resistance
rl=(Rl-R0)/(Rl+R0);
disp(rl,'the reflection coefficient is =');

V=30;//open-circuit output voltage
```

```

Vl=V*(exp(-1*%i*Bd))*(1+rl);
Vl=abs(Vl);
disp(Vl,'the instantaneous voltage at the load(in V) is =');



//(c) Calculate the instantaneous power delivered to the load


Pl=(Vl^2)/Rl;
disp(Pl,'the instantaneous power delivered to the load(in W) is =');
```

Scilab code Exa 3.5.1 `Location of Voltage maxima and minima from load`

```

//chapter no.-3,  page no.-104
//Example no.3-5-1

clc;

Zl=1+ %i*1;//Given normalise load impedance
disp('1. Enter Zl=1+(1*i) on the chart');
disp('read .162lamda on the distance scale by drawing a dashed straight line from the centre of the chart through the load point and inersecting the distance circle');

disp('2. move a distance from the point at .162lamda towards the generator and first stop at the
```

```
voltage maxima on the right hand side real axis at .25lambda');
lambda=5;//Given wavelength =5
dVmax=(.25-.162)*lambda;
disp(dVmax,'d1(Vmax) (in cm)=');

disp('Similarly , ,move a distance from the point of .162lambda towards the generator and first stop at the voltage minimum on the left-hand real axis  at .5lambda');
dVmin=(.5-.162)*lambda;
disp(dVmin,'d1(Vmin) (in cm)=');

disp('4.Make a standing wave circle with the centre (1,0) and pass the circle through the point of 1+j1.The location intersected bythe circle at the right portion of the real axis indicates the SWR .this is p=2.6');
```

Scilab code Exa 3.5.2 `Impedance with short circuit minima shift`

```

//Example_no.3-5-2

clc;

disp('1. When the line is shorted ,the first voltage  minimum occurs at the place of the load ');

disp('2 .When the line is loaded ,the first voltage minimum shifts .15lambda from the load .the distance between successive minimas is half the wavelength');

disp('3.plot a SWR cirle for p=2');
```

```
disp('4. Move a distance of .15lambda from the minimum point along the distance scale toward the load and stop at .15lambda');

disp('5.Draw a circle from this point to the centre of the chart.');
disp('6. The intersection between the line and the SWR circle is Zt=1-j*.65');
Zt=1-(%i*.65);
Z0=50;//characeristic impedance of the line
Zl=Zt*Z0;
disp(Zl,'The load impedance is(in ohm)=');
```

Scilab code Exa 3.6.1 `Single Stub Matching`

```

//chapter_no.-3,  page_no.-108
////Example_no.3-6-1
clc;

R0=50;//characteristic impedance
Zl=50/(2+%i*(2+sqrt(3)));
zl=R0/Zl;//normaised load impedance
yl=1/zl;//normaised load admittance
disp('1. compute the normalised load admittance and enter it on the smith chart');

disp('2 .Draw a SWR circle throuh the point of yl so that he circle intersects the unity circle at the point yd ');
yd=1- %i*2.6;
disp(yd,'yd=');

disp('note that there are infinite number of yd.take the one that allows the stub to be attached as
```

```
    closely as possible the load');

disp('3. since the charcteristic impedance of the
    stub is different from that of the line ,the
    condition for impedance matching at the junction
    requires Y11=Yd + Ys ,where Ys is the susceptance
     that the stub will contribute');
  disp('it is clear that the stub and the portion of
       the line from the load to the junction are in
      parallel ,as seen by the main line extending to
      the generator .the admittance must be converted
       to normalised values for matching on the smith
       chart .the our equation becomes');

  disp('y11*Y0= yd*Y0 + ys*y0s');
  y11=1;
  Y0=100;//charcteristic impedance of the stub
  Y0s=50;
  ys=(y11-yd)*(Y0/Y0s);

  disp('4. the distance between the load and the
      stub position can be calculated from the
      distance scale as d=(.302-.215)*lambda');

  disp('5.since the stub contributes a susceptance
      of j5.20 ,enter j5.20 on the chart and
      determine the required distance l from the
      short circuited end(z=0,y=infinity),which
      corresponds to the right side of the real axis
      on the chart,by transversing the chart towards
      the generator until the point of j5.20 is
      reached.  Then l=(.5 -.031)lambda =.469lambda.
       When a line is matched at the junction ,there
      will be no standing wave in the line from the
      stub to the generator');

  disp('If an inductive stub is required yd = 1+j
      *.26 and the susceptance will be ys =-j*5.2');
```

```

  disp('7.The position of the stub from the load is d=(.5-(.215-.198))lambda = .483lambda      and the length of the short-circuted stub is l=.031 lambda');
```

Scilab code Exa 3.6.2 `Double Stub Matching`

```

//chapter_no.-3,  page_no.-111
//Example_no.3-6-2
clc;

Zl=100+(%i*100);
R0=50;//charcteristic impedance of the stub and the line

zl=Zl/R0;
disp('1. compute the normalised load admittance and enter it on the smith chart');

disp('2 .plot a SWR circle and read the normalised load admittance 180 degree out of phase with zl on the SWR circle : ');
yl=1/zl;
disp(yl,'yl=');

disp('3. Draw the spacing circle of (3/8)lambda by rotating the constant-conductance unity circle (g=1) through a phase angle of 2Bd=2B(3/8lambda)=3/2(%pi)towards the load .now y11 must be on this spacing circle ,since yd2 will be on the g=1 circle(y11 and yd2 are 3/8lambda apart)');

disp('4. move yl for a distance of .4lambda from
```

```
   .458 to .358 along the SWR p circle toward the
   generator and read yd1 on the chart:');

yd1=.55- %i*1.08;
disp('yd1=.55-%i*1.08')
disp('5. there are two possible solutions for y11.
   they can be found by carrying yd1 along the
   constant-conducatnce (g=0.55)circle that
   intersects the spacing circle at two points
          y11=.55-j(.11), y11=.55-j(1.88)');

y11=.55-(%i*.11);
y112=.55-(%i*1.88);

disp('at the junction 1-1  y11=yd1+ys1');
ys1=y11-yd1;
disp(ys1,'ys1=');
ys12=y112-yd1;
disp(ys12,'ys12=');

disp('7. the length of the stub 1 are found as l1
   =(.25+.123)lambda=.373lambda  l1`=(.25-.107)
   lambda=.143lambda');

disp('8. the 3/8lambda section of the line
   transforms y11 to yd2 and y11 to yd2` along their
    constant standing-wave circles respectively .
   That is  yd2=1-(%i*.61)  and yd2`=1+(%i*2.60)');

yd2=1-(%i*.61);
yd22=1+(%i*2.60);

disp('9. Then stub 2  must contribute ys2=(.61*%i)
   and ys2`=(-2.6*%i)');
disp('10. the length of the stub 1 are found as l2
   =(.25+.087)lambda=.337lambda  l1`=(.308-.25)
   lambda=.058lambda');
disp('11. It can be seen that normaised impedance yl
```

```
 located inside the hatched area cannot be
brought to lie on the locus of y11 or y112 for a
possible match by the parallel connection of any
short-circuited stub because the spacing circle
and g=2 circle are mutually tangent.Thus the area
 of g=2circle is called the forbidden region of
the normalised load admittance for possible match
.')
```

Chapter 4

microwave waveguides and components

Scilab code Exa 4.1.1 `TE10 in Rectangular Waveguide`

```

//CHAPTER-4
// EXAMPLE: 4-1-1,page no.-128.

//(a) program to find the cut-off frequency (fc) of an airfilled rectangular waveguide in TE10 mode.


a=0.07         ;      b=0.035     ;                                        //wave-guide dimensions in metres
f=3.5*(10^9);                                                                    //Given that guide is operating at a frequency of 3.5 GHZ
c=3*(10^8);                                                                      // c is the speed of the light
```

```
m=1   ;   n=0;        //Given that guide operates in the dominant mode TE10

fc=c/(a*2);        //since ,fc=(c/2)*sqrt(((m/a)^2)+((n/b)^2)). For TE10 mode m=1,n=0,fc=c/2*a
disp(fc/(10^9),'cut-off frequency for TE10 mode in GHZ=');              //display fc  ,fc is divided by 10^9 to obtain frequency in GHZ



// (b) program to find the  phase velocity of the wave in the guide at a frequency of 3.5GHZ

f=3.5*(10^9);        //Given that guide is operating at a frequency of 3.5.GHZ
vg=c/(sqrt(1-((fc/f)^2)));        //since  ,  phase velocity=c/(sqrt(1-((fc/f)^2)))
disp(vg,'phase velocity for a wave at a frequency of 3.5 GHZ  (m/s)=');        //display the phase velocity




// (c) program to find the guide wavelength(lg of the wav  at a frequency of  3.5GHZ


```

```
lo=c/f;                // lo= wavelength in an unbounded dielectric and lo is in metres
lginmetres=lo/(sqrt(1-((fc/f)^2)));                //since , lg=lo/sqrt(1-(fc/f^2));  guide_wavelength(lg)_is_in_metres
lgincm=100*lginmetres;                //guide_wavelength (lg) is_in_centimetres
disp(lgincm,'Guide_wavelength_for_a_wave_at_frequency_of_3.5 GHZ_(cm)=')  //display_the_guide_wavelength
```

Scilab code Exa 4.1.2 `TE10 mode in Rectangular Waveguide`

```


// chapter no.-4
// Example-4-1-2 , page no.-133


//Program to find the peak value of the electric field occuring in the guide.


clc;
m=1; n=0;                //given guide transports energy in the TE10 mode.
f=30*(10^9);                //The impressed frequency is 30GHZ
uo=(4*(%pi))*(10^-7);eo=8.85*(10^(-12));
```

```
                  //scientific values of permeability
     and permittivity in free space
a=.02; b=.01;
                                                        //
    dimensions of wave−guide given in metres
energyrate=0.5*746;
                                                  //given ,the
    rate of transport of energy =0.5 hp    ,1 horse
    power(1 hp)= 746 watts.

