

Scilab Textbook Companion for
Electronic Devices
by T. L. Floyd¹

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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
1 semiconductor basics	6
2 diode applications	9
3 Special purpose diodes	26
4 Bipolar Junction Transistors	33
5 Transistor Bias Circuits	38
6 BJT Amplifiers	44
7 Field Effect Transistors	53
8 FET Amplifiers	61
9 Power Amplifiers	67
10 Amplifier Frequency Response	72
11 Thyristors and Other Devices	82
12 The Operational Amplifier	85
13 Basic Opamp Circuits	91
14 Special Purpose Opamp Circuits	103

15 Active Filters	109
16 Oscillators	113
17 Voltage Regulators	118
18 Programmable Analog Arrays	122

List of Scilab Codes

Exa 1.1	Different diode models	6
Exa 2.1	Average value half wave rectifier	9
Exa 2.2.a	half wave rectifier	9
Exa 2.2.b	half wave rectifier	11
Exa 2.3	Rectifier peak value	13
Exa 2.4	Average value full wave rectifier	14
Exa 2.5	PIV full wave	14
Exa 2.6	Bridge Rectifier	16
Exa 2.7	Ripple Bridge rectifier	16
Exa 2.8	Voltage Regulator	17
Exa 2.9	Load regulation percentage	18
Exa 2.10	Negative diode limiter	18
Exa 2.11	Posiive Negative Limiter	19
Exa 2.12	Positive diode limiter	22
Exa 2.13	Negative Clamper	23
Exa 3.1	Zener impedance	26
Exa 3.2	Zener Voltage	26
Exa 3.3	Temperature coefficient	27
Exa 3.4	Zener power dissipation	27
Exa 3.5	Zener voltage regulator	28
Exa 3.6	Regulation Variable load	28
Exa 3.7	Zener regulation	29
Exa 3.8	Zener limiting	30
Exa 4.1	DC beta	33
Exa 4.2	Current Voltage Analysis	33
Exa 4.3	Collector characteristic curve	34
Exa 4.4	DC loadline	34
Exa 4.5	Transistor rating	35

Exa 4.6	Maximum Transistor Rating	35
Exa 4.7	Derating Power maximum	36
Exa 4.8	Transistor amplification	36
Exa 4.9	Collector in saturation	36
Exa 5.1	DC bias	38
Exa 5.2	Input resistance	38
Exa 5.3	Voltage divider bias	39
Exa 5.4	Voltage bias PNP	39
Exa 5.5	PNP Transistor	40
Exa 5.6	Qpoint base bias	41
Exa 5.7	Emitter bias	42
Exa 5.8	Q point	43
Exa 6.1	Linear amplifier	44
Exa 6.2	AC Emitter resistance	44
Exa 6.3	Base voltage	44
Exa 6.4	Emitter bypass capacitor	45
Exa 6.5	Effect bypass capacitor	45
Exa 6.6	Gain with load	46
Exa 6.7	Gain swamped amplifier	46
Exa 6.8	Common emitter amplifier	46
Exa 6.9	Current gain	48
Exa 6.10	Darlington emitter follower	49
Exa 6.11	Common base amplifier	51
Exa 6.12	Voltage gain decibel	51
Exa 7.1	cutoff FET	53
Exa 7.2	Drain current	53
Exa 7.3	JFET current voltage	54
Exa 7.4	JFET transconductance	54
Exa 7.5	JFET input resistance	55
Exa 7.6	Self bias	55
Exa 7.7	Q point JFET	55
Exa 7.8	Self bias Q point	56
Exa 7.9	Midpoint bias	56
Exa 7.10	Graphical analysis	57
Exa 7.11	Voltage Divider bias	57
Exa 7.12	Graph voltage divider	58
Exa 7.13	DMOSFET	58
Exa 7.14	EMOSFET	59

