

Scilab Textbook Companion for
Microwave Devices And Circuits
by S. Y. Liao¹

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

August 17, 2013

¹Funded 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	4
2 Electromagnetic plane waves	6
3 Electromagnetic plane waves	10
4 microwave waveguides and components	23
5 microwave transistors and tunnel diodes	38
6 microwave field effect transistors	48
7 transferred electron devices	60
8 Avalanche transit time Devices	64
9 microwave linear beam tubes O type	68
10 Microwave crossed field tubes M type	83
11 Strip lines	95
12 Monolithic Microwave Integrated Circuits	99

List of Scilab Codes

Exa 2.6.5	Calculation of a Gold Film Coating	6
Exa 2.6.6	Computation of a Copper Film Coating	7
Exa 3.1.1	Line characteristic impedance and phase constant . . .	10
Exa 3.2.1	reflection coefficient and transmission coefficient	11
Exa 3.3.1	Standing Wave Ratio	13
Exa 3.4.1	Line Impedance	14
Exa 3.5.1	Location of Voltage maxima and minima from load . .	16
Exa 3.5.2	Impedance with short circuit minima shift	17
Exa 3.6.1	Single Stub Matching	18
Exa 3.6.2	Double Stub Matching	20
Exa 4.1.1	TE ₁₀ in Rectangular Waveguide	23
Exa 4.1.2	TE ₁₀ mode in Rectangular Waveguide	25
Exa 4.2.1	TE ₁₀ Mode in Circular Waveguide	28
Exa 4.2.2	Wave Propagation in Circular Waveguide	30
Exa 4.5.1	Directional Coupler	34
Exa 4.5.2	Operation Of a Balanced Amplifier	36
Exa 5.1.1	Elements of Hybrid Pi Common Emitter Circuit	38
Exa 5.1.2	I V Characteristics of n p n transistor	39
Exa 5.1.3	Silicon Bipolar Transistor	42
Exa 5.1.4	Power Frequency Limitation	44
Exa 5.2.1	Heterojunction Bipolar Transistor	44
Exa 5.2.2	n Ge p GaAs n GaAs HBT	45
Exa 6.1.1	Pinch Off Voltage Of a Silicon JFET	48
Exa 6.1.2	current of a JFET	48
Exa 6.2.1	Pinch Off Voltage Of a MESFET	51
Exa 6.2.2	Current Voltage Characteristics Of a GaAs MESFET .	51
Exa 6.2.3	CutOff frequency of a MESFET	53
Exa 6.3.1	Current of a HEMT	54

Exa 6.3.2	Sensitivity Of HEMT	54
Exa 6.4.1	Threshold Voltage of an Ideal MOSFET	55
Exa 6.4.2	Characteristics Of a MOSFET	56
Exa 6.6.1	Power Dissipation of a Three Phase CCD	58
Exa 6.6.2	Design of N Type Three Phase Surface Channel CCD	58
Exa 7.2.1	Conductivity of an n Type GaAs Gunn Diode	60
Exa 7.2.2	Charactristics of a GaAs Gunn Diode	60
Exa 7.3.1	Criterion of Mode Operation	61
Exa 7.4.1	Output power of an LSA Oscillator	62
Exa 8.2.1	CW Output Power Of an IMPATT Diode	64
Exa 8.3.1	Calculate the avalanche zone velocity	65
Exa 8.4.1	Breakdown voltage Of a BARITT Diode	65
Exa 8.5.1	UP Converter parametric Amplifier	66
Exa 9.2.1	Klystron Amplifier	68
Exa 9.3.1	Four Cavity Klystron	70
Exa 9.3.2	Operation of a FourCavity Klystron	72
Exa 9.3.3	Characteristics of Two Cavity Klystron	74
Exa 9.3.4	Output Power of Four Cavity Klystron	76
Exa 9.4.1	Reflex Klystron	78
Exa 9.5.1	Operation of Travelling WAVE TUBE	79
Exa 9.7.1	Gridded Travelling Wave Tube	81
Exa 10.1.1	Conventional Magnetron	83
Exa 10.1.1.1	Pulsed Magnetron	84
Exa 10.1.2	Linear Magnetron	86
Exa 10.1.2.1	Linear Magnetron	87
Exa 10.1.5	Inverted Coaxial Magnetron	88
Exa 10.1.6	Frequency Agile Magnetron	89
Exa 10.2.1	Crossed Field Amplifier	90
Exa 10.3.1	Amplitron characteristics	91
Exa 10.4.1	Carcinotron Characteristics	93
Exa 11.1.1	Characteristic Impedance of Microstrip line	95
Exa 11.2.1	Characteristics of a Parallel Strip Line	95
Exa 11.3.1	Characteristic Impedance of a Coplanar Stripline	97
Exa 11.4.1	Characteristic Impedance of a Shielded Strip Line	97
Exa 12.4.1	Resistance of a planar resistor	99
Exa 12.4.2	Planar Circular Spiral inductor	99
Exa 12.4.3	Planar Capacitor	100

Chapter 2

Electromagnetic plane waves

Scilab code Exa 2.6.5 Calculation of a Gold Film Coating

```
1 //Caption: Calculation_of_a_gold_film_coating
2 //chapter_no.-2, page_no.-69
3 //Example No.-2-6-5
4
5 clc;
6
7 //(a) Program_to_find_gold-film_surface_resistance
8
9
10 t=80*(10^(-10)); //Film_Thickness
11 o=4.1*(10^7); //Bulk_conductivity
12 p=570*(10^(-10)); //Electron_mean_free_path
13 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)]
14
15 Rs=1/(t*of); //
    the_gold_film_surface_resistance_is_given_by--Rs
    =1/(t*of) in_Ohms_per_square
16 disp(Rs, '
    the_gold_film_surface_resistance_in_Ohms_per_square_is
```

```

    ');
17
18
19
20
21 // (b) Program_to_find_the_microwave_attenuation
22
23 Attenuation=40-20*log10(Rs)           //
    Microwave_attenuation
24
25 disp(Attenuation, 'Microwave--Attenuation_is_in_db_is
    : ');
26
27
28 // (c) Light_transmittance_T
29
30 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%');
31
32
33
34 // (d) light_reflection_loss_R
35
36 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

```

1 //Caption: Computation_of_a_copper_film_coating
2 //chapter_no.-1, page_no.-74

```



```

3 //Example No.-2-6-6
4 clc;
5
6 //(a) Program_to_find_copper-film_surface_resistance
7
8
9 t=60*(10^(-10)); //Film_Thickness
10 o=5.8*(10^7); //Bulk_conductivity
11 p=420*(10^(-10)); //Electron_mean_free_path
12 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)]
13
14
15
16 Rs=1/(t*of); //
    the_copper_film_surface_resistance_is_given_by_Rs
    =1/(t*of) in_Ohms_per_square
17 disp(Rs, '
    the_copper_film_surface_resistance_in_Ohms_per_square_is
    ');
18
19
20 //(b) Program_to_find_the_microwave_attenuation
21
22 Attenuation=40-20*log10(Rs) //
    Microwave_attenuation
23
24 disp(Attenuation, 'Microwave_Attenuation_in db is:');
25
26 //(c) Light_transmittance_T
27
28 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%');  
29  
30 %(d)light_reflection_loss_R  
31  
32 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

```
1 // CAPTION:
   Calculate_the_Line_Characteristic_Impedance_and_Propagation_constants

2 //chapter_no.-3, page_no.-84
3 //Example_no.3-1-1
4
5 clc;
6
7
8 //(a) Calculate_the_line_Characteristic_Impedance
9
10
11 R=2;
12 L=8*(10^-9);
13 C=.23*(10^-12);
14 f=1*(10^9);
15 G=.5*(10^-3);
16 w=2*%pi*f;
17
18 Z0=sqrt((R+(%i*w*L))/(G+(%i*w*C)));
19 x=real(Z0);
```

```

20 y=imag(Z0);
21 o=atand(y,x);
22 disp(o,'the_phase_of_Z0_is =');
23 M=abs(Z0); // magintue_of_Z0
24 disp(M,'the_magnitude_of_Z0_is =');
25 disp(Z0,'the_line_characteristic_impedance is =');
26
27
28
29 //(b) Calculate_the_propagation_constant
30
31 r=sqrt((R+(%i*w*L))*(G+(%i*w*C)));
32 x=real(r);
33 y=imag(r);
34 o=atand(y,x);
35 disp(o,'the_phase_of_r_is =');
36 M=abs(r); // magintue_of_r
37 disp(M,'the_magnitude_of_r_is =');
38 disp(r,'the_propagation_constant is =');

```

Scilab code Exa 3.2.1 reflection coefficient and transmission coefficient

```

1 //CAPTION:
   Calculate_the_reflection_coefficient_and_the_transmission_coefficient
2
3 //chapter_no.-3, page_no.-89
4 //Example_no.3-2-1
5 clc;
6
7
8 //(a) Calculate_the_reflection_coefficient
9
10
11 Z1=70+(%i*50);

```

```

12 Z0=75+(%i*.01);
13 r=(Z1-Z0)/(Z1+Z0);
14 x=real(r);
15 y=imag(r);
16 o=atand(y,x);
17 disp(o,'the_phase_of_reflection_coefficient_is =');
18 M=abs(r); // magintue_of_r
19 disp(M,'the_magnitude_of_reflection_coefficient_is =
    ');
20 disp(r,'the_reflection_coefficient_is =');
21
22
23
24
25 // (b) Calculate_the_transmission_coefficient
26
27
28 T=(2*Z1)/(Z1+Z0);
29 x=real(T);
30 y=imag(T);
31 o=atand(y,x);
32 disp(o,'the_phase_of_transmission_coefficient_is =')
    ;
33 M=abs(T); // magintue_of_T
34 disp(M,'the_magnitude_of_transmission_coefficient_is
    =');
35 disp(T,'the_transmission_coefficient_is =');
36
37
38
39 // (c) Verify_the_relationship_shown_in_Eq(3-2-21)
40
41
42 T2=T^2;
43 x=real(T2);
44 y=imag(T2);
45 o=atand(y,x);
46 disp(o,'the_phase_of_T^2_is =');

```

```

47 M=abs(T2); // magintue_of_T^2
48 disp(M, 'the_magnitude_of_T^2_is =');
49 disp(T2, 'T^2 =');
50
51 p=(Z1/Z0)*(1-(r^2));
52 x=real(p);
53 y=imag(p);
54 o=atand(y,x);
55 disp(o, 'the_phase_of_(Z1/Z0)*(1-(r^2))_is =');
56 M=abs(T2); // magintue_of_(Z1/Z0)*(1-(r^2))
57 disp(M, 'the_magnitude_of_(Z1/Z0)*(1-(r^2))_is =');
58 disp(p, '(Z1/Z0)*(1-(r^2)) = ');
59 disp('since T^2=(Z1/Z0)*(1-(r^2)) hence
      the_relationship_shown_in_Eq(3-2-21) is verified'
      );
60
61
62
63
64 //(d)
      Verify_the_transmission_coefficient_equals_equals_the_algebraic_su
      (2-3-18)
65
66
67 y=r+1;
68
69 disp(T, 'T =');
70 disp(y, 'r+1 = ');
71 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

```
1 //CAPTION: Standing-Wave-Ratio
```

```

2 //chapter_no.-3, page_no.-93
3 //Example_no.3-3-1
4 clc;
5
6 //(a) Calculate_the_reflection_coefficient
7
8
9 Z1=73-(%i*42.5);
10 Z0=50+(%i*.01);
11 r1=(Z1-Z0)/(Z1+Z0);
12 x=real(r1);
13 y=imag(r1);
14 o=atan2(y,x);
15 disp(o,'the_phase_of_reflection_coefficient_is =');
16
17 M=abs(r1); //magintue_of_r
18 disp(M,'the_magnitude_of_reflection_coefficient_is =
    ');
19 disp(r1,'the_reflection_coefficient_is =');
20
21
22
23 //(b) Calculate_the_standing-wave_ratio
24
25
26 p=(1+M)/(1-M);
27 disp(p,'the_standing-wave_ratio_is =');

```

Scilab code Exa 3.4.1 Line Impedance

```

1 //CAPTION: Line_impedance
2
3 //chapter_no.-3, page_no.-99
4 //Example_no.3-4-1
5

```