kc=%pi/a;
                                                           //kc
     is cutoff wave number   , kc=sqrt((m∗%pi/a)+(n∗
    %pi/b)) ,For m=1,n=0 =&gt; kc=%pi/a
bg=sqrt((((2*%pi*f)^2)*(uo*eo)) - (kc^2));
                 //bg is the phase constant in radian/
    metre, bg=sqrt((wˆ2)∗(uo∗eo))−(kcˆ2)); where w=2∗
    %pi∗f
Zg=((2*%pi*30*(10^9))*uo)/bg;
                                        //Zg is the
    characteristic wave impedence ,Zg=(w∗uo)/bg;
    where w=2∗%pi∗f

syms x z Eoy Hoz
                                                     //Defining
    the variables

Ex=0;

    //since, Ex=Eox∗cos((m∗%pi∗x)/a)∗sin((n∗%pi∗y)/b)
    ∗exp(−%i∗bg∗z)..For m=1 , n=0 =&gt; Ex=0
Ey = Eoy*sin((%pi*x)/a)*exp(-%i*bg*z);
                     //since ,Ey = Eoy∗sin((m∗%pi∗x)/a
    )∗cos((n∗%pi∗y)/b)∗exp(−%i∗bg∗z) (here put m=1,n
    =0)
Ez=0;

    // For TE mode Ez=0
```

```

Hx=(Eoy/Zg)*sin((%pi*x)/a)*exp(-%i*bg*z);                    //since , Hx=Hox*sin(m*%pi*x)/a)*cos((n*%pi*y)/b)*exp(-%i*bg*z). put m=1,n=0 and Hox=(Eoy/Zg)
Hy = 0 ;                                                      //since ,Hy = Hoy*cos((m*%pi*x)/a)*sin((n*%pi*y)/b)*exp(-%i*bg*z) here(for m=1,n=0) =&gt; Hy=0
Hz=Hoz*cos((%pi*x)/a)*exp(-%i*bg*z);                          //Hz=Hoz*cos(m*%pi*x)/a)*cos((n*%pi*y)/b)*exp(-%i*bg*z). put m=1,n=0 .

Hxc=Hx';                                                      //power formula of poynting involves integrating (Ey*cojugate(Hx))over guide dimension.Thus we take conjugate of hx for propagation of wave in z direction

power=(Ey*Hxc);                                               //(Taking the term (Ey*cojugate(Hx)) from power formula of poynting vector
power=power/(Eoy^2);        //normalise power with respect to (Eoy^2) so as to definitely integrate remaining terms in x and y.

temp = str2max2sym(power.str1);
PowerToIntegrate = max2scistr(temp.str1) ;      //coverting_type_sym_into_type_string

I=integrate(PowerToIntegrate,'x',0,a);  //integrate X=(Ey*cojugate(Hx))(which is normalised with respect to Eoy^2) with respect
```

```
to x dimension from 0 to a. Thus the result of above multiplication(Ey*Hxc)/(Eoy^2) = 1333*sin(2599825*x/16551)^2/519323 is written here for definite intergration.

I=I*b; //since definite integral is independent of y. Hence dimension in y direction i.e,b can be taken out

I=real(I); //since from poyting formula [energyrate = (0.5*(real(I))*(Eoy^2))].So we consider only real part of I.


Eoy=sqrt((energyrate*2)/I); // since ,energyrate =373= (0.5*(real(I))*(Eoy^2))

disp((Eoy/1000),'the peak value of the electric field intensity in(KV/m)'); // display peak value of electric field .Divide by 1000 to obtain the electric field intensity in KV/m.
```

Scilab code Exa 4.2.1 `TE10 Mode in Circular Waveguide`

```

//CHAPTER-4
// EXAMPLE:4-2-1, page no.-144.

```

```
// (a) program to find the cut off frequency (fc) of circular waveguide in TE11 mode


radius=0.05  ;                                  //Given .Here radius is in metres.
f=3*(10^9);                                     //operating frequency is 3 GHZ
uo=(4*(%pi))*(10^-7) ; eo=8.85*(10^(-12));                    //scientific values of permeability and permittivity in free space
m=1          ;           n=1;                                                        //Given that a TE11 mode is propagating.
X=1.841;                                        //For TE11 mode in circular waveguide X= (kc*radius) =1.841

kc=X/radius;                                    //cut-off wave number
fc=kc/((2*%pi)*(sqrt(uo*eo)));                                                       //since fc=kc/((2*%pi)*(sqrt(uo*eo)));
disp(fc/(10^9),'cut-off frequency for TE10 mode in GHZ=');                   // display cut-off frequency in GHZ by dividing by (10^9) for TE10 mode




// (b) program to find the guide wavelength(lg)
```

```
    of the wave  at operating frequency of 3GHZ


bg=sqrt((((2*%pi*3*(10^9))^2)*(uo*eo)) - (kc^2));
        //bg is the phase constant in radian/metre,
    bg=sqrt((w^2)*(uo*eo))-(kc^2)); where w=2*%pi*f
lginmetres=(2*%pi)/bg;
                                        //
    Guide wavelength is in meters
lgincm=100*lginmetres;
                                        //
    Guide wavelength is in centimetres
disp(lgincm,'
    Guide wavelength for a wave at a frequency of 3.5
    GHZ  (cm)=');  //
    display Guide wavelength for TE10 mode



//  (c)
    program to find the Guide wavelength in the wave guide

zg=(2*%pi*(3*(10^9))*uo)/bg;
                                    //
    Zg is the characteristic wave impedence  ,Zg=(w*uo
    )/bg; where w=2*%pi*f
disp(zg,'wave impedence zg in the wave guide(ohm)=')
        //display wave impedence in the wave guide
```

Scilab code Exa 4.2.2 `Wave Propagation in Circular Waveguide`

```

//chapter-4
//Example-4-2-2  page no.-147

```

```
//program to find all the TE(n,p) and TM(n,p)
   modes for which energy transmisssion is possible.

radius=.02;

   //Given.  Here radius is in metres.
uo=(4*(%pi))*(10^-7); eo=8.85*(10^(-12));
                                           //
   scientific values of permeability and permittivity in free space

f=(10^10);

   //guide is operating at the frequency of 10GHZ
wc=(2*%pi*f);

   //since ,  wc=(2*%pi*f)
kc=wc*sqrt(uo*eo);

   //kc is cut-off wave number
X=kc*radius ;

   //the  product  X=(kc*radius)
   for a given mode is constant
disp(kc*radius,'The value of the product  X=(kc*
   radius)is  =  ');                        //
   display the product X=(kc*a)
disp('Any  mode  having  a  product  (kc*radius)  less
   than  or  equal  to  4.18  will  propagate  the  wave
   with  a  frequency  of  10  GHZ  .This  is  (kc*radius)&
   lt;=4.18');



syms  i  j

   //Defining the variables



p=[3.832  1.841  3.054  4.201  5.317  6.416;7.016  5.331
```

```
    6.706 8.015 9.282 10.520 ; 10.173 8.536 9.969
    11.346 12.682 13.987]//represent_the_values_of
    X_for_

    different_modes_in_a_form_of_matrix.
    Where_columns_represent

    the_n_values_of_mode_and_rows_represent_the_m_values_of_mode
    .

for i=1:1:3

    //value_of_i_traverse_across_the_rows
for j=1:1:6

    //value_of_j_traverse_across_the_columns
if(X &gt;=p(i,j))

    //check_if_the_value_in(n,p)
    _matrix_is_less_than_or_equal_to_X
disp(p(i,j),i,j-1,'TE mode(n,p) and corresponding
    value of X=');                //
    display_TE_mode_for_which_value_in [(n,p)matrix]
    &lt;= X and print

    corresponding_value_of_X
end

    //end if
end

    //end for
end

    //end for


m=[2.405 3.832 5.136 6.380 7.588 ; 5.520 7.106 8.417
```

```
  9.761 11.065 ;         //
   represent_the_values_of_X_for_different_modes_in_a_form_of_matrix
   .Where

   columns_represent_the_n_values_of_mode_and_rows_represent_the_m_va
   .
 8.645 10.173 11.620 13.015 14.372]

for i=1:1:3

   //value_of_i_traverse_across_the_rows_in [(n,p)
   matrix].
for j=1:1:5

   //value_of_j_traverse_across_the_columns in [(n,p
   )matrix].
if(X &gt;=m(i,j))

   //check_if_the_value_in(n,p)
   _matrix_is_less_than_or_equal_to_X
disp(m(i,j),i,j-1,'TM mode(n,p) and corresponding
   value of X=');            //
   display_TM_mode_for_which_value in [(n,p)matrix]
  &lt;= X and_print

   corresponding_value_of_X.
end

   //end if
end

   //end for
end

   //end for
```

Scilab code Exa 4.5.1 `Directional Coupler`

```


//Chapter -4
//EXAMPLE: 4-5-1  PAGE NO. 170

//(a) program to find the amount of the power delivered in the load Zl

PT4=8;                //Given. Transmitted power to Bolometer 1 at port 4
s=2;                  //Given.VSWR of 2.0 is introduced on arm 4 by Bolometer 1
r4=(s-1)/(s+1);                                               //reflection coefficient at port 4(r4)
PR4=8/8;                                                      //(r4^2)=PR4/PI4=PR4/(PR4+PT4)=PR4/PR4+8=1/9  =&gt; 8PR4=8
PI4=PT4 + PR4;                                                //PI4=power incident at port 4 ;PT4=power transmitted at port 4;PR4=power reflected at port 4
disp(PI4,'power incident at the port 4 is (mW)=');
disp(PR4,'power reflected from the port 4 is (mW) =');
```

```

disp('Since port 3 is matched and the Bolometer at port 3 reads 2mw ,then 1 mw must be radiated through the holes .Since 20 dB is equivalent to a power of 100:1,the power input at port 1 is given by=');