Exa 7.15	DMOSFET bias	59
Exa 7.16	EMOSFET bias	59
Exa 7.17	EMOSFET drain current	60
Exa 8.1	Voltage gain	61
Exa 8.2	Rds effect	61
Exa 8.3	External source resistance	61
Exa 8.4	Unloaded amplifier	62
Exa 8.5	AC load effect	63
Exa 8.6	Input resistance	63
Exa 8.7	DMOSFET amplifier	63
Exa 8.8	MOSFET Q points	64
Exa 8.9	EMOSFET amplifier	64
Exa 8.10	Common gate amplifier	65
Exa 9.1	classA power amplifier	67
Exa 9.2	class A efficiency	68
Exa 9.3	class AB pushpull	69
Exa 9.4	Single supply pushpull	69
Exa 9.5	Power of amplifier	69
Exa 9.6	MOSFET pushpull amplifier	70
Exa 9.7	class C amplifier	71
Exa 9.8	class C efficiency	71
Exa 10.1	Gain in decibel	72
Exa 10.2	Critical frequency	73
Exa 10.3	Lower critical frequency	73
Exa 10.4	Voltage gains	74
Exa 10.5	Output RC circuit	74
Exa 10.6	Bypass RC circuit BJT	75
Exa 10.7	input RC circuit FET	76
Exa 10.8	Low frequency response FET	76
Exa 10.9	Low frequency response BJT	77
Exa 10.10	input RC circuit BJT	78
Exa 10.11	Critical frequency BJT output	79
Exa 10.12	FET capacitors	79
Exa 10.13	Critical frequency FET input	79
Exa 10.14	Critical frequency FET input	80
Exa 10.15	Bandwidth	80
Exa 10.16	Bandwidth transistor	81
Exa 10.17	Bandwidth 2stage amplifier	81

Exa 10.18	Bandwidth 2stage amplifier	81
Exa 11.1	Four layer diode	82
Exa 11.2	Anode current	82
Exa 11.3	Unijunction transistor	83
Exa 11.4	turn on off UJT	83
Exa 11.5	Critical angle	83
Exa 12.1	CMRR opamp	85
Exa 12.2	Slew rate	85
Exa 12.3	Non inverting amplifier	86
Exa 12.4	Inverting amplifier	86
Exa 12.5	Impedance noninverting amplifier	86
Exa 12.6	Voltage follower impedance	87
Exa 12.7	Impedance inverting amplifier	87
Exa 12.8	Open Loop gain	88
Exa 12.9	phase RC lag	88
Exa 12.10	Gain and phase lag	89
Exa 12.11	Closed loop bandwidth	90
Exa 12.12	Amplifier bandwidth	90
Exa 13.1	Comparator	91
Exa 13.2	Trigger points	93
Exa 13.3	Comparator hysteresis Zener bounding	93
Exa 13.4	Summing amplifier unity gain	95
Exa 13.5	Summing amplifier	95
Exa 13.6	Averaging amplifier	96
Exa 13.7	Scaling adder	96
Exa 13.8	Opamp integrator	97
Exa 13.9	Opamp differentiator	99
Exa 14.1	Gain setting resistor	103
Exa 14.2	Voltage gain Instrumentation amplifier	103
Exa 14.3	Isolation amplifier	104
Exa 14.4	Voltage gain Isolation amplifier	104
Exa 14.5	Transconductance OTA	104
Exa 14.6	Voltage gain OTA	105
Exa 14.7	Output OTA amplitude modulator	105
Exa 14.8	Output log amplifier	107
Exa 14.9	Transistor log amplifier	107
Exa 14.10	Antilog amplifier	107
Exa 15.1	Band pass filter	109

Exa 15.2	Butterworth response	109
Exa 15.3	Sallen Key lowpass filter	110
Exa 15.4	4 pole filter	110
Exa 15.5	Sallen Key highpass filter	111
Exa 15.6	Cascaded filter	111
Exa 15.7	State variable filter	111
Exa 15.8	Band stop filter	112
Exa 16.1	Wien bridge oscillator	113
Exa 16.2	Phase shift oscillator	114
Exa 16.3	FET Colpitts oscillator	114
Exa 16.4	Triangular wave oscillator	114
Exa 16.5	Sawtooth VCO	116
Exa 16.6	555 timer	116
Exa 17.1	Percentage line regulation	118
Exa 17.2	Load regulation percentage	118
Exa 17.3	Series regulator	119
Exa 17.4	Overload protection	119
Exa 17.5	Shunt regulator	119
Exa 17.6	Positive linear voltage regulator	120
Exa 17.7	External pass filter	120
Exa 17.8	Power rating 7824	120
Exa 17.9	Current regulator	121
Exa 18.1	Switching capacitor	122
AP 1	Phase shift in degrees	123
AP 2	Open loop gain	123
AP 3	Voltage gain in decibel	123
AP 4	Power gain in decibel	123
AP 5	value of K	123
AP 6	Drain current value	124