```

6  clc;
7
8
9  //(a) Calculate_the_input_impedance
10
11
12  syms x ;//x_is_wavelength
13  Bd=(((2*%pi)/x)*(x/4));
14  disp(Bd, 'from_Eq(3-4-26)_the_line_that_is_2.25
        _wavelengths_long_looks_like_a_quarter-wave_line,
        then Bd= ');
15
16  R0=50; //input_impedance
17  R1=75; //load_resistance
18  Zin=(R0^2)/R1;
19  disp(Zin, 'From_Eq(3-4-26), the_input_impedance ((
        in_ohms) is = ');
20
21
22  //(b)
        Calculate_the_magnitude_of_the_instantaneous_load_voltage

23
24
25  R0=50; //input_impedance
26  R1=75; //load_resistance
27  r1=(R1-R0)/(R1+R0);
28  disp(r1, 'the_reflection_coefficient is =');
29
30
31
32  //(b)
        Calculate_the_magnitude_of_the_instantaneous_load_voltage

33
34
35  R0=50; //input_impedance
36  R1=75; //load_resistance

```



```

37 r1=(R1-R0)/(R1+R0);
38 disp(r1,'the_reflection_coefficient_is =');
39
40 V=30; //open-circuit_output_voltage
41
42 V1=V*(exp(-1*i*Bd))*(1+r1);
43 V1=abs(V1);
44 disp(V1,'the_instantaneous_voltage_at_the_load(in V)
    _is =');
45
46
47
48 //(c)
    Calculate_the_instantaneous_power_delivered_to_the_load

49
50
51 P1=(V1^2)/R1;
52 disp(P1,'
    the_instantaneous_power_delivered_to_the_load(in
    W)is =');

```

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

```

1 //CAPTION:
    location_Determination_of_voltage_maximum_and_minimum_from_load

2 //chapter_no.-3, page_no.-104
3 //Example_no.3-5-1
4
5 clc;
6
7 Zl=1+ %i*1; //Given normalise load impedance
8 disp('1. Enter Zl=1+(1*i) on the chart');
9 disp('read .162lamda on the distance scale by

```

```

    drawing a dashed straight line from the centre of
    the chart through the load point and intersecting
    the distance circle');
10
11 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');
12 lambda=5; // Given wavelength =5
13 dVmax=(.25-.162)*lambda;
14 disp(dVmax, 'd1(Vmax) (in cm)=');
15
16 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');
17 dVmin=(.5-.162)*lambda;
18 disp(dVmin, 'd1(Vmin) (in cm)=');
19
20 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 by the 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

```

1 //CAPTION: Impedance_determination_with_short-
    circuit_Minima_Shift
2 //chapter_no.-3, page_no.-106
3 //Example_no.3-5-2
4
5 clc;
6
7 disp('1. When the line is shorted ,the first voltage

```

```

        minimum occurs at the place of the load ');
8
9 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 ');
10
11 disp('3.plot a SWR cirle for p=2');
12 disp('4. Move a distance of .15lambda from the
    minimum point along the distance scale toward the
    load and stop at .15lambda');
13
14 disp('5.Draw a circle from this point to the centre
    of the chart. ');
15 disp('6. The intersection between the line and the
    SWR circle is  $Z_t=1-j*.65$  ');
16 Zt=1-(%i*.65);
17 Z0=50; //characteristic impedance of the line
18 Zl=Zt*Z0;
19 disp(Zl, 'The load impedance is (in ohm)=');

```

Scilab code Exa 3.6.1 Single Stub Matching

```

1 //CAPTION: Single-Stub_Matching
2 //chapter_no.-3, page_no.-108
3 ///Example_no.3-6-1
4 clc;
5
6 R0=50; //characteristic impedance
7 Zl=50/(2+%i*(2+sqrt(3)));
8 z1=R0/Zl; //normaised load impedance
9 y1=1/z1; //normaised load admittance
10 disp('1. compute the normalised load admittance and
    enter it on the smith chart');
11

```

```

12 disp('2 .Draw a SWR circle throuh the point of y1 so
      that he circle intersects the unity circle at
      the point yd ');
13 yd=1- %i*2.6;
14 disp(yd, 'yd=');
15
16 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');
17
18 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  $Y_{11}=Y_d + Y_s$  ,where  $Y_s$  is the susceptance
      that the stub will contribute');
19 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');
20
21 disp('y11*Y0= yd*Y0 + ys*y0s ');
22 y11=1;
23 Y0=100; //characteristic impedance of the stub
24 Y0s=50;
25 ys=(y11-yd)*(Y0/Y0s);
26
27 disp('4. the distance between the load and the
      stub position can be calculated from the
      distance scale as  $d=(.302-.215)*\lambda$  ');
28
29 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( $z=0,y=\infty$ ), 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 $l = (.5 - .031)\lambda = .469\lambda$. When a line is matched at the junction, there will be no standing wave in the line from the stub to the generator');

```

30
31 disp('If an inductive stub is required  $y_d = 1 + j$ 
      *.26 and the susceptance will be  $y_s = -j * 5.2$  ');
32
33 disp('7. The position of the stub from the load is
       $d = (.5 - (.215 - .198))\lambda = .483\lambda$  and
      the length of the short-circuited stub is  $l = .031 \lambda$  ');

```

Scilab code Exa 3.6.2 Double Stub Matching

```

1 //CAPTION: Double_stub_matching
2 //chapter_no.-3, page_no.-111
3 //Example_no.3-6-2
4 clc;
5
6 Z1=100+(%i*100);
7 R0=50; //characteristic impedance of the stub and the
      line
8
9 z1=Z1/R0;
10 disp('1. compute the normalised load admittance and
      enter it on the smith chart');
11
12 disp('2 .plot a SWR circle and read the normalised
      load admittance 180 degree out of phase with z1
      on the SWR circle : ');
13 y1=1/z1;
14 disp(y1, 'y1=');
15

```

```

16 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)');
17
18 disp('4. move y1 for a distance of .4lambda from
    .458 to .358 along the SWR p circle toward the
    generator and read yd1 on the chart:');
19
20 yd1=.55- %i*1.08;
21 disp('yd1=.55-%i*1.08 ')
22 disp('5. there are two possible solutions for y11.
    they can be found by carrying yd1 along the
    constant-conducacnce (g=0.55) circle that
    intersects the spacing circle at two points
    y11=.55-j(.11) , y11=.55-j(1.88) ');
23
24 y11=.55-(%i*.11);
25 y112=.55-(%i*1.88);
26
27 disp('at the junction 1-1  y11=yd1+ys1 ');
28 ys1=y11-yd1;
29 disp(ys1, 'ys1=');
30 ys12=y112-yd1;
31 disp(ys12, 'ys12=');
32
33 disp('7. the length of the stub 1 are found as l1
    =(.25+.123)lambda=.373lambda  l1 '=(.25-.107)
    lambda=.143lambda ');
34
35 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) ');
36
37 yd2=1-(%i*.61);

```

```

38 yd22=1+(%i*2.60);
39
40 disp('9. Then stub 2 must contribute ys2=(.61*%i)
      and ys2'=(−2.6*%i)');
41 disp('10. the length of the stub 1 are found as l2
      =(0.25+0.087)lambda=.337lambda l1'=(0.308−0.25)
      lambda=.058lambda');
42 disp('11. It can be seen that normalised impedance y1
      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=2 circle 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

```
1 //CAPTION: TE10_In_Rectangular_Waveguide
2 //CHAPTER-4
3 // EXAMPLE: 4-1-1,page no.-128.
4
5 //(a)program_to_find_the_cut-off_frequency_(fc)
   _of_an_airfilled_rectangular_waveguide_in_TE10_mode
   .
6
7
8 a=0.07 ; b=0.035 ; //wave-
   guide_dimensions_in_metres
9 f=3.5*(10^9);
   // Given_that_guide_is_operating_at_a_frequency_of
   3.5 GHZ
10 c=3*(10^8);
   // c_is_the_speed_of_the_light
```



```

11 m=1 ; n=0;

    //
    Given_that_guide_operates_in_the_dominant_mode_TE10

12
13 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
14 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

15
16
17
18 // (b) program_to_find_the_phase_velocity_of_the
    wave_in_the_guide_at_a_frequency_of_3.5GHZ
19
20 f=3.5*(10^9);

    //Given
    that_guide_is_operating_at_a_frequency_of_3.5.GHZ
21 vg=c/(sqrt(1-((fc/f)^2)));

    //since , phase_velocity=c/(sqrt(1-((fc/f)^2)))
22 disp(vg, '
    phase_velocity_for_a_wave_at_a_frequency_of_3.5
    GHZ--(m/s)='); //display_the_phase_velocity

23
24
25
26
27 // (c) program_to_find_the_guide_wavelength(
    lg_of_the_wav__at_a_frequency_of_3.5GHZ
28
29

```

```

30 lo=c/f;

    // lo= wavelength in an unbounded dielectric and
    lo is in metres
31 lginmetres=lo/(sqrt(1-((fc/f)^2)));

    //since ,
    lg=lo/sqrt(1-(fc/f^2));  guide_wavelength(lg)
    _is_in_metres
32 lgincm=100*lginmetres;

    //guide_wavelength (lg) is_in_centimetres
33 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

```

1 //CAPTION: TE10_Mode_In_Rectangular_Waveguide
2
3 // chapter no.-4
4 // Example-4-1-2 , page no.-133
5
6
7 //Program to find the peak value of the electric
  field occuring in the guide.
8
9
10 clc;
11 m=1; n=0;

    //
    given guide transports energy in the TE10 mode.
12 f=30*(10^9);

    //The
    impressed frequency is 30GHZ
13 uo=(4*(%pi))*(10^-7);eo=8.85*(10^(-12));

```

```

//scientific values of permeability
and permittivity in free space
14 a=.02; b=.01;
//
dimensions of wave-guide given in metres
15 energyrate=0.5*746;
//given ,the
rate of transport of energy =0.5 hp ,1 horse
power(1 hp)= 746 watts.
16
17 kc=%pi/a;
//kc
is cutoff wave number , kc=sqrt((m*%pi/a)+(n*
%pi/b)) ,For m=1,n=0 => kc=%pi/a
18 bg=sqrt(((2*%pi*f)^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
19 Zg=((2*%pi*30*(10^9))*uo)/bg;
//Zg is the
characteristic wave impedance ,Zg=(w*uo)/bg;
where w=2*%pi*f
20
21 syms x z Eoy Hoz
//Defining
the variables
22
23 Ex=0;
//since , Ex=Eox*cos((m*%pi*x)/a)*sin((n*%pi*y)/b)
*exp(-%i*bg*z) .. For m=1 , n=0 => Ex=0
24 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)
25 Ez=0;

// For TE mode Ez=0

```

```

26
27 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)
28 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) => Hy=0
29 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 .
30
31 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
32
33 power=(Ey*Hxc);
           //(Taking
           the term (Ey*cojugate(Hx)) from power formula of
           poynting vector
34 power=power/(Eoy^2);
           //normalise power with respect to (Eoy^2) so as
           to definitely integrate remaining terms in x and
           y.
35
36 temp = str2max2sym(power.str1);
37 PowerToIntegrate = max2scistr(temp.str1) ; //
           coverting_type_sym_into_type_string
38
39 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.
40
41 I=I*b;
    //since definite integral is independent of y.
    Hence dimension in y direction i.e,b can be taken
    out
42
43 I=real(I);
    //since from poyting formula [energyrate = (0.5*(
    real(I))*(Eoy^2))].So we consider only real
    part of I.
44
45
46 Eoy=sqrt((energyrate*2)/I);
    // since ,energyrate =373= (0.5*(real(I))*(Eoy^2)
    )
47
48 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

```

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

```

```

5 // (a) program_to_find_the_cut_off_frequency_(fc)
   _of_circular_waveguide_in_TE11_mode
6
7
8 radius=0.05 ;

   //Given .Here radius_is_in_metres.
9 f=3*(10^9);

   //operating_frequency_is_3_GHZ
10 uo=(4*(%pi))*(10^-7) ; eo=8.85*(10^(-12));
   //
   scientific_values_of_permeability_and_permittivity_in_free_space

11 m=1 ; n=1; //
   Given_that_a_TE11_mode_is_propagating.
12 X=1.841;

   //For_TE11_mode_in_circular_waveguide_X= (kc*
   radius) =1.841
13
14 kc=X/radius;

   //cut-off_wave_number
15 fc=kc/((2*%pi)*(sqrt(uo*eo))); //
   since fc=kc/((2*%pi)*(sqrt(uo*eo)));
16 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

17
18
19
20
21 // (b) program_to_find_the_guide_wavelength(lg)