PI2=100*PI4; //attenuation=20=10*log(PI1/PI4)
disp(PI2,'power input at port 2 is given by (mW)=');

PR2=100*PR4; //attenuation=20=10*log(PR2/PR4)
disp(PR2,'power reflected from the load at port 2 is given by (mW)=');

PT2=PI2-PR2; //transmitted power = incident power - reflected power
disp(PT2,'power dissipated in the load at port 2 is given by (mW) =');




//(b)Program to find the VSWR on arm 2

r=sqrt(PR2/PI2); //reflection coefficient at port 2
s=(1+r)/(1-r); //VSWR ON ARM 2
```

```
disp(s,'value_of_VSWR_ON_ARM 2:::= ');
```

Scilab code Exa 4.5.2 `Operation Of a Balanced Amplifier`

```

//chapter-4
//Example4-5-2   page no. 174

//(a)Program_to_find_out_the_input_and_output_VSWRs.

s11=0;                       //for_balanced_amplifier s11=0
s=(1+s11)/(1-s11);                                    //Input_VSWR
disp(s,'input vswr=');

s22=0;                       //for_balanced_amplifier s22=0
s=(1+s22)/(1-s22);                                    //output_VSWR
disp(s,'output vswr=');



//(b)Program_to_find_out_the_output_power_in_watts

PO=200*10*2;                 //output_power(PO)=[powerinput]*[power_gain_of_each_GaAs_chip]*[n]   ,here n=2
disp(PO/1000,'Output_POWER_in_Watts');
```

```
                    //display_power_in_watts_by_dividing_by_1000



//(C)Program to find out the linear output power gain in db

GAIN=10*log10(2);                    //BECAUSE_TWO_CHIPS_ARE_IN_PARALLEL. Gain=(power gain of each GaAs chip)*log(n),n=2.
disp(GAIN,'Linear_output_power_gain_in_db=');          //display_linear_output_power_gain_in_db
```

Chapter 5

microwave transistors and tunnel diodes

Scilab code Exa 5.1.1 `Elements of Hybrid Pi Common Emitter Circuit`

```

//CHAPTER NO.-5
//Example No.5-1-1 , Page No.-195

//(a) Program_to_find_the_mutual_inductance_gm.


ic=6*(10^-3);//Collector_Current
vt=26*(10^-3); //vt=26 mV_at_300k_is_the_voltage_equivalent_of_temperature
gm=ic/vt;//the_mutual_inductance_is gm=(ic/vt)
disp(gm,'the_mutual_inductance_is gm(in mho)=');

//(b) Program_to_find_the_input_inductance_gb_and_resistance_R

hfe=120;//hfe= common-emitter_current_gain_factor
```

```
gb=gm/hfe;//input_inductance
R=1/gb; //Resistance

disp(gb,'input_inductance gb(in mho)=');
disp(R,'input_resistance R (in ohms)=');

//(c) Program_to_find_the_electron_diffusion_coefficient_Dn

un=1600;//electron_Mobility
Dn=un*vt; // Dn=un*kt/q=un*26*(10^-3);

disp(Dn,'electron_diffusion_coefficient_Dn(in cm2/s)=');

//(d)Program_to_find_the_diffusion_capacitance_Cbe
Wb=(10^-8); //cross_sectional_area
Cbe=(gm*(Wb^2))/(2*Dn*(10^-7));
Cbe=Cbe/(10^-12);
disp(Cbe,'diffusion_capacitance_Cbe(in pF)=');
```

Scilab code Exa 5.1.2 `I V Characteristics of n p n transistor`

```

//CHAPTER NO.-5
//Example No.5-1-2 , Page No.-203

//(a) Program_to_find_the_impurity_desities_in_the_emitter,base_and_collector_regions

disp('the impurity densities (in cm-3)are read from Fig A-1 in the Appendix A as NdE=1*(10^19)[the impurity density in the n-type emitter region],
```

```
NaB=1.5*(10^17) [the impurity density in the p-type base region],NdC=3*(10^14)[the impurity density in the n-type collector region]');
NdE=1*(10^19);
NaB=1.5*(10^17);
NdC=3*(10^14);

//(b)Program to find the mobilities in the emitter , base and collector regions
disp('the mobilities(in cm2/v*s)are read from fig A-2 in the Appendix A as upe=80[mobility in the emitter] , unE=105[mobility in the emitter] , upB=400[mobility in the base] , unC=1600[mobility in the collector]');
upE=80;
unE=105;
upB=400;
unC=1600;

//(c) Program to find the diffusion lengths in the emitter ,base and collector regions
disp('the diffusion constants are computed to be ');
Vt=26*(10^-3);

DpE=upE*Vt;
DnE=unE*Vt;
DpB=upB*Vt;
DnC=unC*Vt;
disp(DpE,'DpE=');
disp(DnE,'DnE=');
disp(DpB,'DpB=');
disp(DnC,'DnC=');

//(d)Program to compute the equilibrium densities in the emitter ,base and collector regions

disp('the equlibrium densities are ');
```

```
ni=1.5*(10^10);

pEo=(ni^2)/NdE;
npB=(ni^2)/NaB;
pCo=(ni^2)/NdC;
disp(npB,'npB=');
disp(pEo,'pEo=');
disp(pCo,'pCo=');

//(e)Program_to_compute_the_terminal_currents

disp('the_terminal_currents_are_computed_as follows.
     From Eq 5-1-39,
    the_electron_current_in_the_emitter_is ');
A=2*(10^-2);// cross-section_area
q=1.6*(10^-19);
W=(10^-5);//base_width
Le=(10^-4);//Diffusion_length_in_emitter
Ve=.5;//Emitter_junction_voltage
InE=-(A*q*DnE*(ni^2)*exp(Ve/Vt))/(NaB*W);//Ine=-(Aq*
    Dp*(ni^2)*(exp(Ve/Vt)-1))/(Le*Nd);
InE=InE/(10^-3);
disp(InE,'the_electron_current_in_the_emitter_is(in
    mA)');

disp('From Eq5-1-42,
    _the_hole_current_in_the_emitter_is ');
IpE=(A*q*DpE*(ni^2)*(exp(Ve/Vt)-1))/(Le*NdE);//Ipe=(
    A*q*De*peo*(exp(Ve/Vt)-1))/Le  =  (A*q*Dp*(ni^2)
    *(exp(Ve/Vt)-1))/(Le*Nd)
IpE=IpE/(10^-6);
disp(IpE,'the_electron_current_in_the_emitter_is(in
    uA)');



disp('From Eq-5-1-24,
    the_reverse_saturation_current_in_the_collector_is
```

```
');
ICo=-(A*q*DnE*(ni^2)/(NaB*W))-(A*q*DpE*pEo)/Le;
ICo=ICo/(10^-12);
disp(ICo,'the electron current in the emitter is(in pA)');


disp('From Eq-5-1-40, the electron current which reaches the collector is ');
InC=-(A*q*DnE*(ni^2)*exp(Ve/Vt)/(NaB*W));
InC=InC/(10^-3);
disp(InC,'the electron current which reaches the collector is (in mA)');

IE=(-IpE*(10^-6))+(InE*(10^-3));
IE=IE/(10^-3);
disp(IE,'the emitter current is (in mA)');

IC=(-ICo*(10^-12))-(InC*(10^-3));
IC=IC/(10^-3);
disp(IC,'the collector current is (in mA)');

IB=(IpE*(10^-6))-[((InE*(10^-3)))-(InC*(10^-3))]+(ICo*(10^-12));
IB=IB/(10^-6);
disp(IB,'the current in the base terminal is (in uA)');

disp('NOTE: The recombination-generation currents in the spcae-charge regions are not counted');
```

Scilab code Exa 5.1.3 `Silicon Bipolar Transistor`

```

//CHAPTER NO.-5
//Example No.5-1-3 , Page No.-206

//(a) Program to find the mobilities un and up

 disp('the mobilities(in cm2/v.s )are read from Fig-A-2 in Appendix A as un=200 for NdE=5*(10^18) cm-3 and up=500 for Na=5*(10^16) cm-3');
  un=200;
  up=500;

  //(b) Program to find the diffusion coefficients Dn and Dp

  Vt=26*(10^-3);//Vt=kt/q
  Dn=un*Vt;
  Dp=up*Vt;

  disp(Dn,'diffusion coefficient are Dn(in cm2/s)=');
  disp(Dp,'and  Dp(in cm2/s)=');

//(c) Program to find the emitter efficiency factor y
W=(10^-3);//Base width
Le=(10^-2);//Emitter Length
Na=5*(10^16);//Acceptor density in base region
Nd=5*(10^18);//Donor density in emitter region
y=1/(1+((Dp*Na*W)/(Dn*Nd*Le)));

disp(y,'emitter efficiency factor y=');


//(d) Program to find the transport factor B

t=10^-6;//hole lifetime
B=1-(W^2)/(2*Dn*t);//transport factor
```

```

disp(B,'the transport factor B=');


//(e) Program_to_find_the_current_gain_a

a=B*y;

disp(a,'the current_gain a=');
```

Scilab code Exa 5.1.4 `Power Frequency Limitation`

```

//CHAPTER NO.-5
//Example No.5-1-4 , Page No.-211

//
   Program_to_determine_the_maximum_allowable_power_that_the_transis

  Xc=1;//Reactance
  ft=4*(10^9);//Transit_cut-off_frequency
  Em=1.6*(10^5);//maximum_electric_field
  Vx=4*(10^5);//saturation_drift_velocity

  Pm=(((Em*Vx/(2*%pi)))^2)/(Xc*(ft^2));
 disp(Pm,'the_maximum _allowable_power(in W) _that_the_transisitor_can_carry_is ');
```

Scilab code Exa 5.2.1 `Heterojunction Bipolar Transistor`

```

//CHAPTER NO.-5
```

```
//Example No.5-2-1 , Page No.-213

//(a) Program_to_determine_the_latice_match_present_in_percent

  disp('the_latice_match_present_is_within 1%');