List of Figures

2.1	half wave rectifier	10
2.2	half wave rectifier	12
2.3	PIV full wave	15
2.4	Negative diode limiter	18
2.5	Posiive Negative Limiter	20
2.6	Positive diode limiter	22
2.7	Negative Clamper	24
3.1	Zener limiting	30
6.1	Common emitter amplifier	47
13.1	Comparator	92
13.2	Comparator hysteris Zener bounding	94
13.3	Opamp integrator	98
13.4	Opamp differentiator	100
14.1	Output OTA amplitude modulator	106
16.1	Sawtooth VCO	115

Chapter 1

semiconductor basics

Scilab code Exa 1.1 Different diode models

```
1 //Ex-1.1(a)
2 V_bias=10;
3 R_limit=1000;
4 r_d =10;
5 //Voltages in Volts , Currents in Amperes ,
   Resistances in Ohms
6 //IDEAL MODEL
7 disp('IDEAL MODEL')
8 V_f=0;
9 I_f=V_bias/R_limit;
10 V_R_limit=I_f*R_limit;
11 disp(V_f,'forward voltage in volts');
12 disp(I_f,'forward current in amperes');
13 disp(V_R_limit,'voltage across limiting resistor in
   volts');
14 //PRACTICAL MODEL
15 disp('PRACTICAL MODEL');
16 V_f=0.7;
17 I_f=(V_bias-V_f)/R_limit;
18 V_R_limit=I_f*R_limit;
19 disp(V_f,'forward voltage in volts');
```

```

20 disp(I_f,'forward current in amperes');
21 disp(V_R_limit,'voltage across limiting resistor in
    volts');
22 //COMPLETE MODEL
23 disp('COMPLETE MODEL')
24 I_f=(V_bias-0.7)/(R_limit+r_d');
25 V_f=0.7+I_f*r_d';
26 V_R_limit=I_f*R_limit;
27 disp(V_f,'forward voltage in volts');
28 disp(I_f,'forward current in amperes');
29 disp(V_R_limit,'voltage across limiting resistor in
    volts');
30 //Ex1.1(b)
31 V_bias=5;
32 I_R=1*10^-6;
33 //IDEAL MODEL
34 disp('IDEAL MODEL');
35 I_r=0;
36 V_R=V_bias;
37 V_R_limit=I_r*R_limit;
38 disp(I_r,'reverse current in amperes')
39 disp(V_R,'reverse voltage in volts')
40 disp(V_R_limit,'voltage across limiting resistor in
    volts')
41 //PRACTICAL MODEL
42 disp('PRACTICAL MODEL')
43 I_r=0;
44 V_R=V_bias;
45 V_R_limit=I_r*R_limit;
46 disp(I_r,'reverse current in amperes')
47 disp(V_R,'reverse voltage in volts')
48 disp(V_R_limit,'voltage across limiting resistor in
    volts')
49 //COMPLETE MODEL
50 disp('COMPLETE MODEL')
51 I_r=I_R;
52 V_R_limit=I_r*R_limit;
53 V_R=V_bias-V_R_limit;

```

```
54 disp(I_r, 'reverse current in amperes')
55 disp(V_R, 'reverse voltage in volts')
56 disp(V_R_limit, 'voltage across limiting resistor in
    volts')
```

Chapter 2

diode applications

Scilab code Exa 2.1 Average value half wave rectifier

```
1 //Ex2.1
2 //Average value of half wave rectifier
3 V_p=50; //Peak value is 50V
4 V_avg=V_p/%pi;
5 disp(V_avg, 'average value of half wave rectifier in
   volts')
```

Scilab code Exa 2.2.a half wave rectifier

```
1 //Example - 2.2(a)
2 //let  $V_{in}=5\sin(2\pi f t)$  be input wave ,hence
   frequency=1Hz
3 f=1;
4 V_p_in=5;
5 V_pout=V_p_in-0.7;;
6 disp(V_pout, 'half wave rectifier output in volts')
7 t_d=(asin(0.7/V_p_in))/(2*pi*f)
```