```

```

    _of_the_wave_at_operating_frequency_of_3GHZ
22
23
24 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
25 lginmetres=(2*pi)/bg;
    //
    Guide_wavelength_is_in_meters
26 lgincm=100*lginmetres;
    //
    Guide_wavelength_is_in_centimetres
27 disp(lgincm, '
    Guide_wavelength_for_a_wave_at_a_frequency_of_3.5
    GHZ_(cm)='); //
    display_Guide_wavelength_for_TE10_mode
28
29
30
31 // (c)
    program_to_find_the_Guide_wavelength_in_the_wave_guide

32 zg=(2*pi*(3*(10^9))*uo)/bg;
    //
    Zg_is_the_characteristic_wave_impedence ,Zg=(w*uo
    )/bg; where w=2*pi*f
33 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

```

1 //CAPTION: Wave_Propagation_In_circular_Waveguide
2
3 //chapter-4
4 //Example-4-2-2 page no.-147

```

```

5
6 //program_to_find_all_the_TE(n,p)_and_TM(n,p)
   modes_for_which_energy_transmission_is_possible.
7
8 radius=.02;

   //Given. Here_radius_is_in_metres.
9 uo=(4*(%pi))*(10^-7); eo=8.85*(10^(-12));
   //
   scientific_values_of_permeability_and_permittivity_in_free_space

10 f=(10^10);

   //guide_is_operating_at_the_frequency_of_10GHZ
11 wc=(2*%pi*f);

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

   //kc_is_cut-off_wave_number
13 X=kc*radius ;

   //the product X=(kc*radius)
   for_a_given_mode_is_constant
14 disp(kc*radius, 'The_value_of_the_product X=(kc*
   radius)is = '); //
   display_the_product_X=(kc*a)
15 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)
   <=4.18');

16
17
18 syms i j

   //Defining_the_variables

19
20

```



```

21 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
    .
22
23 for i=1:1:3

    //value_of_i_traverse_across_the_rows
24 for j=1:1:6

    //value_of_j_traverse_across_the_columns
25 if(X >=p(i,j))

    //check_if_the_value_in(n,p)
    _matrix_is_less_than_or_equal_to_X
26 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]
    <= X and print

    corresponding_value_of_X
27 end

    //end if
28 end

    //end for
29 end

    //end for
30
31

```

```

32 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_v
      .
33 8.645 10.173 11.620 13.015 14.372]
34
35 for i=1:1:3

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

      //value_of_j_traverse_across_the_columns in [(n,p
      )matrix].
37 if(X >=m(i,j))

      //check_if_the_value_in(n,p)
      _matrix_is_less_than_or_equal_to_X
38 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]
      <= X and_print

      corresponding_value_of_X.
39 end

      //end if
40 end

      //end for
41 end

      //end for

```

Scilab code Exa 4.5.1 Directional Coupler

```

1 //CAPTION: Directional_Coupler
2
3 //Chapter -4
4 //EXAMPLE: 4-5-1 PAGE NO. 170
5
6 //(a)
   program_to_find_the_amount_of_the_power_delivered_in_the_load_Zl
7
8 PT4=8;

   //Given.
   Transmitted_power_to_Bolometer_1_at_port_4
9 s=2;

   //Given.VSWR_of_2.0_is_introduced_on_arm_4
   _by_Bolometer_1
10 r4=(s-1)/(s+1);
   //
   reflection_coefficient_at_port_4(r4)
11 PR4=8/8;
   //
   (r4^2)=PR4/PI4=PR4/(PR4+PT4)=PR4/PR4+8=1/9 => 8
   PR4=8
12 PI4=PT4 + PR4;
   //PI4=
   power_incident_at_port_4 ;PT4=
   power_transmitted_at_port_4;PR4=
   power_reflected_at_port_4
13 disp(PI4, 'power_incident_at_the_port_4_is_(mW)=');
14 disp(PR4, 'power_reflected_from_the_port_4_is_(mW) =',
   );

```

```

15
16 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='');
17
18 PI2=100*PI4;

    //attenuation=20=10*log(PI1/PI4)
19 disp(PI2, 'power_input_at_port_2_is_given_by_(mW)='');
20
21 PR2=100*PR4;

    //attenuation=20=10*log(PR2/PR4)
22 disp(PR2, '
    power_reflected_from_the_load_at_port_2_is_given_by_
    (mW)='');
23
24 PT2=PI2-PR2;

    //transmitted power = incident power - reflected
    power
25 disp(PT2, '
    power_dissipated_in_the_load_at_port_2_is_given_by_
    (mW) =');
26
27
28
29
30 //(b) Program_to_find_the_VSWR_on arm 2
31
32 r=sqrt(PR2/PI2);

    //reflection_coefficient_at_port 2
33 s=(1+r)/(1-r);

    //VSWR ON ARM 2

```

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

Scilab code Exa 4.5.2 Operation Of a Balanced Amplifier

```
1 //CAPTION: Operation_Of_a_Balanced_Amplifier
2
3 //chapter -4
4 //Example4-5-2 page no. 174
5
6 //(a) Program_to_find_out_the_input_and_output_VSWRs.
7
8 s11=0;

    //for_balanced_amplifier s11=0
9 s=(1+s11)/(1-s11);

    Input_VSWR
10 disp(s, 'input vswr=');
11
12 s22=0;

    //for_balanced_amplifier s22=0
13 s=(1+s22)/(1-s22);

    output_VSWR
14 disp(s, 'output vswr=');
15
16
17
18 //(b) Program_to_find_out_the_output_power_in_watts
19
20 PO=200*10*2;

    //output_power(PO)=[powerinput]*[
    power_gain_of_each_GaAs_chip]*[n] , here n=2
```

```

21 disp(P0/1000, 'Output_POWER_in_Watts');
    //
    display_power_in_watts_by_dividing_by_1000
22
23
24
25 //(C)Program to find out the linear output power
    gain in db
26
27 GAIN=10*log10(2);
    //
    BECAUSE_TWO_CHIPS_ARE_IN_PARALLEL. Gain=(power
    gain of each GaAs chip)*log(n),n=2.
28 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

```
1 //CAPTION: Equivalent_Elements_of_a_Hybrid-Pi-Common
   -Emitter_Circuit
2 //CHAPTER NO.-5
3 //Example No.5-1-1 , Page No.-195
4
5 //(a) Program_to_find_the_mutual_inductance_gm.
6
7
8 ic=6*(10^-3); // Collector_Current
9 vt=26*(10^-3); //vt=26
   mV_at_300k_is_the_voltage_equivalent_of_temperature
10 gm=ic/vt; //the_mutual_inductance_is gm=(ic/vt)
11 disp(gm, 'the_mutual_inductance_is gm(in mho)=');
12
13 //(b)
   Program_to_find_the_input_inductance_gb_and_resistance_R
14
```

```

15 hfe=120; //hfe= common-emitter-current-gain-factor
16 gb=gm/hfe; //input inductance
17 R=1/gb; //Resistance
18
19 disp(gb, 'input inductance gb(in mho)=');
20 disp(R, 'input resistance R (in ohms)=');
21
22 //(c)
    Program-to-find-the-electron-diffusion-coefficient-Dn

23
24 un=1600; //electron_Mobility
25 Dn=un*vt; // Dn=un*kt/q=un*26*(10^-3);
26
27 disp(Dn, 'electron diffusion coefficient Dn (in cm2/s)
    =');
28
29 //(d) Program-to-find-the-diffusion-capacitance-Cbe
30 Wb=(10^-8); //cross-sectional_area
31 Cbe=(gm*(Wb^2))/(2*Dn*(10^-7));
32 Cbe=Cbe/(10^-12);
33 disp(Cbe, 'diffusion capacitance Cbe (in pF)=');

```

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

```

1 //CAPTION:I-V_Characteristics_of_an_n-p-n_Transistor
2 //CHAPTER NO.-5
3 //Example No.5-1-2 , Page No.-203
4
5 //(a)
    Program-to-find-the-impurity-desities-in-the-emitter
    ,base-and-collector-regions
6
7 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]');
8 NdE=1*(10^19);
9 NaB=1.5*(10^17);
10 NdC=3*(10^14);
11
12 //(b)Program_to_find_the_mobilities_in_the_emitter ,
    base and collector_regions
13 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]');
14 upE=80;
15 unE=105;
16 upB=400;
17 unC=1600;
18
19 //(c)
    Program_to_find_the_diffusion_lengths_in_the_emitter
    ,base and collector_regions
20 disp('the_diffusion_constants_are_computed_to_be');
21 Vt=26*(10^-3);
22
23 DpE=upE*Vt;
24 DnE=unE*Vt;
25 DpB=upB*Vt;
26 DnC=unC*Vt;
27 disp(DpE , 'DpE=');
28 disp(DnE , 'DnE=');
29 disp(DpB , 'DpB=');
30 disp(DnC , 'DnC=');
31
32 //(d)Program_to_compute_the_equilibrium_densities_in
    the emitter ,base and collector_regions
33

```

```

34 disp('the_equilibrium_densities_are ');
35 ni=1.5*(10^10);
36
37 pEo=(ni^2)/NdE;
38 npB=(ni^2)/NaB;
39 pCo=(ni^2)/NdC;
40 disp(npB, 'npB=');
41 disp(pEo, 'pEo=');
42 disp(pCo, 'pCo=');
43
44 //(e) Program_to_compute_the_terminal_currents
45
46 disp('the_terminal_currents_are_computed_as_follows.
      From Eq 5-1-39,
      the_electron_current_in_the_emitter_is ');
47 A=2*(10^-2); // cross-section_area
48 q=1.6*(10^-19);
49 W=(10^-5); // base_width
50 Le=(10^-4); // Diffusion_length_in_emitter
51 Ve=.5; // Emitter_junction_voltage
52 InE=-(A*q*DnE*(ni^2)*exp(Ve/Vt))/(NaB*W); // InE=-(Aq*
      Dp*(ni^2)*(exp(Ve/Vt)-1))/(Le*Nd);
53 InE=InE/(10^-3);
54 disp(InE, 'the_electron_current_in_the_emitter_is (in
      mA) ');
55
56 disp('From Eq5-1-42,
      _the_hole_current_in_the_emitter_is ');
57 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)
58 IpE=IpE/(10^-6);
59 disp(IpE, 'the_electron_current_in_the_emitter_is (in
      uA) ');
60
61
62
63 disp('From Eq-5-1-24,

```

```

        the_reverse_saturation_current_in_the_collector_is
        ');
64 ICo=-(A*q*DnE*(ni^2)/(NaB*W))-(A*q*DpE*pEo)/Le;
65 ICo=ICo/(10^-12);
66 disp(ICo, 'the_electron_current_in_the_emitter_is (in
        pA) ');
67
68
69 disp('From Eq-5-1-40,
        _the_electron_current_which_reaches_the_collector
        is ');
70 InC=-(A*q*DnE*(ni^2)*exp(Ve/Vt)/(NaB*W));
71 InC=InC/(10^-3);
72 disp(InC, '
        the_electron_current_which_reaches_the_collector_is
        (in mA) ');
73
74 IE=(-IpE*(10^-6))+(InE*(10^-3));
75 IE=IE/(10^-3);
76 disp(IE, 'the_emitter_current_is (in mA) ');
77
78 IC=(-ICo*(10^-12))-(InC*(10^-3));
79 IC=IC/(10^-3);
80 disp(IC, 'the_collector_current_is (in mA) ');
81
82 IB=(IpE*(10^-6))-[((InE*(10^-3)))-(InC*(10^-3))]+(
        ICo*(10^-12));
83 IB=IB/(10^-6);
84 disp(IB, 'the_current_in_the_base_terminal_is (in uA)
        ');
85
86 disp('NOTE: The_recombination-
        generation_currents_in_the_spcae-
        charge_regions_are_not_counted ');