  //(b) Program_to_find_the_conduction-band_differential_between_Ge_and_GeAs
  X1=4;//electron_affinity
  X2=4.07;//electron_affinity
  AE=X1-X2;
disp(AE,'the_conduction-band differential_is(in eV)=');

//(c) Program_to_find_the_valence-band_differential_between_Ge_and_GeA
   Eg2=1.43;//energy_gap
 Eg1=.8;//energy_gap
  Ev=Eg2-Eg1-AE
disp(Ev,'the valence-band differential is(in eV) =');
```

Scilab code Exa 5.2.2 `n Ge p GaAs n GaAs HBT`

```

//CHAPTER NO.-5
//Example No.5-2-2 , Page No.-215

//(a) Program_to_compute_the_built-in voltage_in_the p-GaAs_side
 Na=6*(10^16); //Acceptor_density_in_p-GaAs_side
  w02=-26*(10^-3)*log(Na/(1.8*(10^6)));
disp(w02,'the_built-in_voltage(in V)  in_the p-GaAs_side');
```

```

//(b) Program to compute the hole mobility

disp('The hole mobility is read from Fig -A-2 in Appendix A as up=400(cm2/v.s)');
up=400;

//(c) Program to compute the hole diffusion constant
Dp=up*26*(10^-3);

disp(Dp,'The hole diffusion constant is Dp(cm2/s)=');


 //(d) Program to compute the minority hole density in n-Ge

 ni=1.5*(10^10);
 Nd=5*(10^18);//Donor density in n-Ge region
 pno=(ni^2)/Nd;
  disp(pno,'the minority hole density (cm-3)in n-Ge is =');

    //(e) Program to compute the minority electron density in p-GaAs region
 Na=6*(10^16);
npo=((1.8*10^6)^2)/Na;
  disp(npo,'the minority electron density(in cm-3) in p-GaAs region is =');


  //(e) Program to compute the hole diffusion length
  tp=6*(10^-6);//hole lifetime
  Lp=sqrt(tp*Dp);
  disp(Lp,'the hole diffusion length(in cm) is =');
```

```

//(e) Program_to_compute_the_emitter-junction_current

A=2*(10^-2);//cross_section
VE=1;//bias_voltage_at_emitter_junction
q=1.6*(10^-19);
l=VE/(26*(10^-3));
I=(A*q*Dp*pno*(exp(l)-1))/(Lp);
disp(I,'the_emitter-junction_current(in A)is =');
```

Chapter 6

microwave field effect transistors

Scilab code Exa 6.1.1 `Pinch Off Voltage Of a Silicon JFET`

```

//chapter_no.-6,  page_no.-229
//Example_no.6-1-1

clc;
a=.1*(10^-6);//channel_height
Nd=8*(10^23);//Electron_Concetration
er=11.80;//relative_dielectrin_constant
e=8.854*(10^-12)*er;//medium_dielecric_constant
q=1.6*(10^-19);//electronic_charge
Vp=(q*Nd*(a^2))/(2*e);//pinch-off_voltage

disp(Vp,'pinch-off volatge in(Volts)is');
```

Scilab code Exa 6.1.2 `current of a JFET`

```

//chapter_no.-6,  page_no.-233
//Example_no.6-1-2

clc;

//(a)Calculate_the_pinch-off_Voltage_in_Volts
a=.2*(10^-4);//channel_height
Nd=1*(10^17);//Electron_Concetration
er=11.80;//relative_dielectrin_constant
e=8.854*(10^-14)*er;//medium_dielecric_constant
q=1.6*(10^-19);//electronic_charge
Vp=(q*Nd*(a^2))/(2*e);//pinch-off_voltage

disp(Vp,'pinch-off volatge in(Volts)is');


//(b)Calculate_the_pinch-off_current

un=800;//electron_mobility
L=8*(10^-4);//channel_length
Z=50*(10^-4);//channel_width
a=.2*(10^-4);//channel_height
Nd=1*(10^17);//Electron_Concetration
er=11.80;//relative_dielectrin_constant
e=8.854*(10^-14)*er;//medium_dielecric_constant
q=1.6*(10^-19);//electronic_charge
Ip=(un*(q^2)*(Nd^2)*Z*(a^3))/(L*e);//pinch-off_voltage
Ip=Ip*1000;
disp(Ip,'pinch-off current in(mA)is');


//(c)Calculate_the_built-in_voltage

Nd=1*(10^17);//Electron_Concetration
Na=1*(10^19);//hole_density
w0=26*(10^-3)*log((Nd*Na)/((1.5*10^10)^2));
```

```
disp(w0,'built-in voltage in(volts)is');



//(d) Calculate␣the␣drain␣current

Vd=10;//drain␣voltage
Vg=-1.5;//gate␣voltage
Vg=-1*Vg;//we␣take␣only␣magnitude
x=((Vd+Vg+w0)/(Vp))^(3/2);
x=(2/3)*x;
y=((Vg+w0)/(Vp))^(3/2);
y=(2/3)*y;
Id=(Vd/Vp)-x+y;
Id=Ip*Id;
disp(Id,'the␣drain␣current (mA)is');



//(e) Calculate␣the␣saturation␣drain␣current␣at Vg=0

Vg=-1.5;//gate␣voltage
Vg=-1*Vg;//we␣take␣only␣magnitude
x=(Vg+w0)/(Vp);
y=((Vg+w0)/(Vp))^(3/2);
y=(2/3)*y;
Idsat=(1/3)-x+y;
Idsat=(Id)*Idsat;
disp(Idsat,'the␣saturation␣drain␣current␣(mA)is');


//(f) Calculate␣the␣cut-off␣frequency

fc=(2*un*q*Nd*(a^2))/(%pi*e*(L^2));
disp(fc/(10^9),'the␣cut-off␣frequency(Ghz)');
```

Scilab code Exa 6.2.1 `Pinch Off Voltage Of a MESFET`

```
//CAPTION: Pinch-Off_Voltage_Of_a_MESFET
//chapter_no.-6, page_no.-239
//Example_no.6-2-1

clc;

a=.1*(10^-6);//channel_height
Nd=8*(10^23);//Electron_Concetration
er=13.10;//relative_dielectrin_constant
e=8.854*(10^-12)*er;//medium_dielecric_constant
q=1.6*(10^-19);//electronic_charge
Vp=(q*Nd*(a^2))/(2*e);//pinch-off_voltage

disp(Vp,'pinch-off volatge in(Volts)is');
```

Scilab code Exa 6.2.2 `Current Voltage Characteristics Of a GaAs MESFET`

```

//chapter_no.-6, page_no.-244
//Example_no.6-2-2

clc;


//(a) Calculate_the_pinch-off_voltage

a=.1*(10^-6);//channel_height
Nd=8*(10^23);//Electron_Concetration
er=13.1;//relative_dielectrin_constant
e=8.854*(10^-12)*er;//medium_dielecric_constant
```

```
q=1.6*(10^-19);//electronic_charge
Vp=(q*Nd*(a^2))/(2*e);//pinch-off_voltage

disp(Vp,'pinch-off volatge in(Volts)is');



//(b)Calculate_the_velocity_ratio

un=.08;//electron_mobility
vs=2*(10^5);
L=14*(10^-6);
n=(Vp*un)/(vs*L)
disp(n,'the velocity ratio');


//(c) Calculate_the_saturation_drain_current_at Vg=0

L=14*(10^-6);
Z=36*(10^-6);
Ipsat=(q*Nd*un*a*Z*Vp)/(3*L);
Ipsat=Ipsat*1000;
disp(Ipsat,'the_saturation_drain_current_(mA)is');



//(d) Calculate_the_drain_current

Vd=5;
Vg=2;
u=((Vd+Vg)/Vp)^(1/2);
p=((Vg)/Vp)^(1/2);
Id=(3*((u^2)-(p^2))-2*((u^3)-(p^3)))/(1+(n*((u^2)-(p^2))));

Id=Id*Ipsat;
disp(Id,'the_drain_current_(mA)is');
```

Scilab code Exa 6.2.3 `CutOff frequency of a MESFET`

```


//chapter no.-6,  page no.-247
//Example no.6-2-3

clc;

//(a)  Calculate the cut-off frequency

gm=.05;
Cgs=.60*(10^-12);

fco=(gm)/(2*%pi*Cgs);
fco=fco/(10^9);

disp(fco,'the cut-off frequency(in  Ghz)is ');

//(b)Calculate the maximum operating frequency


Rd=450;
Rs=2.5;
Rg=3;
Ri=2.5;

fmax=(fco/2)*((Rd/(Rs+Rg+Ri))^(1/2));

disp(fmax,'the maximum operating frequency(in  Ghz)is ');
```

Scilab code Exa 6.3.1 `Current of a HEMT`

```

//chapter_no.-6,   page_no.-251
//Example_no.6-3-1
clc;

//Calculate_the_Drain_Current

q=1.60*(10^-19);
n=5.21*(10^15);
W=150*(10^-6);
v=2*(10^5);

Ids=q*n*W*v;
Ids=1000*Ids;
disp(Ids,'the_drain_current_is(mA)');
```

Scilab code Exa 6.3.2 `Sensitivity Of HEMT`

```

//chapter_no.-6,   page_no.-253
//Example_no.6-3-2

clc;



//(a)  Calculate_the_conduction_band-edge_difference_between_GaAs_and_AlGaAs

Ega=1.8;
Egg=1.43;
AEc=Ega-Egg;
disp(AEc,'the_conduction_band-edge_difference_is=');
```

```

//(b) Calculate the sesitivity of the HEMT

q=1.6*(10^-19);
Nd=2*(10^24);
wms=.8;
Vth=.13;
er=4.43;
e=er*(8.854*(10^-12));
S=-[(2*q*Nd*(wms-AEc-Vth))/(e)]^(1/2);//sesitivity of the HEMT
S=S/(10^6);
disp(S,'the sensitivity of the HEMT (mV/nm) is=')
disp(-1*S,'d/dv(Vth)(mV/nm)is=');
```

Scilab code Exa 6.4.1 `Threshold Voltage of an Ideal MOSFET`