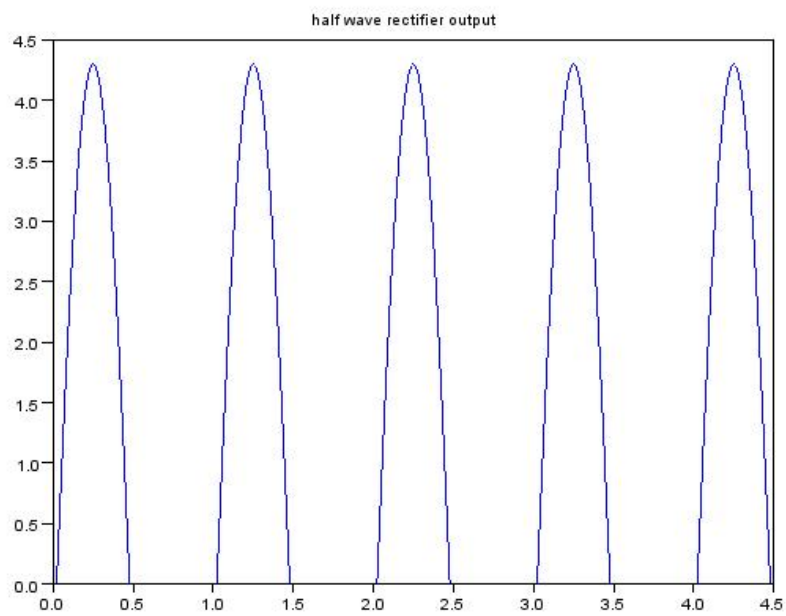


Figure 2.1: half wave rectifier


```

8 //t_d is the time till which diode will be reverse
   biased ie , till it reaches knee voltage
9 T=1/f;
10 clf();
11 //let n be double the number of cycles of output
   shown in graph
12 for n=0:1:8
13     t=T.*n/2:0.0005:T.*(n+1)/2 //time for each
   half cycle
14     if modulo(n,2)==0 then //positive half cycle
   , diode is forward biased
15         V_in=V_p_in*sin(2*%pi*f.*t)
16         Vout=V_in-0.7 //0.7 is knee
   voltage of diode
17         a=bool2s(Vout>0) //replace elements
   of Vout by 0 till input is 0.7
18         y=a.*Vout
19     else //negative half
   cycle , diode is reverse biased
20         [p,q]=size(t);
21         y=zeros(p,q);
22     end
23     plot(t,y)
24 end
25 xtitle('half wave rectifier output')

```

Scilab code Exa 2.2.b half wave rectifier

```

1 //Example -2.2(b)
2 //let V_in=100*sin(2*%pi*f.*t) be input wave ,hence
   frequency=1Hz
3 f=1;
4 T=1/f;