```

Scilab code Exa 5.1.3 Silicon Bipolar Transistor

```
1 //CAPTION: Silicon_Bipolar_Transistor
2 //CHAPTER NO.-5
3 //Example No.5-1-3 , Page No.-206
4
5 //(a) Program_to_find_the_mobilities_un_and_up
6
7 disp('the mobilities(in cm2/v.s )are read from Fig-
      A-2 in Appendix A as un=200 for NdE=5*(1018) cm
      -3 and up=500 for Na=5*(1016) cm-3');
8 un=200;
9 up=500;
10
11 //(b)
      Program_to_find_the_diffusion_coefficients_Dn_and_Dp
12 Vt=26*(10-3); //Vt=kt/q
13 Dn=un*Vt;
14 Dp=up*Vt;
15
16 disp(Dn, 'diffusion_coefficient_are_Dn (in cm2/s)=')
      ;
17 disp(Dp, 'and_Dp (in cm2/s)=');
18
19 //(c)
      Program_to_find_the_emitter_efficiency_factor_y
20 W=(10-3); //Base_width
21 Le=(10-2); //Emitter_Length
22 Na=5*(1016); // Acceptor_density_in_base_region
23 Nd=5*(1018); // Donor_density_in_emitter_region
24 y=1/(1+((Dp*Na*W)/(Dn*Nd*Le)));
25
26 disp(y, 'emitter_efficiency_factor_y=');
27
28
29 //(d) Program_to_find_the_transport_factor_B
30
```

```

31 t=10^-6; // hole_lifetime
32 B=1-(W^2)/(2*Dn*t); // transport_factor
33
34 disp(B, 'the transport factor B=');
35
36
37 //(e) Program_to_find_the_current_gain_a
38
39 a=B*y;
40
41 disp(a, 'the current_gain a=');

```

Scilab code Exa 5.1.4 Power Frequency Limitation

```

1 //CAPTION: Power-Frequency Limitation
2 //CHAPTER NO.-5
3 //Example No.5-1-4 , Page No.-211
4
5 //
   Program_to_determine_the_maximum_allowable_power_that_the_transis
6
7 Xc=1; //Reactance
8 ft=4*(10^9); //Transit_cut-off_frequency
9 Em=1.6*(10^5); //maximum_electric_field
10 Vx=4*(10^5); //saturation_drift_velocity
11
12 Pm=(((Em*Vx)/(2*pi))^2)/(Xc*(ft^2));
13 disp(Pm, 'the_maximum _allowable_power (in W)
   _that_the_transistor_can_carry_is ');

```

Scilab code Exa 5.2.1 Heterojunction Bipolar Transistor

```

1 //CAPTION: Heterojunction_Bipolar_Transistor (HBT)
2 //CHAPTER NO.-5
3 //Example No.5-2-1 , Page No.-213
4
5 //(a)
   Program_to_determine_the_lattice_match_present_in_percent

6   disp('the_lattice_match_present_is_within 1%');
7
8   //(b) Program_to_find_the_conduction-
   band_differential_between_Ge_and_GeAs
9   X1=4; //electron_affinity
10  X2=4.07; //electron_affinity
11  AE=X1-X2;
12  disp(AE, 'the_conduction-band differential_is (in eV)
   =');
13
14  //(c) Program_to_find_the_valence-
   band_differential_between_Ge_and_GeA
15  Eg2=1.43; //energy_gap
16  Eg1=.8; //energy_gap
17  Ev=Eg2-Eg1-AE
18  disp(Ev, 'the_valence-band differential_is (in eV) =')
   ;

```

Scilab code Exa 5.2.2 n Ge p GaAs n GaAs HBT

```

1 //CAPTION: n-Ge-p-GaAs-n-GaAs HBT
2 //CHAPTER NO.-5
3 //Example No.5-2-2 , Page No.-215
4
5 //(a) Program_to_compute_the_built-in_voltage_in_the
   p-GaAs_side
6  Na=6*(10^16); //Acceptor_density_in_p-GaAs_side
7  w02=-26*(10^-3)*log(Na/(1.8*(10^6)));

```

```

8 disp(w02, 'the_built-in_voltage (in V) in the p-
   GaAs_side ');
9
10 //(b) Program_to_compute_the_hole_mobility
11
12 disp('The hole mobility is read from Fig -A-2 in
   Appendix A as  $\mu_p=400(\text{cm}^2/\text{v.s})$  ');
13  $\mu_p=400$ ;
14
15 //(c)
   Program_to_compute_the_hole_diffusion_constant
16  $D_p=\mu_p*26*(10^{-3})$ ;
17
18 disp( $D_p$ , 'The_hole_diffusion_constant_is  $D_p(\text{cm}^2/\text{s})=$ '
   ');
19
20
21 //(d) Program_to_compute_the_miniority_hole_density
   in_n-Ge
22
23  $n_i=1.5*(10^{10})$ ;
24  $N_d=5*(10^{18})$ ; // Donor_density_in_n-Ge_region
25  $p_{no}=(n_i^2)/N_d$ ;
26 disp( $p_{no}$ , 'the_miniority_hole_density (cm-3)in_n-
   Ge_is =');
27
28 //(e)
   Program_to_compute_the_miniority_electron_density_in_p
   -GaAs_region
29  $N_a=6*(10^{16})$ ;
30  $n_{po}=((1.8*10^6)^2)/N_a$ ;
31 disp( $n_{po}$ , 'the_miniority_electron_density (in cm-3)
   in_p-GaAs_region_is =');
32
33
34 //(e)
   Program_to_compute_the_hole_diffusion_length
35  $\tau_p=6*(10^{-6})$ ; // hole_lifetime

```

```
36     Lp=sqrt(tp*Dp);
37     disp(Lp, 'the_hole_diffusion_length(in cm) is =');
38
39     //(e) Program_to_compute_the_emitter-
         junction_current
40
41     A=2*(10^-2); // cross_section
42     VE=1; // bias_voltage_at_emitter_junction
43     q=1.6*(10^-19);
44     l=VE/(26*(10^-3));
45     I=(A*q*Dp*pno*(exp(l)-1))/(Lp);
46     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

```
1 //CAPTION: Pinch-Off_Voltage_Of_a_Silicon_JFET
2 //chapter_no.-6, page_no.-229
3 //Example_no.6-1-1
4
5 clc;
6 a=.1*(10^-6); //channel_height
7 Nd=8*(10^23); //Electron_Concentration
8 er=11.80; //relative_dielectrin_constant
9 e=8.854*(10^-12)*er; //medium_dielecric_constant
10 q=1.6*(10^-19); //electronic_charge
11 Vp=(q*Nd*(a^2))/(2*e); //pinch-off_voltage
12
13 disp(Vp, 'pinch-off volatge in (Volts) is ');
```

Scilab code Exa 6.1.2 current of a JFET

```

1 //CAPTION: Current_of_a_JFET
2 //chapter_no.-6, page_no.-233
3 //Example_no.6-1-2
4
5 clc;
6
7 //(a) Calculate_the_pinch-off_Voltage_in_Volts
8 a=.2*(10^-4); //channel_height
9 Nd=1*(10^17); //Electron_Concentration
10 er=11.80; //relative_dielectrin_constant
11 e=8.854*(10^-14)*er; //medium_dielecric_constant
12 q=1.6*(10^-19); //electronic_charge
13 Vp=(q*Nd*(a^2))/(2*e); //pinch-off_voltage
14
15 disp(Vp, 'pinch-off volatge in(Volts) is ');
16
17
18 //(b) Calculate_the_pinch-off_current
19
20 un=800; //electron_mobility
21 L=8*(10^-4); //channel_length
22 Z=50*(10^-4); //channel_width
23 a=.2*(10^-4); //channel_height
24 Nd=1*(10^17); //Electron_Concentration
25 er=11.80; //relative_dielectrin_constant
26 e=8.854*(10^-14)*er; //medium_dielecric_constant
27 q=1.6*(10^-19); //electronic_charge
28 Ip=(un*(q^2)*(Nd^2)*Z*(a^3))/(L*e); //pinch-
    off_voltage
29 Ip=Ip*1000;
30 disp(Ip, 'pinch-off current in(mA) is ');
31
32
33 //(c) Calculate_the_built-in_voltage
34
35 Nd=1*(10^17); //Electron_Concentration
36 Na=1*(10^19); //hole_density
37 w0=26*(10^-3)*log((Nd*Na)/((1.5*10^10)^2));

```

```

38 disp(w0, 'built-in voltage in (volts) is ');
39
40
41
42 //(d) Calculate_the_drain_current
43
44 Vd=10; //drain_voltage
45 Vg=-1.5; //gate_voltage
46 Vg=-1*Vg; //we_take_only_magnitude
47 x=((Vd+Vg+w0)/(Vp))^(3/2);
48 x=(2/3)*x;
49 y=((Vg+w0)/(Vp))^(3/2);
50 y=(2/3)*y;
51 Id=(Vd/Vp)-x+y;
52 Id=Ip*Id;
53 disp(Id, 'the_drain_current (mA) is ');
54
55
56
57 //(e) Calculate_the_saturation_drain_current_at Vg=0
58
59 Vg=-1.5; //gate_voltage
60 Vg=-1*Vg; //we_take_only_magnitude
61 x=(Vg+w0)/(Vp);
62 y=((Vg+w0)/(Vp))^(3/2);
63 y=(2/3)*y;
64 Idsat=(1/3)-x+y;
65 Idsat=(Id)*Idsat;
66 disp(Idsat, 'the_saturation_drain_current_(mA) is ');
67
68
69 //(f) Calculate_the_cut-off_frequency
70
71 fc=(2*un*q*Nd*(a^2))/(%pi*e*(L^2));
72 disp(fc/(10^9), 'the_cut-off_frequency (Ghz) ');

```

Scilab code Exa 6.2.1 Pinch Off Voltage Of a MESFET

```
1 //CAPTION: Pinch-Off_Voltage_Of_a_MESFET
2 //chapter_no.-6, page_no.-239
3 //Example_no.6-2-1
4
5 clc;
6
7 a=.1*(10^-6); //channel_height
8 Nd=8*(10^23); //Electron_Concentration
9 er=13.10; //relative_dielectric_constant
10 e=8.854*(10^-12)*er; //medium_dielectric_constant
11 q=1.6*(10^-19); //electronic_charge
12 Vp=(q*Nd*(a^2))/(2*e); //pinch-off_voltage
13
14 disp(Vp, 'pinch-off volatge in (Volts) is ');
```

Scilab code Exa 6.2.2 Current Voltage Characteristics Of a GaAs MES-FET

```
1 //CAPTION: Current-
   Voltage_Characteristics_Of_a_GaAs_MESFET
2 //chapter_no.-6, page_no.-244
3 //Example_no.6-2-2
4
5 clc;
6
7
8 //(a) Calculate_the_pinch-off_voltage
9
10 a=.1*(10^-6); //channel_height
11 Nd=8*(10^23); //Electron_Concentration
```

```

12 er=13.1; //relative_dielectrin_constant
13 e=8.854*(10^-12)*er; //medium_dielecric_constant
14 q=1.6*(10^-19); //electronic_charge
15 Vp=(q*Nd*(a^2))/(2*e); //pinch-off_voltage
16
17 disp(Vp, 'pinch-off volatge in (Volts) is ');
18
19
20
21 //(b) Calculate_the_velocity_ratio
22
23 un=.08; //electron_mobility
24 vs=2*(10^5);
25 L=14*(10^-6);
26 n=(Vp*un)/(vs*L)
27 disp(n, 'the velocity ratio ');
28
29
30 //(c) Calculate_the_saturation_drain_current_at Vg=0
31
32 L=14*(10^-6);
33 Z=36*(10^-6);
34 Ipsat=(q*Nd*un*a*Z*Vp)/(3*L);
35 Ipsat=Ipsat*1000;
36 disp(Ipsat, 'the_saturation_drain_current_ (mA) is ');
37
38
39
40 //(d) Calculate_the_drain_current
41
42 Vd=5;
43 Vg=2;
44 u=((Vd+Vg)/Vp)^(1/2);
45 p=((Vg)/Vp)^(1/2);
46 Id=(3*((u^2)-(p^2))-2*((u^3)-(p^3)))/(1+(n*((u^2)-(p
    ^2)))));
47
48 Id=Id*Ipsat;

```

```
49 disp(Id, 'the_drain_current_(mA) is ');
```

Scilab code Exa 6.2.3 CutOff frequency of a MESFET