```
//chapter no.-6,  page no.-260
//Example no.6-4-1
clc;


//(a) Calculate the strong potential w(inv) for strong inversion

kt=26*(10^-3);
Na=3*(10^17);
Ni=1.5*(10^10);
wsinv=2*kt*log(Na/Ni);
disp(wsinv,'the strong potential w(inv) for strong inversion(volts)');

//(b)Calculate the insulator Capacitance

eir=4;
```

```
ei=8.854*(10^-12)*eir;
d=.01*(10^-6);
Ci=ei/d;
Ci=Ci*(1000);
disp(Ci,'the_insulator_Capacitance(mF/m^2)=');

//(c) Calculate_the_threshold_voltage

q=1.6*(10^-19);
Na=3*(10^23);
er=11.8;
e=8.854*er*(10^-12);
Vth=wsinv+((2/(Ci*(10^-3)))*((e*q*Na*.437)^(1/2)))
disp(Vth,'the_threshold_voltageis ()Volts=');
```

Scilab code Exa 6.4.2 Characteristics Of a MOSFET

```

//chapter_no.-6,  page_no.-262
//Example_no.6-4-2
clc;


//(a)Calculate_the_insulation_capacitance

eir=3.9;
ei=8.854*(10^-12)*eir;
d=.05*(10^-6);
Ci=ei/d;
disp(Ci,'the_insulation_capacitance(in F/m^2)');

//(b)Calculate_the_saturation_drain_current

Z=12*(10^-12);
Vg=5;
```

```
Vth=.10;
vs=1.70*(10^7);
Idsat=Z*Ci*(Vg-Vth)*vs;
Idsat=Idsat*10^7;
disp(Idsat,'the saturation drain current(in mA)');

//(c) Calculate the transconductance in the saturation region


Z=12*(10^-12);
vs=1.70*(10^7);
gmsat=Z*Ci*vs;
gmsat=gmsat*10^7;
disp(gmsat,'the transconductance in the saturation region(in millimhos)');



//(d) Calculate the maximum operating frequency in the saturation regio

vs=1.70*(10^7);
L=4*(10^-6);
fm=vs/(2*%pi*L);
fm=fm/(10^2);
fm=fm/(10^9);
disp(fm,'the maximum operating frequency in the saturation region(in GHz)');
```

Scilab code Exa 6.6.1 `Power Dissipation of a Three Phase CCD`

```


//chapter_no.-6,  page_no.-278
//Example_no.6-6-1
clc;


// Calculate_the_power_dissipation_per_bit
n=3;
f=10*(10^6);
V=10;
Qmax=.04*(10^-12);
P=n*f*V*Qmax;
P=P*(10^6);
disp(P,'the_power_dissipation_per_bit(uW)is=');
```

Scilab code Exa 6.6.2 `Design of N Type Three Phase Surface Channel CCD`

```

//chapter_no.-6,  page_no.-279
//Example_no.6-6-2

clc;


//(a)Calculate_the_insulator_capacitance

eir=3.9;
ei=8.854*(10^-12)*eir;
d=.15*(10^-6);
Ci=ei/d;
Ci=Ci*(10^5);
disp(Ci,'the_insulation_capacitance(in nF/cm^2)');

//(b)Calculate_the_maximum_stored_charges_per_well
```

```

Nmax=2*(10^12);
q=1.6*(10^-19);
A=.5*(10^-4);
Qmax=Nmax*A*q;
Qmax=Qmax*(10^12);
disp(Qmax,'the maximum stored charges per well(picocoulombs)');

//(c)  Calculate the required applied gate voltage

Nmax=2*(10^12);
q=1.6*(10^-19);
Vg=(Nmax*q)/(Ci*10^-9);
disp(Vg,'the required applied gate voltage(in Volts)');



//(d)Calculate the clock frequency

P=.67*(10^-3);
n=3;
f=P/(n*Vg*Qmax*(10^-12));
f=f/(10^6);
disp(f,'the clock frequency(in MHz)');
```

Chapter 7

transferred electron devices

Scilab code Exa 7.2.1 `Conductivity of an n Type GaAs Gunn Diode`

```

//chapter_no.-7,  page_no.-294
//Example_no.7-2-1
clc;


//Calculate_the_conductivity_of_the_diode
e=1.6*(10^-19);
nl=(10^10)*(10^6);//electron_density_at_lower_valley
nu=(10^8)*(10^6);//electron_density_at_upper_valley
ul=8000*(10^-4);//electron_mobility_at_lower_valley
uu=180*(10^-4);//electron_mobility_at_upper_valley
o=e*((nl*ul)+(nu*uu));
o=o*1000;
disp(o,'the_conductivity_of_the_diode(in mmhos)is ='
   );
```

Scilab code Exa 7.2.2 `Charactristics of a GaAs Gunn Diode`

```

//chapter no.-7,  page no.-298
//Example no.7-2-2
clc;

//(a)Calculate the electron drift velocity
q=1.6*(10^-19);
f=10*(10^9);//operating frequency
L=10*(10^-6);//Device Length
vd=f*L;
disp(vd,'the electron drift velocity(in m/sec)is =');
vd=vd*100;
disp(vd,'the electron drift velocity(in cm/sec)is =');
vd=vd/100;

//(b)Calculate the current density

n=2*(10^14)*(10^6);
J=q*n*vd;
disp(J,'the electron drift(n A/m^2)is =');
J=J/(10^4);
disp(J,'the electron drift(n A/cm^2)is =');


//(c)CAPTION: Calculate the negative electron mobility

E=3200;//applied field
vd=vd*(100);
un=-1*(vd/E);
disp(un,'negative electron mobility(in cm^2/V*sec)is =');
```

Scilab code Exa 7.3.1 `Criterion of Mode Operation`

```

//chapter no.-7,  page no.-298
//Example no.7-2-2
clc;

//(a)Calculate the electron drift velocity
q=1.6*(10^-19);
f=10*(10^9);//operating frequency
L=10*(10^-6);//Device Length
vd=f*L;
disp(vd,'the electron drift velocity(in m/sec)is =');
vd=vd*100;
disp(vd,'the electron drift velocity(in cm/sec)is =');
vd=vd/100;

//(b)Calculate the current density

n=2*(10^14)*(10^6);
J=q*n*vd;
disp(J,'the electron drift(n A/m^2)is =');
J=J/(10^4);
disp(J,'the electron drift(n A/cm^2)is =');


//(c)CAPTION:Calculate the negative electron mobility

E=3200;//applied field
vd=vd*(100);
un=-1*(vd/E);
disp(un,'negative electron mobility(in cm^2/V*sec)is =');
```

Scilab code Exa 7.4.1 `Output power of an LSA Oscillator`

```

//chapter_no.-7,   page_no.-311
//Example_no.7-4-1

clc;

//Calculate_the_output_power
n=.06;//conversion_efficiency
M=3.5;//Multiplication_factor
Eth=320*(10^3);//threshold_field
L=12*(10^-6);//Device_Length
n0=10^21;//Donor_concentration
e=1.6*(10^-19);
v0=1.5*(10^5);//Average_carrier_velocity
A=3*(10^-8);//Area
P=n*(M*Eth*L)*(n0*e*v0*A);
P=P*1000;
disp(P,'the_output_power(in mW)is =');
```

Chapter 8

Avalanche transit time Devices

Scilab code Exa 8.2.1 `CW Output Power Of an IMPATT Diode`

```

//chapter no.-8,  page no.-331
//Example no.8-2-1

clc;

//(a)Calculate the maximum CW power

n=.15;//efficiency
Vomax=100;//maximum operating voltage
Iomax=200*(10^-3);//maximum operating current
Pdc=Vomax*Iomax;
P=n*Pdc;
disp(P,'the maximum CW power(in  Watts)is  =');

//(b)  Calculate the resonant frequency

L=6*(10^-6);//drift-region Length
vd=2*(10^5);//carrier drift velocity
f=vd/(2*L);
f=f/(10^9);
```

```
disp(f,'the_resonant_frequency(in GHz)is =');
```

Scilab code Exa 8.3.1 `Calculate the avalanche zone velocity`

```

//chapter_no.-8, page_no.-334
//Example_no.8-3-1

clc;
J=20*(10^3);//current_density
q=1.6*(10^-19);
NA=2*(10^15);//Doping_Concentration
vs=J/(q*NA);
disp(vs,'avalanche-zone_velocity(in cm/s)is =');

disp('This means that the avalanch-zone velocity is much larger than the scattering-limited velocity');
```

Scilab code Exa 8.4.1 `Breakdown voltage Of a BARITT Diode`

```

//chapter_no.-8, page_no.-338
//Example_no.8-4-1

clc;

//(a) Calculate_the_break_down_voltage
q=1.6*(10^-19);
N=2.8*(10^21);//Donor_Concentration
L=6*(10^-6);//silicon_length
er=11.8;//Relative_dielectric_constant
es=8.854*(10^-12)*er;
```

```
Vbd=(q*N*(L^2))/es;
disp(Vbd,'the break down voltage is double its critical voltage as (in Volts) is =');

//(b) Calculate the break down electric field


Ebd=Vbd/L;
disp(Ebd,'the break down electric field (in V/m) is =');
Ebd=Ebd/100;
disp(Ebd,'the break down electric field (in V/cm) is =');
```

Scilab code Exa 8.5.1 `UP Converter parametric Amplifier`

```

//chapter no.-8,  page no.-346
//Example no.8-5-1
clc;

//(a) Calculate the power gain
R=25;//R=f0/fs  , ratio of output frequency over signal frequency
rQ=10;//figure of merit
x=((rQ)^2)/R;
PG=(R*x)/((1+sqrt(1+x))^2);
PG=10*log10(PG);//calculating in dB
disp(PG,'Up-converter power gain (in dB) is =');