```

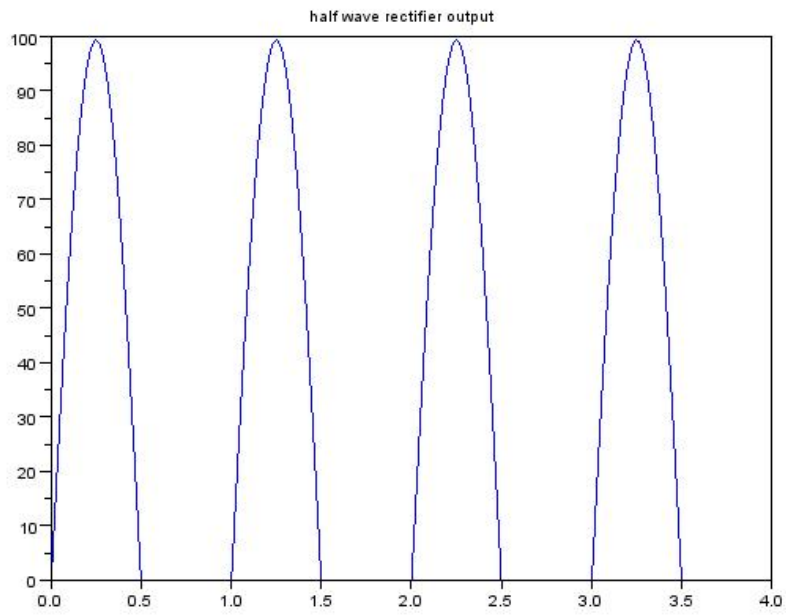


Figure 2.2: half wave rectifier

```

5 V_p_in=100;
6 V_pout=(V_p_in-0.7);
7 disp(V_pout,'output of half wave rectifier in volts'
      )
8 t_d=(asin(0.7/V_p_in))/(2*%pi*f)
9 //t_d is the time till which diode will be reverse
  biased ie, till it reaches knee voltage
10 clf();
11 //let n be double the number of cycles of output
  shown in graph
12 for n=0:1:7
13     t=T.*n/2:0.0005:T.*(n+1)/2    // time for each
  half cycle
14     if modulo(n,2)==0 then        //positive half cycle
15         V_in=V_p_in*sin(2*%pi*f.*t)
16         Vout=V_in-0.7            //0.7 is knee
  voltage of diode
17         a=bool2s(Vout>0)         //replace elements
  of Vout by 0 till input is 0.7
18         y=a.*Vout
19     else                          //negative half
  cycle
20         [p,q]=size(t);
21         y=zeros(p,q);
22     end
23     plot(t,y)
24 end
25 xtitle('half wave rectifier output')

```

Scilab code Exa 2.3 Rectifier peak value

```

1 //Ex2.3
2 V_p_in=156;    //Peak input voltage
3 V_p_pri=156;  //Peak voltage of primary of
  transformer

```

```

4 n=1/2;      //Turn ratio is 2:1
5 V_p_sec=n*V_p_pri;
6 V_p_out=(V_p_sec-0.7);
7 disp(V_p_out,'peak output voltage of half wave
    rectifier in volts')    //Peak output voltage

```

Scilab code Exa 2.4 Average value full wave rectifier

```

1 //Ex2.4
2 //Average value of output of full wave rectifier
3 V_p=15;    //Peak voltage
4 V_avg=(2*V_p)/%pi;
5 disp(V_avg,'Average value of output of full wave
    rectifier in volts')    //Result

```

Scilab code Exa 2.5 PIV full wave

```

1 //Ex2.5
2 //Assume frequency of input to be 1Hz
3 f=1;
4 T=1/f;
5 V_p_pri=100;    //Peak voltage across primary
    winding
6 n=1/2;          //turn ratio is 2:1
7 V_p_sec=n*V_p_pri;
8 V_sec=V_p_sec/2;    //voltage across each secondary
    is half the total voltage
9 clf();
10 subplot(121)
11 xtitle('voltage across each secondary')
12 t=0:0.0005:2;

```

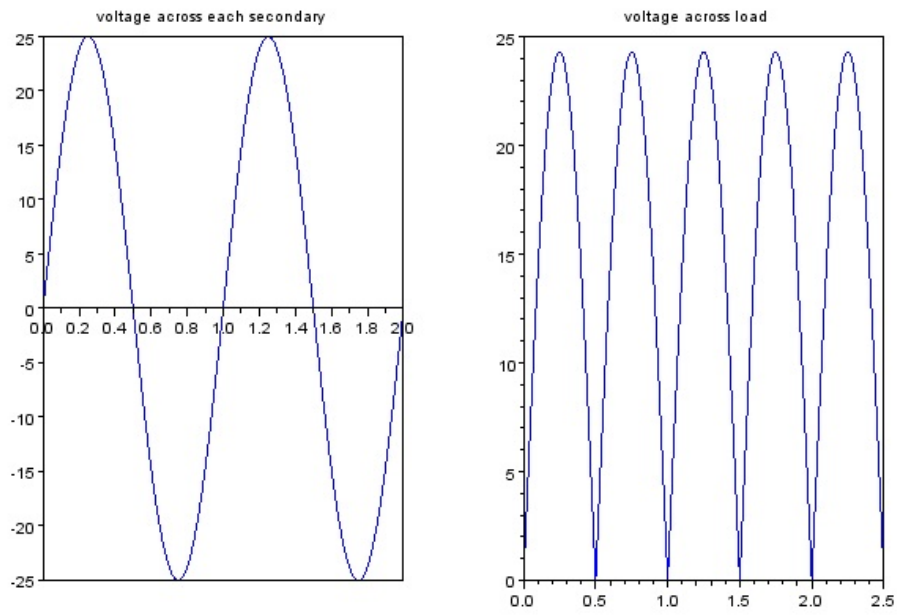


Figure 2.3: PIV full wave

```

13 x=V_sec*sin(2*%pi*f.*t);
14 plot(t,x)
15 subplot(122)
16 xtitle('voltage across load')
17 //let n be double the number of cycles of output
    shown in graph
18 for n=0:1:4
19     t=n.*T/2:0.0005:(n+1).*(T/2);
20 V_pout=V_sec-0.7;
21 V=V_pout*sin(2*%pi*f.*t)
22 a=bool2s(V*(-1)^n>0);
23 y=(-1)^n.*a.*V;
24 plot(t,y)
25 end
26 disp(V_pout,'full wave rectifier output voltage')
27 PIV=2*V_pout+0.7;
28 disp(PIV,'PIV in volts')