```
1 //CAPTION: CutOff_frequency_of_a_MESFET
2
3 //chapter_no.-6, page_no.-247
4 //Example_no.6-2-3
5
6 clc;
7
8 //(a) Calculate_the_cut-off_frequency
9
10 gm=.05;
11 Cgs=.60*(10^-12);
12
13 fco=(gm)/(2*%pi*Cgs);
14 fco=fco/(10^9);
15
16 disp(fco, 'the_cut-off_frequency (in Ghz) is ');
17
18 //(b) Calculate_the_maximum_operating_frequency
19
20
21 Rd=450;
22 Rs=2.5;
23 Rg=3;
24 Ri=2.5;
25
26 fmax=(fco/2)*((Rd/(Rs+Rg+Ri))^(1/2));
27
28 disp(fmax, 'the_maximum_operating_frequency (in Ghz) is
    ');
```

Scilab code Exa 6.3.1 Current of a HEMT

```
1 //CAPTION: Current_of_a_HEMT
2 //chapter_no.-6, page_no.-251
3 //Example_no.6-3-1
4 clc;
5
6 // Calculate_the_Drain_Current
7
8 q=1.60*(10^-19);
9 n=5.21*(10^15);
10 W=150*(10^-6);
11 v=2*(10^5);
12
13 Ids=q*n*W*v;
14 Ids=1000*Ids;
15 disp(Ids, 'the_drain_current_is (mA)');
```

Scilab code Exa 6.3.2 Sensitivity Of HEMT

```
1 //CAPTION: Sensitivity_Of_HEMT
2 //chapter_no.-6, page_no.-253
3 //Example_no.6-3-2
4
5 clc;
6
7
8
9 //(a) Calculate_the_conduction_band -
    edge_difference_between_GaAs_and_AlGaAs
10
11 Ega=1.8;
```

```

12 Egg=1.43;
13 AEc=Ega-Egg;
14 disp(AEc, 'the_conduction_band-edge_difference_is=');
15
16 //(b) Calculate_the_sensitivity_of_the_HEMT
17
18 q=1.6*(10^-19);
19 Nd=2*(10^24);
20 wms=.8;
21 Vth=.13;
22 er=4.43;
23 e=er*(8.854*(10^-12));
24 S=-[(2*q*Nd*(wms-AEc-Vth))/(e)]^(1/2);//
    sensitivity_of_the_HEMT
25 S=S/(10^6);
26 disp(S, 'the_sensitivity_of_the_HEMT_(mV/nm)_is=')
27 disp(-1*S, 'd/dv(Vth)(mV/nm)_is=');

```

Scilab code Exa 6.4.1 Threshold Voltage of an Ideal MOSFET

```

1 //CAPTION: Threshold_Voltage_of_an_Ideal_MOSFET
2
3 //chapter_no.-6, page_no.-260
4 //Example_no.6-4-1
5 clc;
6
7
8 //(a) Calculate_the_strong_potential_w(inv)
    _for_strong_inversion
9
10 kt=26*(10^-3);
11 Na=3*(10^17);
12 Ni=1.5*(10^10);
13 wsinv=2*kt*log(Na/Ni);
14 disp(wsinv, 'the_strong_potential_w(inv)

```



```

        _for_strong_inversion (volts) ');
15
16 // (b) Calculate_the_insulator_Capacitance
17
18 eir=4;
19 ei=8.854*(10^-12)*eir;
20 d=.01*(10^-6);
21 Ci=ei/d;
22 Ci=Ci*(1000);
23 disp(Ci, 'the_insulator_Capacitance (mF/m^2)=');
24
25 // (c) Calculate_the_threshold_voltage
26
27 q=1.6*(10^-19);
28 Na=3*(10^23);
29 er=11.8;
30 e=8.854*er*(10^-12);
31 Vth=wsinv+((2/(Ci*(10^-3)))*((e*q*Na*.437)^(1/2)))
32 disp(Vth, 'the_threshold_voltage is ( ) Volts=');

```

Scilab code Exa 6.4.2 Characteristics Of a MOSFET

```

1 //CAPTION: Characteristics_Of_a_MOSFET
2 //chapter_no.-6, page_no.-262
3 //Example_no.6-4-2
4 clc;
5
6
7 // (a) Calculate_the_insulation_capacitance
8
9 eir=3.9;
10 ei=8.854*(10^-12)*eir;
11 d=.05*(10^-6);
12 Ci=ei/d;
13 disp(Ci, 'the_insulation_capacitance (in F/m^2)');

```

```

14
15 //(b) Calculate_the_saturation_drain_current
16
17 Z=12*(10^-12);
18 Vg=5;
19 Vth=.10;
20 vs=1.70*(10^7);
21 Idsat=Z*Ci*(Vg-Vth)*vs;
22 Idsat=Idsat*10^7;
23 disp(Idsat, 'the_saturation_drain_current (in mA) ');
24
25 //(c)
    Calculate_the_transconductance_in_the_saturation
    region
26
27
28 Z=12*(10^-12);
29 vs=1.70*(10^7);
30 gmsat=Z*Ci*vs;
31 gmsat=gmsat*10^7;
32 disp(gmsat, 'the_transconductance_in_the_saturation
    region (in millimhos) ');
33
34
35
36 //(d)
    Calculate_the_maximum_operating_frequency_in_the_saturation_region
37
38 vs=1.70*(10^7);
39 L=4*(10^-6);
40 fm=vs/(2*%pi*L);
41 fm=fm/(10^2);
42 fm=fm/(10^9);
43 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

```
1 //CAPTION: Power_Dissipation_of_a_Three-Phase_CCD
2
3 //chapter_no.-6, page_no.-278
4 //Example_no.6-6-1
5 clc;
6
7
8 // Calculate_the_power_dissipation_per_bit
9 n=3;
10 f=10*(10^6);
11 V=10;
12 Qmax=.04*(10^-12);
13 P=n*f*V*Qmax;
14 P=P*(10^6);
15 disp(P, 'the_power_dissipation_per_bit (uW) is=');
```

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

```
1 //CAPTION: Design_of_an_N-Type_Three-Phase_Surface-
   Channel_CCD
2 //chapter_no.-6, page_no.-279
3 //Example_no.6-6-2
4
5 clc;
6
7
8 //(a) Calculate_the_insulator_capacitance
9
10 eir=3.9;
```

```

11 ei=8.854*(10^-12)*e0;
12 d=.15*(10^-6);
13 Ci=ei/d;
14 Ci=Ci*(10^5);
15 disp(Ci, 'the_insulation_capacitance (in nF/cm^2) ');
16
17 //(b) Calculate_the_maximum_stored_charges_per_well
18
19 Nmax=2*(10^12);
20 q=1.6*(10^-19);
21 A=.5*(10^-4);
22 Qmax=Nmax*A*q;
23 Qmax=Qmax*(10^12);
24 disp(Qmax, 'the_maximum_stored_charges_per_well(
    picocoulombs) ');
25
26 //(c) Calculate_the_required_applied_gate_voltage
27
28 Nmax=2*(10^12);
29 q=1.6*(10^-19);
30 Vg=(Nmax*q)/(Ci*10^-9);
31 disp(Vg, 'the_required_applied_gate_voltage (in_Volts)
    ');
32
33
34
35 //(d) Calculate_the_clock_frequency
36
37 P=.67*(10^-3);
38 n=3;
39 f=P/(n*Vg*Qmax*(10^-12));
40 f=f/(10^6);
41 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

```
1 //CAPTION: Conductivity_of_an_n-Type_GaAs_Gunn_Diode
2 //chapter_no.-7, page_no.-294
3 //Example_no.7-2-1
4 clc;
5
6
7 // Calculate_the_conductivity_of_the_diode
8 e=1.6*(10^-19);
9 nl=(10^10)*(10^6); //electron_density_at_lower_valley
10 nu=(10^8)*(10^6); //electron_density_at_upper_valley
11 ul=8000*(10^-4); //electron_mobility_at_lower_valley
12 uu=180*(10^-4); //electron_mobility_at_upper_valley
13 o=e*((nl*ul)+(nu*uu));
14 o=o*1000;
15 disp(o, 'the_conductivity_of_the_diode(in mmhos) is ='  
    );
```

Scilab code Exa 7.2.2 Characteristics of a GaAs Gunn Diode

```

1 //CAPTION: Charactristics_of_a_GaAs_Gunn_Diode
2 //chapter_no.-7, page_no.-298
3 //Example_no.7-2-2
4 clc;
5
6 //(a) Calculate_the_electron_drift_velocity
7 q=1.6*(10^-19);
8 f=10*(10^9); //operating_frequency
9 L=10*(10^-6); //Device_Length
10 vd=f*L;
11 disp(vd, 'the_electron_drift_velocity (in m/sec) is =')
12     ;
13 vd=vd*100;
14 disp(vd, 'the_electron_drift_velocity (in cm/sec) is =')
15     );
16 vd=vd/100;
17
18 //(b) Calculate_the_current_density
19
20 n=2*(10^14)*(10^6);
21 J=q*n*vd;
22 disp(J, 'the_electron_drift (n A/m^2) is =');
23 J=J/(10^4);
24 disp(J, 'the_electron_drift (n A/cm^2) is =');
25
26
27 //(c)CAPTION:
28     Calculate_the_negative_electron_mobility
29
30 E=3200; // applied_field
31 vd=vd*(100);
32 un=-1*(vd/E);
33 disp(un, 'negative_electron_mobility (in cm^2/V*sec) is
34     =');

```

Scilab code Exa 7.3.1 Criterion of Mode Operation

```
1 //CAPTION: Criterion_of_Mode_Operation
2 //chapter_no.-7, page_no.-304
3 //Example_no.7-3-1
4
5 clc;
6
7 //
   Calculate_the_criterion_for_classifying_the_modes_of_operation

8 er=13.1;
9 e=1.6*(10^-19);
10 E=8.854*(10^-12)*er; // dielectric_constant
11 vd=2.5*(10^5); // electron_drift_velocity
12 un=.015; // negative_electron_mobility
13
14 disp('the_criterion_from_Eq -7-3-3
   is_for_classifying_the_modes_of_operation_for_the_gunn_effect_di
   noL > E*v/e*un');
15
16 x=(E*vd)/(e*un);
17 x=x/(10^4);
18 disp(x, 'the_criterion_is E*vd/e*un (in /cm^2)=');
19
20 disp(x, '
   This_means_that_the_product_of_the_doping_concentration_and_the_d
   no*L > ');
```

Scilab code Exa 7.4.1 Output power of an LSA Oscillator

```
1 //CAPTION: Output_power_of_an_LSA_Oscillator
2 //chapter_no.-7, page_no.-311
3 //Example_no.7-4-1
4
```

```
5 clc;  
6  
7 // Calculate_the_output_power  
8 n=.06; // conversion_efficiency  
9 M=3.5; // Multiplication_factor  
10 Eth=320*(10^3); // threshold_field  
11 L=12*(10^-6); // Device_Length  
12 n0=10^21; // Donor_concentration  
13 e=1.6*(10^-19);  
14 v0=1.5*(10^5); // Average_carrier_velocity  
15 A=3*(10^-8); // Area  
16 P=n*(M*Eth*L)*(n0*e*v0*A);  
17 P=P*1000;  
18 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

```
1 //CAPTION: CW_Output_Power_Of_an_IMPATT_Diode
2 //chapter_no.-8, page_no.-331
3 //Example_no.8-2-1
4
5 clc;
6
7 //(a) Calculate_the_maximum_CW_power
8
9 n=.15; //efficiency
10 Vomax=100; //maximum_operating_voltage
11 Iomax=200*(10^-3); //maximum_operating_current
12 Pdc=Vomax*Iomax;
13 P=n*Pdc;
14 disp(P, 'the_maximum_CW_power(in Watts) is =');
15
16 //(b) Calculate_the_resonant_frequency
17
18 L=6*(10^-6); //drift-region_Length
19 vd=2*(10^5); //carrier_drift_velocity
20 f=vd/(2*L);
21 f=f/(10^9);
```

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

Scilab code Exa 8.3.1 Calculate the avalanche zone velocity

```
1 //CAPTION: Calculate_the_avalanche-zone_velocity
2 //chapter_no.-8, page_no.-334
3 //Example_no.8-3-1
4
5 clc;
6 J=20*(10^3); //current_density
7 q=1.6*(10^-19);
8 NA=2*(10^15); //Doping_Concentration
9 vs=J/(q*NA);
10 disp(vs, 'avalanche-zone_velocity (in cm/s) is =');
11
12 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