//(b) Calculate the noise figure

Td=350;//Diode temperature
To=300;//ambient Temperature
```

```
F=1+(((2*Td)/To)*((1/rQ)+(1/rQ^2)));
F=10*log10(F);//calculating in dB
disp(F,'the noise figure(in dB)is =');


//(c)Calculate the band width

r=.4//factor of merit figure
BW=2*r*sqrt(R);   //R=fo/fs
disp(BW,'the band width is =');
```

Chapter 9

microwave linear beam tubes O type

Scilab code Exa 9.2.1 `Klystron Amplifier`

```
// CAPTION:Klystron Amplifier
//chapter no.-9,  page no.-377
//Example no.9-2-1

clc;

//(a) Calculate the input gap voltage to give maximum voltage V2

disp('For maximum V2, J1(X) must be maximum. This means J1(X)=.582 at X=1.841. The electron velocity just leaving the cathode is');
X=1.841;
J1(X)=.582;
V0=10^3;
v0=.593*(10^6)*sqrt(V0);
disp(v0,'');
```

```
f=(3*(10^9));
d=1*(10^-3);//Gap␣spacing␣in␣either␣cavity
w=(2*%pi*f);
Og=(w*d)/v0;
disp(Og,'The␣gap␣transit␣angle␣(in radian)is =');
disp('The␣beam-coupling␣coefficient␣is');
Bi=sin(Og/2)/(Og/2);
Bo=Bi;
disp(Bi,'');
disp('The␣dc␣transit␣angle␣(in radian)␣between␣the␣cavities␣is =');
L=4*(10^-2);//Spacing␣between␣the␣two␣cavities
O0=(w*L)/v0;
disp(O0,'');
disp('The␣maximum␣input␣voltage␣V1␣(in Volts)␣is␣then␣given␣by =');
V1max=(2*V0*X)/(Bi*O0);
disp(V1max,'');




//(b) Calculate␣the␣voltage␣gain

R0=40*(10^3);
Rsh=30*(10^3);//Effective␣shunt␣impedance␣excluding␣beam␣loading

Av=((Bo^2)*O0*J1(X)*Rsh)/(R0*X);
disp(Av,'The␣voltage␣gain␣is␣found ,neglecting␣the␣beam␣loading␣in␣the␣output␣cavity=');




//(c)Calculate␣the␣efficiency␣of the ␣amplifier

```

```
I0=25*(10^-3);
I2=2*I0*J1(X);
V2=Bo*I2*Rsh;
efficiency=(Bo*I2*V2)/(2*I0*V0);
efficiency=100*efficiency;
disp(efficiency,'the efficiency of the  amplifier , neglecting beam loading =');


//(d)Calculate the beam loading conductance

G0=25*(10^-6);
Og=(Og*180)/%pi;
GB=(G0/2)*((Bo^2)-(Bo*cos((28.6*%pi)/180)));
disp(GB,'the beam loading conductance GB (mho)is =');

RB=1/GB;
disp(RB,'then the beam loading resistance RB (rho)is =');
disp('
   In comparasion with RL and Rsho or the effective shunt resistance 
   ,
   the beam loading resistance is like an open circuit and thus can b
    neglected in the preceding calculations');
```

Scilab code Exa 9.3.1 `Four Cavity Klystron`

```

//chapter no.-9,  page no.-385
//Example no.9-3-1

clc;

//(a) Calculate the dc electron velocity
```

```
V0=14.5*(10^3);
v0=.593*(10^6)*sqrt(V0);
disp(v0,'the dc electron velocity(in m/s)is =');


//(b) Calculate the dc phase constant

f=(10*(10^9));
Be=(2*%pi*f)/v0;
disp(Be,'the dc phase constant(in rads/m)is =');



//(c)Calculate the plasma frequency

po=1*(10^-6);//dc electron charge density
wp=((1.759*(10^11)*po)/(8.854*(10^-12)))^(1/2);
disp(wp,'the plasma frequency(in rad/s)is =');


//(d) Calculate the reduced plasma frequency for R=0.4

R=0.4;
wq=R*wp;
disp(wq,'the reduced plasma frequency for R=0.4(in rad/s)is =');



//(e)Calculate the dc beam current density

J0=po*v0;
disp(J0,'the dc beam current density(in A/m2)is =');



//(f)
```

```
    Calculate_the_instantaneous_beam_current_density


p=1*(10^-8);
v=1*(10^5);//velocity_perturbation
J=(p*v0)-(po*v);
disp(J,'the_instantaneous_beam_current_density(in A/
   m2)is =');
```

Scilab code Exa 9.3.2 `Operation of a FourCavity Klystron`

```
//CAPTION:Operation_of_a_Four-Cavity_Klystron
//chapter_no.-9,  page_no.-386
//Example_no.9-3-2

clc;

//(a) Calculate_the_dc_electron_velocity
V0=18*(10^3);
v0=.593*(10^6)*sqrt(V0);
disp(v0,'the_dc_electron_velocity(in m/s)is =');


//(b) Calculate_the_dc_electron_phase_constant

f=(10*(10^9));//Operating_frequency
w=2*%pi*f
Be=w/v0;
disp(Be,'the_dc_electron_phase_constant(in rads/m)is
    =');



//(c) Calculate_the_plasma_frequency

```

```
po=1*(10^-8);//dc electron beam current density
wp=((1.759*(10^11)*po)/(8.854*(10^-12)))^(1/2);
disp(wp,'the plasma frequency(in rad/s)is =');


//(d) Calculate the reduced plasma frequency for R=0.5

R=0.5;
wq=R*wp;
disp(wq,'the reduced plasma frequency for R=0.5(in rad/s)is =');



//(e) Calculate the reduced plasma phase constant

Bq=wq/v0;
disp(Bq,'the reduced plasma phase constant(in rad/m) is =');




//(f) Calculate the transit time across the input gap

d=1*(10^-2);//gap distance
t=d/v0;
t=t*(10^9);
disp(t,'the transit time across the input gap(in ns) is =');




//(g) Calculate the electron velocity leaving the input gap
```

```

V1=10;
Bi=1;//beam_coupling_coefficient
Vt1=v0*(1+(((Bi*V1)/(2*V0))*sin(w*t*(10^-9))));
disp(Vt1,'the_electron_velocity_leaving_the_input_gap(in m/s)is =');
```

Scilab code Exa 9.3.3 `Characteristics of Two Cavity Klystron`

```
// CAPTION:Characteristics_of_Two-Cavity_Klystron
//chapter_no.-9, page_no.-388
//Example_no.9-3-3
clc;

//(a)Calculate_the_plasma_frequency
po=1*(10^-6);//dc_electron_beam_current_density
wp=((1.759*(10^11)*po)/(8.854*(10^-12)))^(1/2);
disp(wp,'the_plasma_frequency(in rad/s)is =');


//(b) Calculate_the_reduced_plasma_frequency_for_R=0.5

R=0.5;
f=(8*(10^9));
w=2*%pi*f;
wq=R*wp;
disp(wq,'the_reduced_plasma_frequency_for_R=0.5(in rad/s)is =');

//(c)Calculate_the_induced_current_in_the_output_cavity
```

```

V0=20*(10^3);
I0=2;//beam current
V1=10;//Signal voltage
Bo=1;//Beam coupling coefficient
I2=(I0*w*(Bo^2)*V1)/(2*V0*wq);
disp(I2,'the induced current in the output cavity(in Ampere)is =');




//(d) Calculate the induced voltage in the output cavity

Rshl=30*(10^3);//total shunt resistance including load
V2=I2*Rshl;
V2=V2/1000;
disp(V2,'the induced voltage in the output cavity(in KV)is =');


//(e) Calculate the output power delivered to the load


Rsh=10*(10^3);//shunt resistance of  the cavity
Rshl=30*(10^3);//total shunt resistance including load
Pout=(I2^2)*Rshl;
Pout=Pout/1000;
disp(Pout,'the output power delivered to  the load(in KW)is =');



```

```
//(f) Calculate_the_power_gain


powergain=(((I0*w)^2)*(Bo^4)*Rsh*Rshl)/(4*((V0*wq)^2));
powergain=10*log10(powergain);//powergain_in_dB
disp(powergain,'the_power_gain is =');


//(g) Calculate_the_electronic_efficiency


n=(Pout*1000)/(I0*V0);
n=n*100;
disp(n,'the_electronic_efficiency (in %)is =');
```

Scilab code Exa 9.3.4 Output Power of Four Cavity Klystron

```
// CAPTION:Output_Power_of_Four-Cavity_Klystron
//chapter_no.-9,  page_no.-390
//Example_no.9-3-4

clc;

//(a) Calculate_the_plasma_frequency
po=5*(10^-5);//dc_electron_beam_current_density
wp=((1.759*(10^11)*po)/(8.854*(10^-12)))^(1/2);
disp(wp,'the_plasma_frequency(in rad/s)is =');


//(b) Calculate_the_reduced_plasma_frequency_for_R=0.6

R=0.6;
f=(4*(10^9));
```

```
w=2*%pi*f;
wq=R*wp;
disp(wq,'the reduced plasma frequency for R =0.6(in rad/s)is  =');

//(c) Calculate the induced current in the output cavity


Rsh=10*(10^3);//shunt resistance of  the cavity
Rshl=5*(10^3);//total shunt resistance including load
V0=10*(10^3);
I0=0.7;//beam current
V1=2;//Signal voltage
Bo=1;//Beam coupling coefficient
I4=(((I0*w)^3)*(Bo^6)*V1*(Rsh^2))/(8*((V0*wq)^3));
disp(I4,'the induced current in the output cavity(in Ampere)is  =');




//(d) Calculate the induced voltage in the output cavity



V4=I4*Rshl;
V4=V4/1000;
disp(V4,'the induced voltage in the output cavity(in KV)is  =');


//(e) Calculate the output power delivered to the load
```

```

Pout=(I4^2)*Rshl;
Pout=Pout/1000;
disp(Pout,'the output power delivered to  the load(in KW)is  =');
```

Scilab code Exa 9.4.1 `Reflex Klystron`