```

Scilab code Exa 2.6 Bridge Rectifier

```

1 //Ex-2.6
2 V_rms=12; //rms secondary voltage
3 V_p_sec=sqrt(2)*V_rms; //peak secondary voltage
4 V_th=0.7; //knee voltage of diode
5 V_p_out=V_p_sec-2*V_th; //in one cycle, 2 diodes
    conduct
6 PIV=V_p_out+V_th; //applying KVL
7 disp('Peak output voltage in volts= ');
8 disp(V_p_out);
9 disp('PIV across each diode in volts= ');
10 disp(PIV)

```

Scilab code Exa 2.7 Ripple Bridge rectifier

```

1 //Ex2.7
2 R_l=2200; //load resistance in Ohm
3 C=50*10^-6; //capacitance in Farad
4 V_rms=115; //rms of primary
5 V_p_pri=sqrt(2)*V_rms; //peak voltage across
   primary
6 n=0.1; //turn ratio is 10:1
7 V_p_sec=n*V_p_pri; //primary voltage across
   secondary
8 V_p_rect=V_p_sec-1.4 //unfiltered peak rectified
   voltage
9 //we subtract 1.4 because in each cycle 2 diodes
   conduct & 2 do not
10 f=120; //frequency of full wave rectified voltage
11 V_r_pp=(1/(f*R_l*C))*V_p_rect; //peak to peak
   ripple voltage
12 V_DC=(1-(1/(2*f*R_l*C)))*V_p_rect;
13 r=V_r_pp/V_DC;
14 disp(r, 'Ripple factor ')

```

Scilab code Exa 2.8 Voltage Regulator

```

1 //Ex2.8
2 V_REF=1.25; //in volts
3 V_R1=V_REF;
4 R1=220; //in ohms
5 I_ADJ=50*10^-6 //in amperes
6 // MAX VALUE OF R2=5000 Ohms
7 // V_out=V_REF*(1+(R2/R1))+I_ADJ*R2
8 R2_min=0;
9 V_out_min=V_REF*(1+(R2_min/R1))+I_ADJ*R2_min;
10 R2_max=5000;
11 V_out_max=V_REF*(1+(R2_max/R1))+I_ADJ*R2_max;
12 disp(V_out_min, 'minimum output voltage in volts');
13 disp(V_out_max, 'maximum output voltage in volts');

```

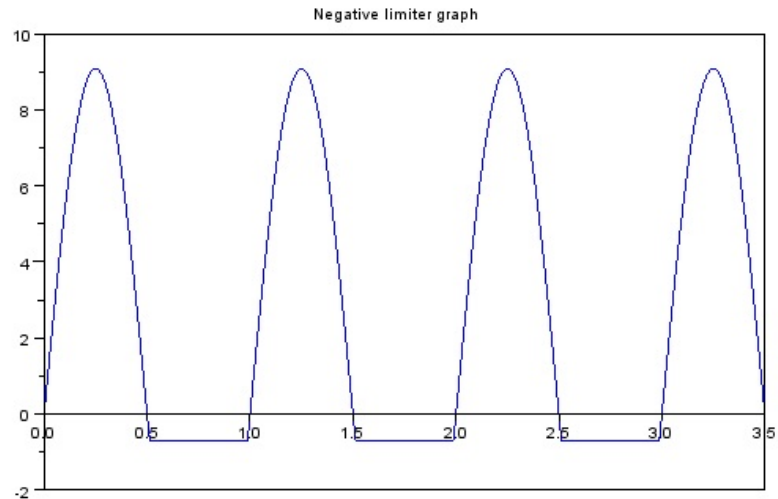


Figure 2.4: Negative diode limiter

Scilab code Exa 2.9 Load regulation percentage

```

1 //Ex2.9
2 V_NL=5.18 //No load output voltage
3 V_FL=5.15 //Full load output voltage
4 load_reg=((V_NL-V_FL)/V_FL)*100 //In percentage
5 disp('load regulation percent= ')
6 disp(load_reg)