```
1 //CAPTION: Breakdown_voltage_Of_a_BARITT_Diode
2 //chapter_no.-8, page_no.-338
3 //Example_no.8-4-1
4
5 clc;
6
7 //(a) Calculate_the_break-down_voltage
8 q=1.6*(10^-19);
9 N=2.8*(10^21); //Donor_Concentration
10 L=6*(10^-6); //silicon_length
11 er=11.8; //Relative_dielectric_constant
12 es=8.854*(10^-12)*er;
```

```

13 Vbd=(q*N*(L^2))/es;
14 disp(Vbd, '
    the_break_down_voltage_is_double_its_critical_voltage_as
    (in Volts)is =');
15
16 //(b) Calculate_the_break_down_electric_field
17
18
19 Ebd=Vbd/L;
20 disp(Ebd, 'the_break_down_electric_field (in V/m) is ='
    );
21 Ebd=Ebd/100;
22 disp(Ebd, 'the_break_down_electric_field (in V/cm) is ='
    ');

```

Scilab code Exa 8.5.1 UP Converter parametric Amplifier

```

1 // CAPTION: UP-Converter_parametric_Amplifier
2 //chapter_no.-8, page_no.-346
3 //Example_no.8-5-1
4 clc;
5
6 //(a) Calculate_the_power_gain
7 R=25; //R=f0/fs ,
    ratio_of_output_frequency_over_signal_frequency
8 rQ=10; // figure_of_merit
9 x=((rQ)^2)/R;
10 PG=(R*x)/((1+sqrt(1+x))^2);
11 PG=10*log10(PG); // calculating_in_dB
12 disp(PG, 'Up-converter_power_gain_(in dB) is =');
13
14 //(b) Calculate_the_noise_figure
15
16 Td=350; // Diode_temperature
17 To=300; // ambient_Temperature

```

```
18 F=1+(((2*Td)/To)*((1/rQ)+(1/rQ^2)));
19 F=10*log10(F); // calculating_in_dB
20 disp(F, 'the_noise_figure(in dB) is =');
21
22
23 //(c) Calculate_the_band_width
24
25 r=.4 // factor_of_merit_figure
26 BW=2*r*sqrt(R); //R=fo/fs
27 disp(BW, 'the_band_width_is =');
```

Chapter 9

microwave linear beam tubes O type

Scilab code Exa 9.2.1 Klystron Amplifier

```
1 // CAPTION: Klystron_Amplifier
2 //chapter_no.-9, page_no.-377
3 //Example_no.9-2-1
4
5 clc;
6
7 //(a)
   Calculate_the_input_voltage_to_give_maximum_voltage_V2
8
9 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
   ');
10 X=1.841;
11 J1(X)=.582;
12 V0=10^3;
13 v0=.593*(10^6)*sqrt(V0);
14 disp(v0, '');
```

```

15 f=(3*(10^9));
16 d=1*(10^-3); // Gap_spacing_in_either_cavity
17 w=(2*%pi*f);
18 Og=(w*d)/v0;
19 disp(Og, 'The_gap_transit_angle_(in_radian)is =');
20 disp('The_beam-coupling_coefficient_is ');
21 Bi=sin(Og/2)/(Og/2);
22 Bo=Bi;
23 disp(Bi, '');
24 disp('The_dc_transit_angle_(in_radian)
    _between_the_cavities_is =');
25 L=4*(10^-2); // Spacing_between_the_two_cavities
26 O0=(w*L)/v0;
27 disp(O0, '');
28 disp('The_maximum_input_voltage_V1_(in_Volts)
    _is_then_given_by =');
29 V1max=(2*V0*X)/(Bi*O0);
30 disp(V1max, '');
31
32
33
34
35 // (b) Calculate_the_voltage_gain
36
37 R0=40*(10^3);
38 Rsh=30*(10^3); //
    Effective_shunt_impedance_excluding_beam_loading
39
40 Av=((Bo^2)*O0*J1(X)*Rsh)/(R0*X);
41 disp(Av, 'The_voltage_gain_is_found ,
    neglecting_the_beam_loading_in_the_output_cavity
    =');
42
43
44
45
46 // (c) Calculate_the_efficiency_of_the_amplifier
47

```

```

48 I0=25*(10^-3);
49 I2=2*I0*J1(X);
50 V2=Bo*I2*Rsh;
51 efficiency=(Bo*I2*V2)/(2*I0*V0);
52 efficiency=100*efficiency;
53 disp(efficiency, 'the_efficiency_of_the_amplifier,
      neglecting_beam_loading =');
54
55
56 //(d) Calculate_the_beam_loading_conductance
57
58 G0=25*(10^-6);
59 Og=(Og*180)/%pi;
60 GB=(G0/2)*((Bo^2)-(Bo*cos((28.6*%pi)/180)));
61 disp(GB, 'the_beam_loading_conductance_GB (mho) is =')
      ;
62
63 RB=1/GB;
64 disp(RB, 'then_the_beam_loading_resistance_RB (rho) is
      =');
65 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

```

1 //CAPTION: Four-Cavity_Klystron
2 //chapter_no.-9, page_no.-385
3 //Example_no.9-3-1
4
5 clc;
6
7 //(a) Calculate_the_dc_electron_velocity

```

```

8 V0=14.5*(10^3);
9 v0=.593*(10^6)*sqrt(V0);
10 disp(v0,'the_dc_electron_velocity(in m/s) is =');
11
12
13 //(b) Calculate_the_dc_phase_constant
14
15 f=(10*(10^9));
16 Be=(2*%pi*f)/v0;
17 disp(Be,'the_dc_phase_constant(in rads/m) is =');
18
19
20
21 //(c) Calculate_the_plasma_frequency
22
23 po=1*(10^-6); // dc_electron_charge_density
24 wp=((1.759*(10^11)*po)/(8.854*(10^-12)))^(1/2);
25 disp(wp,'the_plasma_frequency(in rad/s) is =');
26
27
28 //(d) Calculate_the_reduced_plasma_frequency_for_R
    =0.4
29
30 R=0.4;
31 wq=R*wp;
32 disp(wq,'the_reduced_plasma_frequency_for_R=0.4(in
    rad/s) is =');
33
34
35
36 //(e) Calculate_the_dc_beam_current_density
37
38 J0=po*v0;
39 disp(J0,'the_dc_beam_current_density(in A/m2) is =');
40
41
42
43 //(f)

```



```

    Calculate_the_instantaneous_beam_current_density
44
45
46 p=1*(10^-8);
47 v=1*(10^5); // velocity_perturbation
48 J=(p*v0)-(po*v);
49 disp(J, 'the_instantaneous_beam_current_density (in A/
    m2) is =');

```

Scilab code Exa 9.3.2 Operation of a FourCavity Klystron

```

1 //CAPTION: Operation_of_a_Four-Cavity_Klystron
2 //chapter_no.-9, page_no.-386
3 //Example_no.9-3-2
4
5 clc;
6
7 //(a) Calculate_the_dc_electron_velocity
8 V0=18*(10^3);
9 v0=.593*(10^6)*sqrt(V0);
10 disp(v0, 'the_dc_electron_velocity (in m/s) is =');
11
12
13 //(b) Calculate_the_dc_electron_phase_constant
14
15 f=(10*(10^9)); // Operating_frequency
16 w=2*%pi*f
17 Be=w/v0;
18 disp(Be, 'the_dc_electron_phase_constant (in rads/m) is
    =');
19
20
21
22 //(c) Calculate_the_plasma_frequency
23

```

```

24 po=1*(10^-8); // dc_electron_beam_current_density
25 wp=((1.759*(10^11)*po)/(8.854*(10^-12)))^(1/2);
26 disp(wp, 'the_plasma_frequency(in rad/s) is =');
27
28
29 //(d) Calculate_the_reduced_plasma_frequency_for_R
    =0.5
30
31 R=0.5;
32 wq=R*wp;
33 disp(wq, 'the_reduced_plasma_frequency_for_R=0.5(in
    rad/s) is =');
34
35
36
37 //(e) Calculate_the_reduced_plasma_phase_constant
38
39 Bq=wq/v0;
40 disp(Bq, 'the_reduced_plasma_phase_constant (in rad/m)
    is =');
41
42
43
44
45 //(f)
    Calculate_the_transit_time_across_the_input_gap
46
47 d=1*(10^-2); // gap_distance
48 t=d/v0;
49 t=t*(10^9);
50 disp(t, 'the_transit_time_across_the_input_gap (in ns)
    is =');
51
52
53
54
55 //(g)
    Calculate_the_electron_velocity_leaving_the_input_gap

```

```

56
57 V1=10;
58 Bi=1; // beam_coupling_coefficient
59 Vt1=v0*(1+(((Bi*V1)/(2*V0))*sin(w*t*(10^-9))));
60 disp(Vt1, '
    the_electron_velocity_leaving_the_input_gap(in m/
    s) is =');

```

Scilab code Exa 9.3.3 Characteristics of Two Cavity Klystron

```

1 // CAPTION: Characteristics_of_Two-Cavity_Klystron
2 // chapter_no.-9, page_no.-388
3 // Example_no.9-3-3
4 clc;
5
6 // (a) Calculate_the_plasma_frequency
7 po=1*(10^-6); // dc_electron_beam_current_density
8 wp=((1.759*(10^11)*po)/(8.854*(10^-12)))^(1/2);
9 disp(wp, 'the_plasma_frequency(in rad/s) is =');
10
11
12 // (b) Calculate_the_reduced_plasma_frequency_for_R
    =0.5
13
14 R=0.5;
15 f=(8*(10^9));
16 w=2*%pi*f;
17 wq=R*wp;
18 disp(wq, 'the_reduced_plasma_frequency_for_R=0.5(in
    rad/s) is =');
19
20 // (c)
    Calculate_the_induced_current_in_the_output_cavity

```

```

21
22 V0=20*(10^3);
23 I0=2; //beam_current
24 V1=10; //Signal_voltage
25 Bo=1; // Beam_coupling_coefficient
26 I2=(I0*w*(Bo^2)*V1)/(2*V0*wq);
27 disp(I2, 'the_induced_current_in_the_output_cavity (in
    Ampere) is =');
28
29
30
31
32 //(d)
    Calculate_the_induced_voltage_in_the_output_cavity

33
34 Rsh1=30*(10^3); //
    total_shunt_resistance_including_load
35 V2=I2*Rsh1;
36 V2=V2/1000;
37 disp(V2, 'the_induced_voltage_in_the_output_cavity (in
    KV) is =');
38
39
40 //(e) Calculate_the_output_power_delivered_to
    the_load

41
42
43 Rsh=10*(10^3); //shunt_resistance_of_the_cavity
44 Rsh1=30*(10^3); //
    total_shunt_resistance_including_load
45 Pout=(I2^2)*Rsh1;
46 Pout=Pout/1000;
47 disp(Pout, 'the_output_power_delivered_to_the_load (in
    KW) is =');
48
49
50

```

```

51 //(f) Calculate_the_power_gain
52
53
54 powergain=(((I0*w)^2)*(Bo^4)*Rsh*Rshl)/(4*((V0*wq)
    ^2));
55 powergain=10*log10(powergain); //powergain_in_dB
56 disp(powergain, 'the_power_gain is =');
57
58
59 //(g) Calculate_the_electronic_efficiency
60
61
62 n=(Pout*1000)/(I0*V0);
63 n=n*100;
64 disp(n, 'the_electronic_efficiency (in %) is =');

```

Scilab code Exa 9.3.4 Output Power of Four Cavity Klystron

```

1 // CAPTION: Output_Power_of_Four-Cavity_Klystron
2 //chapter_no.-9, page_no.-390
3 //Example_no.9-3-4
4
5 clc;
6
7 //(a) Calculate_the_plasma_frequency
8 po=5*(10^-5); //dc_electron_beam_current_density
9 wp=((1.759*(10^11)*po)/(8.854*(10^-12)))^(1/2);
10 disp(wp, 'the_plasma_frequency (in rad/s) is =');
11
12
13 //(b) Calculate_the_reduced_plasma_frequency_for_R
    =0.6
14
15 R=0.6;
16 f=(4*(10^9));