```
// CAPTION:Reflex Klystron
//chapter no.-9,  page no.-399
//Example no.9-4-1

clc;

//(a)  Calculate the value of the repeller voltage
V0=600;
n=2;//mode=2
fr=9*(10^9);
w=2*%pi*fr;
L=1*(10^-3);
em=1.759*(10^11);//em=e/m
x=((em)*(((2*%pi*n)-(%pi/2))^2))/(8*(w^2)*(L^2));//x=V0/(V0+Vr)^2
y=V0/x;//y=(V0+Vr)^2
z=sqrt(y);//z=V0+Vr
Vr=z-V0;
disp(Vr,'the value of the repeller voltage(volts)is =');





//(b)  Calculate the direct current necessary to give a microwave gap vo
```

```

disp('Assume_that_Bo=1');
disp('V2 = I2*Rsh = 2*I0*J1(X)*Rsh ');
disp('the_direct_current_I0_is_I0 = V2/ 2*J1(X)*Rsh'
   );
V2=200;
Rsh=15*(10^3);
X=1.841
J1(X)=.582;
I0 = V2/(2*J1(X)*Rsh);
I0=I0*1000;
disp(I0,'
   the_direct_current_necessary_to_give_a_microwave_gap_voltage_of_20
   (mA)is =');



//(c) Calculate_the_electronic_efficiency

disp('From Eq(9-4-11),Eq(9-4-12) and Eq(9-4-20),
   the_electronic_efficiency_is');

efficiency=(2*X*J1(X))/((2*%pi*n)-(%pi/2));
efficiency=efficiency*100;
disp(efficiency,'the_electronic_efficiency(in %)is =
   ');
```

Scilab code Exa 9.5.1 Operation of Travelling WAVE TUBE

```
// CAPTION: Operation_of_Travelling-WAVE_TUBE(TWT)
//chapter_no.-9, page_no.-416
//Example_no.9-5-1

clc;
```

```
//(a) Calculate_the_gain_parameter

I0=30*(10^-3);//Beam_current
V0=3*(10^3);//Beam_voltage
Z0=10;//characteristic_impedance_of_the_helix
C=(((I0*Z0)/(4*V0))^(1/3));
disp(C,'From Eq(9-5-56) the gain parameter is =');


//(b) Calculate_the_output_power_gain_in_dB

N=50;//Crcular_length
Ap=-9.54+(47.3*N*C);
disp(Ap,'the_output_power_gain_(in_dB) is =');



//(c) Calculate_the_four_propagation_constants

f=10*(10^9);
V0=3*(10^3);
w=2*(%pi)*f;
v0=.593*(10^6)*sqrt(V0);
Be=w/v0;

r1=(-1*Be*C*(sqrt(3)/2))+%i*Be*(1+(C/2));
disp(r1,'the_first_propagtaion_constant_is =');

r2=(Be*C*(sqrt(3)/2))+%i*Be*(1+(C/2));
disp(r2,'the_second_propagtaion_constant_is =');
r3=%i*Be*(1-C);
disp(r3,'the_third_propagtaion_constant is =');

r4=-1*%i*Be*(1-((C^3)/4));
disp(r4,'the_fourth_propagtaion_constant is =');
```

Scilab code Exa 9.7.1 `Gridded Travelling Wave Tube`

```

//chapter no.-9,  page no.-427
//Example no.9-7-1
clc;


//(a) Calculate the number of electrons returned per second
Ir=.85;//returned current
q=1.6*(10^-19);//electronic charge
Nr=Ir/q;
disp(Nr,'the number of electrons returned (per second)  is =');





//(b) Calculate the Energy associated with these returning electrons in 


V=11*(10^3);//overdepreesion collector voltage
t=20*(10^-3);
W=V*Nr*t;
disp(W,'the Energy associated with these returning electrons in 20ms (in eV)  is =');


```

```

//(c) Calculate the Power for returning electrons


P=V*Ir;
P=P/1000;
disp(P,'the Power for returning electrons(in KW)is =');


//(d) Calculate the Heat associated with the returning electrons

t=20*(10^-3);
H=.238*P*1000*t;
disp(H,'the Heat associated with the returning electrons(in calories)is =');


//(e) Calculate the temperature

mass=250*(10^-3);
specificheat=.108;
T=H/(mass*specificheat);
disp(T,'the temperature(in degree Celsius)is =');

//(f) Calculate whether the output iron pole piece is melted


disp('the output iron pole piece is melted');
```

Chapter 10

Microwave crossed field tubes M type

Scilab code Exa 10.1.1 `Conventional Magnetron`

```
//CAPTION: Conventional Magnetron
//chapter no.-10,  page no.-448
//Example no.10-1-1

clc;

//(a)  Calculate the cyclotron angular frequency

em=1.759*(10^11);//em=e/m=charge is to mass ratio
B0=.336;//Magnetic flux density
wc=(em)*B0;
disp(wc,'The cyclotron angular frequency(in  rad)is  =  ');



//(b)  Calculate the cutoff voltage for a fixed B0


```

```
a=5*(10^-2);//radius_of_cathode_cylinder
b=10*(10^-2);//radius_of_vane_edge_to_centre
Voc=(em*(B0^2)*(b^2)*((1-((a/b)^2))^2))/8;
Voc=Voc/(10^5);
disp(Voc,'the_cutoff_voltage_for_a_fixed_B0(in KV)is =');



//(c) Calculate_the_cutoff_magnetic_flux_density_for_a_fixed_V0


V0=26*(10^3);//Anode_voltage
Boc=(((8*V0)/em)^(1/2))/(b*(1-((a/b)^2)));
Boc=Boc*1000;
disp(Boc,'the_cutoff_magnetic_flux_density_for_a_fixed_V0(in mWb/m^2)is =');
```

Scilab code Exa 10.1.1.A `Pulsed Magnetron`

```
// CAPTION: Pulsed_Magnetron
//chapter_no.-10, page_no.-452
//Example_no.10-1-1A

clc;

//(a) Calculate_the_angular_resonant_frequency

f=9*(10^9);//Operating_frequency
wr=2*%pi*f;
disp(wr,'the_angular_resonant_frequency(in rad)is =');
```

```


//(b) Calculate the unloaded quality factor


C=2.5*(10^-12);//vane capacitance
Gr=2*(10^-4);//Resonator capacitance
Qun=wr*C/Gr;
disp(Qun,'the unloaded quality factor');




//(c) Calculate the loaded quality factor


C=2.5*(10^-12);//vane capacitance
Gr=2*(10^-4);//Resonator capacitance
Gl=2.5*(10^-5);//loaded capacitance
Ql=wr*C/(Gl+Gr);
disp(Ql,'the loaded quality factor');



//(d) Calculate the external quality factor


C=2.5*(10^-12);//vane capacitance
Gl=2.5*(10^-5);//loaded capacitance
Qex=wr*C/Gl;
disp(Qex,'the external quality factor');


//(e) Calculate the circuit efficiency

n=(1/(1+(Qex/Qun)));
n=n*100;
disp(n,'the circuit efficiency(in %) is=');
```

```


//(f) Calculate_the_electronic_efficiency


V0=5.5*(10^3);//Anode_Voltage
I0=4.5;//Beam_current
Plost=18.5*(10^3);//power_loss
ne=((V0*I0)-(Plost))/(V0*I0);
ne=ne*100;
disp(ne,'the_electronic_efficiency(in %) is=');
```

Scilab code Exa 10.1.2 `Linear Magnetron`

```
//CAPTION:Linear_Magnetron
//chapter_no.-10,  page_no.-457
//Example_no.10-1-2

clc;


//(a) Calculate_the_Hall_cutoff_voltage_for_fixed_Bo
em=1.759*(10^11);//em=e/m
Bo=.01;//Magnetic_flux_density
d=5*(10^-2);//Distance_between_cathode_and_anode
Voc=(1/2)*(em)*(Bo^2)*(d^2);
Voc=Voc/1000;
disp(Voc,'the_Hall_cutoff_voltage_for_fixed_Bo(in KV)is =');




//(b) Calculate_the_Hall_cutoff_magnetic_field_density_for_fixed_Vo
```

```


V0=10*(10^3);//Anode_voltage
Boc=(1/d)*sqrt((2*V0)/(em));
Boc=Boc*1000;//in mWb
disp(Boc,'the_Hall_cutoff_magnetic_field_density_for_fixed_Vo(in mWb/m^2)is =');
```

Scilab code Exa 10.1.2.a `Linear Magnetron`

```
//CAPTION: Linear_Magnetron
//chapter_no.-10, page_no.-459
//Example_no.10-1-2a

clc;

//(a) Calculate_the_electron_velocity_at_the_hub_surface

em=1.759*(10^11);//em=e/m
Bo=.015;//Magnetic_flux_density
d=5*(10^-2);//Distance_between_cathode_and_anode
h=2.77*(10^-2);//hub_thickness
V=em*Bo*h;
disp(V,'the_electron_velocity_at_the_hub_surface(in m/s)is =');




//(b) Calculate_the_phase_velocity_for_synchronism

```

```
disp(V,'the phase velocity for synchronism is Vph=w/
   B =');



//(c) Calculate the Hartree anode voltage


wB=V;//wB=w/B

Voh=((V*Bo*d))-((1/2)*(1/em)*(V^2));
Voh=Voh/1000;//in KV
disp(Voh,'the Hartree anode voltage (in KV) is =');
```

Scilab code Exa 10.1.5 `Inverted Coaxial Magnetron`

```
// CAPTION:Inverted Coaxial Magnetron
//chapter no.-10, page no.-465
//Example no.10-1-5

clc;


//(a) Calculate the cutoff voltage for fixed Bo
em=1.759*(10^11);//em=e/m
Bo=.01;//Magnetic flux density
a=3*(10^-2);//anode radius
b=4*(10^-2);//Cathode radius
Voc=(1/8)*(em)*(Bo^2)*(a^2)*((1-((b/a)^2))^2);
Voc=Voc/1000;
disp(Voc,'the cutoff voltage for fixed Bo(in KV)is =
   ');



```