```

```

17 w=2*%pi*f;
18 wq=R*wp;
19 disp(wq, 'the_reduced_plasma_frequency_for_R=0.6(in
    rad/s) is =');
20
21 //(c)
    Calculate_the_induced_current_in_the_output_cavity

22
23
24 Rsh=10*(10^3); //shunt_resistance_of the_cavity
25 Rshl=5*(10^3); //
    total_shunt_resistance_including_load
26 V0=10*(10^3);
27 I0=0.7; //beam_current
28 V1=2; //Signal_voltage
29 Bo=1; //Beam_coupling_coefficient
30 I4=((I0*w)^3)*(Bo^6)*V1*(Rsh^2)/(8*((V0*wq)^3));
31 disp(I4, 'the_induced_current_in_the_output_cavity(in
    Ampere) is =');
32
33
34
35
36 //(d)
    Calculate_the_induced_voltage_in_the_output_cavity

37
38
39
40 V4=I4*Rshl;
41 V4=V4/1000;
42 disp(V4, 'the_induced_voltage_in_the_output_cavity(in
    KV) is =');
43
44
45 //(e) Calculate_the_output_power_delivered_to
    the_load

```

```

46
47 Pout=(I4^2)*Rsh1;
48 Pout=Pout/1000;
49 disp(Pout, 'the_output_power_delivered_to_the_load(in
      KW) is =');

```

Scilab code Exa 9.4.1 Reflex Klystron

```

1 // CAPTION: Reflex_Klystron
2 //chapter_no.-9, page_no.-399
3 //Example_no.9-4-1
4
5 clc;
6
7 //(a) Calculate_the_value_of_the_repeller_voltage
8 V0=600;
9 n=2; //mode=2
10 fr=9*(10^9);
11 w=2*%pi*fr;
12 L=1*(10^-3);
13 em=1.759*(10^11); //em=e/m
14 x=((em)*((2*%pi*n)-(%pi/2))^2)/(8*(w^2)*(L^2)); //x
      =V0/(V0+Vr)^2
15 y=V0/x; //y=(V0+Vr)^2
16 z=sqrt(y); //z=V0+Vr
17 Vr=z-V0;
18 disp(Vr, 'the_value_of_the_repeller_voltage(volts) is
      =');
19
20
21
22
23
24 //(b)
      Calculate_the_direct_current_necessary_to_give_a_microwave_gap_vol

```

```

25
26 disp('Assume_that_Bo=1');
27 disp('V2 = I2*Rsh = 2*I0*J1(X)*Rsh ');
28 disp('the_direct_current_I0_is_I0 = V2/ 2*J1(X)*Rsh '
      ');
29 V2=200;
30 Rsh=15*(10^3);
31 X=1.841
32 J1(X)=.582;
33 I0 = V2/(2*J1(X)*Rsh);
34 I0=I0*1000;
35 disp(I0, '
      the_direct_current_necessary_to_give_a_microwave_gap_voltage_of_20
      (mA) is =');
36
37
38
39 //(c) Calculate_the_electronic_efficiency
40
41 disp('From Eq(9-4-11),Eq(9-4-12) and Eq(9-4-20),
      the_electronic_efficiency_is ');
42
43 efficiency=(2*X*J1(X))/((2*pi*n)-(pi/2));
44 efficiency=efficiency*100;
45 disp(efficiency, 'the_electronic_efficiency (in %) is =
      ');

```

Scilab code Exa 9.5.1 Operation of Travelling WAVE TUBE

```

1 // CAPTION: Operation_of_Travelling_WAVE_TUBE(TWT)
2 //chapter_no.-9, page_no.-416
3 //Example_no.9-5-1
4
5 clc;

```



```

6
7 // (a) Calculate_the_gain_parameter
8
9 I0=30*(10^-3); // Beam_current
10 V0=3*(10^3); // Beam_voltage
11 Z0=10; // characteristic_impedance_of_the_helix
12 C=((I0*Z0)/(4*V0))^(1/3);
13 disp(C, 'From Eq(9-5-56) the gain parameter is =');
14
15
16 // (b) Calculate_the_output_power_gain_in_dB
17
18 N=50; // Circular_length
19 Ap=-9.54+(47.3*N*C);
20 disp(Ap, 'the_output_power_gain_(in_dB) is =');
21
22
23
24 // (c) Calculate_the_four_propagation_constants
25
26 f=10*(10^9);
27 V0=3*(10^3);
28 w=2*(%pi)*f;
29 v0=.593*(10^6)*sqrt(V0);
30 Be=w/v0;
31
32 r1=(-1*Be*C*(sqrt(3)/2))+%i*Be*(1+(C/2));
33 disp(r1, 'the_first_propagation_constant_is =');
34
35 r2=(Be*C*(sqrt(3)/2))+%i*Be*(1+(C/2));
36 disp(r2, 'the_second_propagation_constant_is =');
37 r3=%i*Be*(1-C);
38 disp(r3, 'the_third_propagation_constant is =');
39
40 r4=-1*%i*Be*(1-((C^3)/4));
41 disp(r4, 'the_fourth_propagation_constant is =');

```

Scilab code Exa 9.7.1 Gridded Travelling Wave Tube

```
1 // CAPTION: Gridded_Travelling-Wave_Tube(GIWT)
2 //chapter_no.-9, page_no.-427
3 //Example_no.9-7-1
4 clc;
5
6
7 //(a)
   Calculate_the_number_of_electrons_returned_per_second

8 Ir=.85;//returned_current
9 q=1.6*(10^-19);//electronic_charge
10 Nr=Ir/q;
11 disp(Nr, 'the_number_of_electrons_returned_(
   per_second) is =');
12
13
14
15
16
17 //(b)
   Calculate_the_Energy_associated_with_these_returning_electrons_in_

18
19
20 V=11*(10^3);//overdepression_collector_voltage
21 t=20*(10^-3);
22 W=V*Nr*t;
23 disp(W, '
   the_Energy_associated_with_these_returning_electrons_in_20ms
   (in eV) is =');
24
25
```

```

26
27 //(c) Calculate_the_Power_for_returning_electrons
28
29
30 P=V*Ir;
31 P=P/1000;
32 disp(P, 'the_Power_for_returning_electrons (in KW) is =
      ');
33
34
35 //(d)
      Calculate_the_Heat_associated_with_the_returning_electrons

36
37 t=20*(10-3);
38 H=.238*P*1000*t;
39 disp(H, '
      the_Heat_associated_with_the_returning_electrons (
      in calories) is =');
40
41
42 //(e) Calculate_the_temperature
43
44 mass=250*(10-3);
45 specificheat=.108;
46 T=H/(mass*specificheat);
47 disp(T, 'the_temperature (in degree Celsius) is =');
48
49 //(f)
      Calculate_whether_the_output_iron_pole_piece_is_melted

50
51
52 disp('the_output_iron_pole_piece_is_melted');

```

Chapter 10

Microwave crossed field tubes M type

Scilab code Exa 10.1.1 Conventional Magnetron

```
1 //CAPTION: Conventional_Magnetron
2 //chapter_no.-10, page_no.-448
3 //Example_no.10-1-1
4
5 clc;
6
7 //(a) Calculate_the_cyclotron_angular_frequency
8
9 em=1.759*(10^11); //em=e/m=charge_is_to_mass_ratio
10 B0=.336; //Magnetic_flux_density
11 wc=(em)*B0;
12 disp(wc, 'The_cyclotron_angular_frequency (in rad) is =
    ');
13
14
15
16 //(b) Calculate_the_cutoff_voltage_for_a_fixed_B0
17
18
```

```

19 a=5*(10^-2); //radius_of_cathode_cylinder
20 b=10*(10^-2); //radius_of_vane_edge_to_centre
21 Voc=(em*(B0^2)*(b^2)*((1-((a/b)^2))^2))/8;
22 Voc=Voc/(10^5);
23 disp(Voc, 'the_cutoff_voltage_for_a_fixed_B0 (in KV) is
    =');
24
25
26
27 //(c)
    Calculate_the_cutoff_magnetic_flux_density_for_a_fixed_V0

28
29
30 V0=26*(10^3); // Anode_voltage
31 Boc=((8*V0)/em)^(1/2)/(b*(1-((a/b)^2)));
32 Boc=Boc*1000;
33 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

```

1 // CAPTION: Pulsed_Magnetron
2 //chapter_no.-10, page_no.-452
3 //Example_no.10-1-1A
4
5 clc;
6
7 //(a) Calculate_the_angular_resonant_frequency
8
9 f=9*(10^9); // Operating_frequency
10 wr=2*%pi*f;
11 disp(wr, 'the_angular_resonant_frequency (in rad) is =')
    );

```

```

12
13
14 //(b) Calculate_the_unloaded_quality_factor
15
16
17 C=2.5*(10^-12); // vane_capacitance
18 Gr=2*(10^-4); // Resonator_capacitance
19 Qun=wr*C/Gr;
20 disp(Qun, 'the_unloaded_quality_factor ');
21
22
23
24
25 //(c) Calculate_the_loaded_quality_factor
26
27
28 C=2.5*(10^-12); // vane_capacitance
29 Gr=2*(10^-4); // Resonator_capacitance
30 G1=2.5*(10^-5); //loaded_capacitance
31 Ql=wr*C/(G1+Gr);
32 disp(Ql, 'the_loaded_quality_factor ');
33
34
35
36 //(d) Calculate_the_external_quality_factor
37
38
39 C=2.5*(10^-12); // vane_capacitance
40 G1=2.5*(10^-5); //loaded_capacitance
41 Qex=wr*C/G1;
42 disp(Qex, 'the_external_quality_factor ');
43
44
45 //(e) Calculate_the_circuit_efficiency
46
47 n=(1/(1+(Qex/Qun)));
48 n=n*100;
49 disp(n, 'the_circuit_efficiency (in %) is=');

```

```

50
51
52 //(f) Calculate_the_electronic_efficiency
53
54
55 V0=5.5*(10^3); // Anode_Voltage
56 I0=4.5; // Beam_current
57 Plost=18.5*(10^3); // power_loss
58 ne=((V0*I0)-(Plost))/(V0*I0);
59 ne=ne*100;
60 disp(ne, 'the_electronic_efficiency (in %) is=');

```

Scilab code Exa 10.1.2 Linear Magnetron

```

1 //CAPTION: Linear_Magnetron
2 //chapter_no.-10, page_no.-457
3 //Example_no.10-1-2
4
5 clc;
6
7
8 //(a) Calculate_the_Hall_cutoff_voltage_for_fixed_Bo
9 em=1.759*(10^11); //em=e/m
10 Bo=.01; // Magnetic_flux_density
11 d=5*(10^-2); // Distance_between_cathode_and_anode
12 Voc=(1/2)*(em)*(Bo^2)*(d^2);
13 Voc=Voc/1000;
14 disp(Voc, 'the_Hall_cutoff_voltage_for_fixed_Bo (in KV
    )is =');
15
16
17
18
19 //(b)
    Calculate_the_Hall_cutoff_magnetic_field_density_for_fixed_Vo

```

```

20
21
22 V0=10*(10^3); // Anode_voltage
23 Boc=(1/d)*sqrt((2*V0)/(em));
24 Boc=Boc*1000; //in mWb
25 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

```

1 //CAPTION: Linear_Magnetron
2 //chapter_no.-10, page_no.-459
3 //Example_no.10-1-2a
4
5 clc;
6
7 //(a)
   Calculate_the_electron_velocity_at_the_hub_surface

8
9 em=1.759*(10^11); //em=e/m
10 Bo=.015; //Magnetic_flux_density
11 d=5*(10^-2); //Distance_between_cathode_and_anode
12 h=2.77*(10^-2); //hub_thickness
13 V=em*Bo*h;
14 disp(V, 'the_electron_velocity_at_the_hub_surface (in
    m/s) is =');
15
16
17
18
19 //(b) Calculate_the_phase_velocity_for_synchronism
20

```



```

21 disp(V, 'the_phase_velocity_for_synchronism is  $V_{ph}=\omega/B$ 
    B =');
22
23
24
25 //(c) Calculate_the_Hartree_anode_voltage
26
27
28  $\omega B=V$ ; //  $\omega B=\omega/B$ 
29
30  $V_{oh}=(V*B_0*d)-((1/2)*(1/\epsilon m)*(V^2))$ ;
31  $V_{oh}=V_{oh}/1000$ ; // in KV
32 disp(Voh, 'the_Hartree_anode_voltage (in KV) is =');