```

//(b) Calculate_the_cutoff_magnetic_flux_density_for_fixed_Vo



V0=10*(10^3);//Anode_voltage
Boc=(-1/(sqrt(em)))*(sqrt(8*V0))/((a)*(1-((b/a)^2)));
disp(Boc,'the_cutoff_magnetic_flux_density_for_fixed_Vo(in Wb/m^2)is =');
```

Scilab code Exa 10.1.6 `Frequency Agile Magnetron`

```
//CAPTION: Frequency-Agile_Magnetron
//chapter_no.-10, page_no.-467
//Example_no.10-1-6

clc;

//(a) Calculate_the_agile_excursion
t=.2*(10^-6);//pulse_duration
N=14;//pulse_rate_on_target
AC=N/t;//agile_Excursion
AC=AC/(10^6);//in MHz
disp(AC,'the_agile_excursion(in MHz)is =');



//(b) Calculate_the_pulse-to-pulse_frequency_separation


fp=1/t;
```

```
fp=fp/(10^6);//in MHz
disp(fp,'the pulse-to-pulse frequency separation(in MHz)is =');



//(c) Calculate the signal frequency

DC=.001//Duty cycle
f=(DC/t);
f=f/(10^3);//in KHz
disp(f,'the signal frequency(in KHz)is =');



//(d) Calculate the time for N pulses

Time=N/f;
disp(Time,'the time for 14 pulses per second (in ms)is =');




//(e) Calculate the agile rate

Agilerate=1/(2*Time*10^-3);

disp(Agilerate,'the agile rate(in Hz)is =');
```

Scilab code Exa 10.2.1 `Crossed Field Amplifier`

```
//CAPTION:Crossed-Field Amplifier
//chapter no.-10,  page no.-473
//Example no.10-2-1
```

```

clc;

//(a) Calculate the induced RF power

Vao=2*(10^3);//Anode dc voltage
Iao=1.5;//Anode dc current
ne=.20;//Electronic efficiency
Pgen=Vao*Iao*ne;
disp(Pgen,'the induced RF power(in W)is =');




//(b) Calculate the total RF output power


Pin=80;//RF input power
Pout=Pin+(Pgen);
disp(Pout,'the total RF output power(in W)is =');


//(c) Calculate the power gain

g=Pout/Pin;
g=10*log10(g);//in decibels
disp(g,'the power gain(in dB)is =');
```

Scilab code Exa 10.3.1 `Amplitron characteristics`

```
//CAPTION: Amplitron characteristics
//chapter no.-10,  page no.-478
//Example no.10-3-1

clc;
```

```

//(a) Calculate the dc electron-beam velocity

V0=15*(10^3);//Anode voltage
v0=.593*(10^6)*sqrt(V0);
disp(v0,'the dc electron-beam velocity (in m/s)is =');



//(b) Calculate the electron-beam phase constant


f=8*(10^9);
w=2*%pi*f;
Be=w/v0;
disp(Be,'the electron-beam phase constant(in rad/m) is =');





//(c) Calculate the cyclotron angular frequency

em=1.759*(10^11);//em=e/m
Bo=.2;//Magnetic flux density
wc=(em*Bo);
disp(wc,'the cyclotron angular frequency(in rad/s)is =');


//(d) Calculate the cyclotron phase constant

Bm=wc/v0;
disp(Bm,'the cyclotron phase constant(in rad/m)is =');

```

```
//(e)  Calculate the gain parameter

Z0=50;//characteristic impedance
I0=3;//Anode current
C=((I0*Z0)/(4*V0))^(1/3);
disp(C,'the gain parameter is  =');
```

Scilab code Exa 10.4.1 `Carcinotron Characteristics`

```
//CAPTION: Carcinotron Characteristics
//chapter no.-10,  page no.-483
//Example no.10-4-1

clc;

//(a)Calculate the dc electron velocity

V0=20*(10^3);//Anode voltage
v0=.593*(10^6)*sqrt(V0);
disp(v0,'the dc electron velocity (in m/s)is  =');



//(b)  Calculate the electron-beam phase constant


f=4*(10^9);//operating frequency
w=2*%pi*f;
Be=w/v0;
disp(Be,'the electron-beam phase constant(in rad/m) is  =');




```

```
//(c) Calculate the delta differentials


b=.5;//b factor
disp('The Delta differentials are :  s1=');
s1=(%i)*((b-sqrt((b^2)+4))/2);
disp(s1,'   s1=');
s2=(%i)*((b+sqrt((b^2)+4))/2);
disp(s2,'And  s2=');



//(d)Calculate the propagation constants

D=.8;//D factor
disp('the propagation constants are ');
r1=((%i)*(Be+b))+(b*D*s1);
disp(r1,'   r1=');
r2=((%i)*(Be+b))+(b*D*s2);
disp(r2,'   r2=');



//(e)Calculate the oscillation condition

disp('the oscillation occurs at  DN=1.25 for n=1 ');
N=1.25/D;
disp(N,'then N=');

l=(2*%pi*N)/Be;
l=l*100;//in cm
disp(l,'and l= 2*pi*N/Be(in cm) = ')
```

Chapter 11

Strip lines

Scilab code Exa 11.1.1 `Characteristic Impedance of Microstrip line`

```
//CAPTION:
   Characteristic_Impedance_of_Microstrip_line
//chapter_no.-11,  page_no.-495
//Example_no.11-1-1

clc;


er=5.23;//relative_dielectric_constant
h=7;//height_from_microstrip_line_to_the_ground
t=2.8;//thickness_of_the_microstrip_line
w=10;//width_of_the_microstrip_line
Z0=(87*(log((5.98*h)/(t+(.8*w)))))/sqrt(er+1.41);
disp(Z0,'the_characteristic_impedance_of_the_line(in
    ohms)is =');
```

Scilab code Exa 11.2.1 `Characteristics of a Parallel Strip Line`

```
//CAPTION: Characteristics of a Parallel Strip Line
//chapter no.-11, page no.-505
//Example no.11-2-1

clc;

//(a) Calculate the required width of the conducting strip
erd=6;//relative dielectric constant
d=4*(10^-3);//thickness
Z0=50;//characteristic impedance

w=(377*(d))/((sqrt(erd))*Z0);
disp(w,'the required width of the conducting strip(in metres)is =');

//(b) Calculate the strip line capacitance

ed=8.854*(10^-12)*erd;
d=4*(10^-3);//thickness
C=(ed*w)/d;
C=C*(10^12);
disp(C,'the strip line capacitance(in pF/m)is =');




//(c) Calculate the strip line inductance

uc=4*%pi*(10^-7);
d=4*(10^-3);//thickness
C=(uc*d)/w;
C=C*(10^6);
disp(C,'the strip line inductance(in uH/m)is =');

//(d) Calculate the phase velocity of the wave in the parallel strip li
```

```

c=3*(10^8);

vp=c/(sqrt(erd));
disp(vp,'the␣phase␣velocity␣of␣the␣wave␣in␣the␣parallel␣strip␣line (in m/s)is =');
```

Scilab code Exa 11.3.1 `Characteristic Impedance of a Coplanar Stripline`

```

//chapter␣no.-11,␣␣page␣no.-507
//Example␣no.11-3-1

clc;

Pavg=250*(10^-3);//average␣power␣flowing␣in␣the␣positive␣z␣direction
Io=100*(10^-3);//total␣peak␣current
Z0=(2*Pavg)/(Io^2);
disp(Z0,'the␣characteristic␣impedance␣of␣the␣coplanar␣strip␣line (in ohms)is =');
```

Scilab code Exa 11.4.1 `Characteristic Impedance of a Shielded Strip Line`

```

//chapter␣no.-11,␣␣page␣no.-508
//Example␣no.11-4-1


clc;

```

```

//(a)Calculate_the_K_factor

er=2.56//relative_dielectric_constant
w=25;//strip_width
t=14;//strip_thickness
d=70;//shield_depth
K=1/(1-(t/d));
disp(K,'the_K_factor is =');

//(b)Calculate_the_fringe_capacitance

Cf=((8.854*er)*((2*K*log(K+1))-((K-1)*log((K^2)-1))))/%pi;
disp(Cf,'the_fringe_capacitance(in pF/m)is =');


//(c)Calculate_the_characteristic_impedance_of_the_line

Z0=94.15/((((w/d)*K)+(Cf/(8.854*er)))*(sqrt(er)));
disp(Z0,'the_characteristic_impedance_of_the_line(in ohms)is =');
```

Chapter 12

Monolithic Microwave Integrated Circuits

Scilab code Exa 12.4.1 `Resistance of a planar resistor`

```

//chapter_no.-12,  page_no.-534
//Example_no.12-4-1

clc;
l=10*(10^-3);;//resistance_film_length
ps=2.44*(10^-8);//sheet_resistivity_of_gold_film
w=10*(10^-3);//resistive_film_width
t=.1*(10^-6);//resistive_fim_thickness
R=(l*ps)/(w*t);
disp(R,'the_planar_resistance(in ohm/square)is =');
```

Scilab code Exa 12.4.2 `Planar Circular Spiral inductor`

```

//chapter_no.-12,  page_no.-536
```

```
//Example no.12-4-2

clc;
n=5;//number of turns
w=50;//film width
s=100;//separation
d0=2.5*n*(w+s);
L=.03125*(n^2)*d0;
disp(L,'the inductance(in (nH/mil)is =');
```

Scilab code Exa 12.4.3 Planar Capacitor

```

//chapter no.-12,  page no.-537
//Example no.12-4-3

clc;

N=8;//number of fingers
er=13.1;//relative dielectric constant
h=.254;//substarte height
l=.00254;//finger length
w=.051;//finger base width
A1=.089;//contribution of interior finger for h&gt;w
A2=.1;//contribution of two exterior fingers for h&gt;w
C=((er+1)*l*((A1*(N-3))+A2))/w;
disp(C,'the Capacitance(in (pF/cm)is =');
```