```

Scilab code Exa 10.1.5 Inverted Coaxial Magnetron

```

1 // CAPTION: Inverted_Coaxial_Magnetron
2 // chapter_no.-10, page_no.-465
3 // Example_no.10-1-5
4
5 clc;
6
7
8 //(a) Calculate_the_cutoff_voltage_for_fixed_Bo
9  $\epsilon m=1.759*(10^{11})$ ; //  $\epsilon m=e/m$ 
10  $B_0=.01$ ; // Magnetic_flux_density
11  $a=3*(10^{-2})$ ; // anode_radius
12  $b=4*(10^{-2})$ ; // Cathode_radius
13  $V_{oc}=(1/8)*(\epsilon m)*(B_0^2)*(a^2)*((1-((b/a)^2))^2)$ ;
14  $V_{oc}=V_{oc}/1000$ ;
15 disp(Voc, 'the_cutoff_voltage_for_fixed_Bo (in KV) is =
    ');
16
17
18

```

```

19
20 //(b)
    Calculate_the_cutoff_magnetic_flux_density_for_fixed_Vo

21
22
23 V0=10*(10^3); // Anode_voltage
24 Boc=(-1/(sqrt(em)))*(sqrt(8*V0))/((a)*(1-((b/a)^2)))
    ;
25 disp(Boc, '
    the_cutoff_magnetic_flux_density_for_fixed_Vo (in
    Wb/m^2) is =');

```

Scilab code Exa 10.1.6 Frequency Agile Magnetron

```

1 //CAPTION: Frequency-Agile-Magnetron
2 //chapter_no.-10, page_no.-467
3 //Example_no.10-1-6
4
5 clc;
6
7 //(a) Calculate_the_agile_excursion
8 t=.2*(10^-6); //pulse_duration
9 N=14; //pulse_rate_on_target
10 AC=N/t; //agile_Excursion
11 AC=AC/(10^6); //in MHz
12 disp(AC, 'the_agile_excursion (in MHz) is =');
13
14
15
16 //(b) Calculate_the_pulse-to-
    pulse_frequency_separation
17
18
19 fp=1/t;

```

```

20 fp=fp/(10^6); //in MHz
21 disp(fp, 'the_pulse-to-pulse_frequency_separation (in
    MHz) is =');
22
23
24
25 //(c) Calculate_the_signal_frequency
26
27 DC=.001 //Duty_cycle
28 f=(DC/t);
29 f=f/(10^3); //in KHz
30 disp(f, 'the_signal_frequency (in KHz) is =');
31
32
33
34 //(d) Calculate_the_time_for_N_pulses
35
36 Time=N/f;
37 disp(Time, 'the_time_for_14_pulses_per_second_ (in ms)
    is =');
38
39
40
41
42 //(e) Calculate_the_agile_rate
43
44 Agilerate=1/(2*Time*10^-3);
45
46 disp(Agilerate, 'the_agile_rate (in Hz) is =');

```

Scilab code Exa 10.2.1 Crossed Field Amplifier

```

1 //CAPTION: Crossed-Field_Amplifier
2 //chapter_no.-10, page_no.-473
3 //Example_no.10-2-1

```

```

4
5 clc;
6
7 //(a) Calculate_the_induced_RF_power
8
9 Vao=2*(10^3); // Anode_dc_voltage
10 Iao=1.5; // Anode_dc_current
11 ne=.20; // Electronic_efficiency
12 Pgen=Vao*Iao*ne;
13 disp(Pgen, 'the_induced_RF_power (in W) is =');
14
15
16
17
18 //(b) Calculate_the_total_RF_output_power
19
20
21 Pin=80; // RF_input_power
22 Pout=Pin+(Pgen);
23 disp(Pout, 'the_total_RF_output_power (in W) is =');
24
25
26 //(c) Calculate_the_power_gain
27
28 g=Pout/Pin;
29 g=10*log10(g); // in_decibels
30 disp(g, 'the_power_gain (in dB) is =');

```

Scilab code Exa 10.3.1 Amplitron characteristics

```

1 //CAPTION: Amplitron_characteristics
2 //chapter_no.-10, page_no.-478
3 //Example_no.10-3-1
4
5 clc;

```

```

6
7 // (a) Calculate_the_dc_electron-beam_velocity
8
9 V0=15*(10^3); // Anode_voltage
10 v0=.593*(10^6)*sqrt(V0);
11 disp(v0, 'the_dc_electron-beam_velocity_(in m/s) is =
    ');
12
13
14
15 // (b) Calculate_the_electron-beam_phase_constant
16
17
18 f=8*(10^9);
19 w=2*%pi*f;
20 Be=w/v0;
21 disp(Be, 'the_electron-beam_phase_constant(in rad/m)
    is =');
22
23
24
25
26
27 // (c) Calculate_the_cyclotron_angular_frequency
28
29 em=1.759*(10^11); // em=e/m
30 Bo=.2; // Magnetic_flux_density
31 wc=(em*Bo);
32 disp(wc, 'the_cyclotron_angular_frequency(in rad/s) is
    =');
33
34
35 // (d) Calculate_the_cyclotron_phase_constant
36
37 Bm=wc/v0;
38 disp(Bm, 'the_cyclotron_phase_constant(in rad/m) is =
    ');
39

```

```

40 //(e) Calculate_the_gain_parameter
41
42 Z0=50; //characteristic_impedance
43 I0=3; //Anode_current
44 C=((I0*Z0)/(4*V0))^(1/3);
45 disp(C, 'the_gain_parameter is =');

```

Scilab code Exa 10.4.1 Carcinotron Characteristics

```

1 //CAPTION: Carcinotron_Characteristics
2 //chapter_no.-10, page_no.-483
3 //Example_no.10-4-1
4
5 clc;
6
7 //(a) Calculate_the_dc_electron_velocity
8
9 V0=20*(10^3); //Anode_voltage
10 v0=.593*(10^6)*sqrt(V0);
11 disp(v0, 'the_dc_electron_velocity_(in m/s) is =');
12
13
14
15 //(b) Calculate_the_electron-beam_phase_constant
16
17
18 f=4*(10^9); //operating_frequency
19 w=2*%pi*f;
20 Be=w/v0;
21 disp(Be, 'the_electron-beam_phase_constant(in rad/m)
    is =');
22
23
24
25

```

```

26 // (c) Calculate_the_delta_differentials
27
28
29 b=.5; // b_factor
30 disp('The_Delta_differentials_are : s1=');
31 s1=(%i)*((b-sqrt((b^2)+4))/2);
32 disp(s1, 's1=');
33 s2=(%i)*((b+sqrt((b^2)+4))/2);
34 disp(s2, 'And s2=');
35
36
37
38 // (d) Calculate_the_propagation_constants
39
40 D=.8; // D_factor
41 disp('the_propagation_constants_are ');
42 r1=((%i)*(Be+b))+(b*D*s1);
43 disp(r1, 'r1=');
44 r2=((%i)*(Be+b))+(b*D*s2);
45 disp(r2, 'r2=');
46
47
48
49 // (e) Calculate_the_oscillation_condition
50
51 disp('the_oscillation_occurs_at_DN=1.25_for_n=1 ');
52 N=1.25/D;
53 disp(N, 'then N=');
54
55 l=(2*%pi*N)/Be;
56 l=l*100; // in_cm
57 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

```
1 //CAPTION:
   Characteristic_Impedance_of_Microstrip_line
2 //chapter_no.-11, page_no.-495
3 //Example_no.11-1-1
4
5 clc;
6
7
8 er=5.23;//relative_dielectric_constant
9 h=7;//height_from_microstrip_line_to_the_ground
10 t=2.8;//thickness_of_the_microstrip_line
11 w=10;//width_of_the_microstrip_line
12 Z0=(87*(log((5.98*h)/(t+(.8*w)))))/sqrt(er+1.41);
13 disp(Z0,'the_characteristic_impedance_of_the_line(in
   ohms) is =');
```

Scilab code Exa 11.2.1 Characteristics of a Parallel Strip Line


```

1 //CAPTION: Characteristics_of_a_Parallel_Strip_Line
2 //chapter_no.-11, page_no.-505
3 //Example_no.11-2-1
4
5 clc;
6
7 //(a) Calculate the required width of the conducting
      strip
8 erd=6; //relative_dielectric_constant
9 d=4*(10^-3); //thickness
10 Z0=50; //characteristic_impedance
11
12 w=(377*(d))/((sqrt(erd))*Z0);
13 disp(w, 'the_required_width_of_the_conducting_strip(
      in metres)is =');
14
15 //(b) Calculate_the_strip_line_capacitance
16
17 ed=8.854*(10^-12)*erd;
18 d=4*(10^-3); //thickness
19 C=(ed*w)/d;
20 C=C*(10^12);
21 disp(C, 'the_strip_line_capacitance(in pF/m)is =');
22
23
24
25
26 //(c) Calculate_the_strip_line_inductance
27
28 uc=4*%pi*(10^-7);
29 d=4*(10^-3); //thickness
30 C=(uc*d)/w;
31 C=C*(10^6);
32 disp(C, 'the_strip_line_inductance(in uH/m)is =');
33
34 //(d)
      Calculate_the_phase_velocity_of_the_wave_in_the_parallel_strip_line

```

```

35
36 c=3*(10^8);
37
38 vp=c/(sqrt(erd));
39 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

```

1 //CAPTION:
    Characteristic_Impedance_of_a_Coplanar_Stripline
2 //chapter_no.-11, page_no.-507
3 //Example_no.11-3-1
4
5 clc;
6
7 Pavg=250*(10^-3); //
    average_power_flowng_in_the_positive_z_direction
8 Io=100*(10^-3); //total_peak_current
9 Z0=(2*Pavg)/(Io^2);
10 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

```

1 //CAPTION:
    Characteristic_Impedance_of_a_Shielded_Strip_Line
2 //chapter_no.-11, page_no.-508
3 //Example_no.11-4-1
4
5

```

```

6  clc;
7
8
9  //(a) Calculate_the_K_factor
10
11 er=2.56//relative_dielectric_constant
12 w=25;//strip_width
13 t=14;//strip_thickness
14 d=70;//shield_depth
15 K=1/(1-(t/d));
16 disp(K, 'the_K_factor is =');
17
18 //(b) Calculate_the_fringe_capacitance
19
20 Cf=((8.854*er)*((2*K*log(K+1))-((K-1)*log((K^2)-1))))
    )/%pi;
21 disp(Cf, 'the_fringe_capacitance (in pF/m) is =');
22
23
24 //(c)
    Calculate_the_characteristic_impedance_of_the_line

25
26 Z0=94.15/(((w/d)*K)+(Cf/(8.854*er)))*(sqrt(er));
27 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

```
1 //CAPTION: Resistance_of_a_planar_resistor
2 //chapter_no.-12, page_no.-534
3 //Example_no.12-4-1
4
5 clc;
6 l=10*(10^-3); //resistance_film_length
7 ps=2.44*(10^-8); //sheet_resistivity_of_gold_film
8 w=10*(10^-3); //resistive_film_width
9 t=.1*(10^-6); //resistive_fim_thickness
10 R=(l*ps)/(w*t);
11 disp(R, 'the_planar_resistance(in ohm/square) is =');
```

Scilab code Exa 12.4.2 Planar Circular Spiral inductor

```
1 //CAPTION: Planar_Circular_Spiral__inductor
2 //chapter_no.-12, page_no.-536
```

```

3 //Example_no.12-4-2
4
5 clc;
6 n=5; //number_of_turns
7 w=50; //film_width
8 s=100; //separation
9 d0=2.5*n*(w+s);
10 L=.03125*(n^2)*d0;
11 disp(L, 'the_inductance(in (nH/mil) is =');

```

Scilab code Exa 12.4.3 Planar Capacitor

```

1 //CAPTION: Planar_Capacitor
2 //chapter_no.-12, page_no.-537
3 //Example_no.12-4-3
4
5 clc;
6
7 N=8; //number_of_fingers
8 er=13.1; //relative_dielectric_constant
9 h=.254; //substarte_height
10 l=.00254; //finger_length
11 w=.051; //finger_base_width
12 A1=.089; //contribution_of_interior_finger_for_h > w
13 A2=.1; //contribution_of_two_exterior_fingers_for_h > w
14 C=((er+1)*l*((A1*(N-3))+A2))/w;
15 disp(C, 'the_Capacitance(in (pF/cm) is =');

```