```

Scilab code Exa 2.10 Negative diode limiter


```

1 //Ex2.10
2 //let input wave be  $V_{in}=V_{p\_in}\sin(2\pi f t)$ 
3 f=1; //Frequency is 1Hz
4 T=1/f;
5 R_1=100; //Resistances in ohms
6 R_L=1000; //Load
7 V_p_in=10; //Peak input voltage
8 V_th=0.7; //knee voltage of diode
9 clf();
10 V_p_out=V_p_in*(R_L/(R_L+R_1)); //peak output
    voltage
11 disp(V_p_out,'peak output voltage in volts')
12 //let n be double the number of cycles of output
    shown in graph
13 for n=0:1:6
14     t=T.*n/2:0.0005:T.*(n+1)/2 //time for each
        half cycle
15     V_in=V_p_in*sin(2*pi*f.*t);
16     Vout=V_in*(R_L/(R_L+R_1));
17     if modulo(n,2)==0 then //positive half, diode
        reverse biased
18         y=Vout;
19     else //negative half, diode
        forward biased
20         a=bool2s(Vout<-0.7); //puts zero to
            elements for which diode will conduct
21         b=bool2s(Vout>-0.7);
22         y=-V_th*a+b.*Vout;
23     end
24     plot(t,y)
25     end
26 xtitle('Negative limiter graph')

```

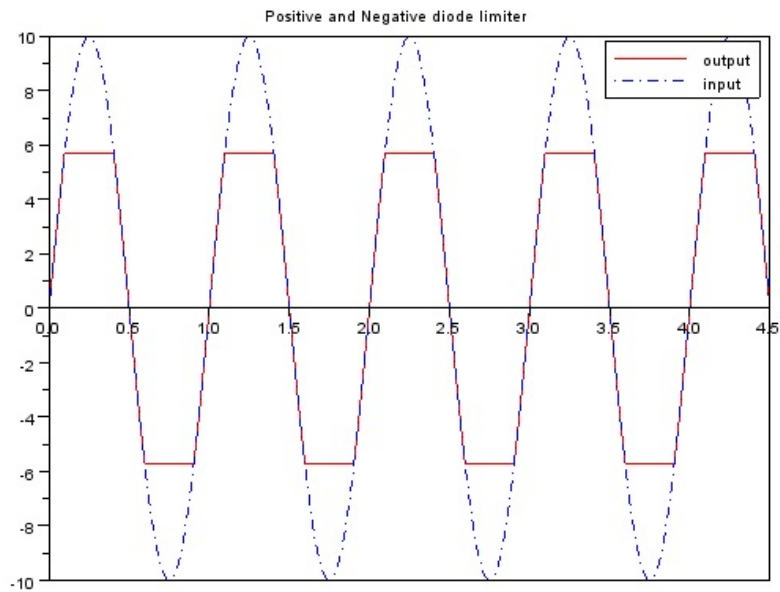


Figure 2.5: Posiive Negative Limiter

Scilab code Exa 2.11 Positive Negative Limiter

```
1 //Ex2.11
2 //let input wave be V_in=V_p_in*sin(2*%pi*f*t)
3 f=1; //Frequency is 1Hz
4 T=1/f;
5 V_p_in=10; //Peak input voltage
6 V_th=0.7; //knee voltage of diode
7 clf();
8 //let n be double the number of cycles of output
  shown in graph
9 for n=0:1:8
10     t=T.*n/2:0.0005:T.*(n+1)/2 //time for each
      half cycle
11     V_in=V_p_in*sin(2*%pi*f.*t);
12     Vout=V_in;
13     if modulo(n,2)==0 then //positive half, D1
      conducts till V_in=5.7V
14         a=bool2s(Vout<5.7);
15         b=bool2s(Vout>5.7);
16         y=a.*Vout+5.7*b; //output follows input
      till 5.7V then is constant at 5.7V
17     else //negative half, D2
      conducts till V_in=-5.7V
18         a=bool2s(Vout<-5.7);
19         b=bool2s(Vout>-5.7);
20         y=-5.7*a+b.*Vout; //output follows input
      till -5.7V then stays constant at -5.7V
21     end
22     plot(t,y,'r')
23
24     plot(t,V_in,'-.'')
25     end
26     hl=legend(['output','input']);
27     xtitle('Positive and Negative diode limiter')
28     disp('max output voltage is 5.7V')
29     disp('min output voltage is -5.7V')
```

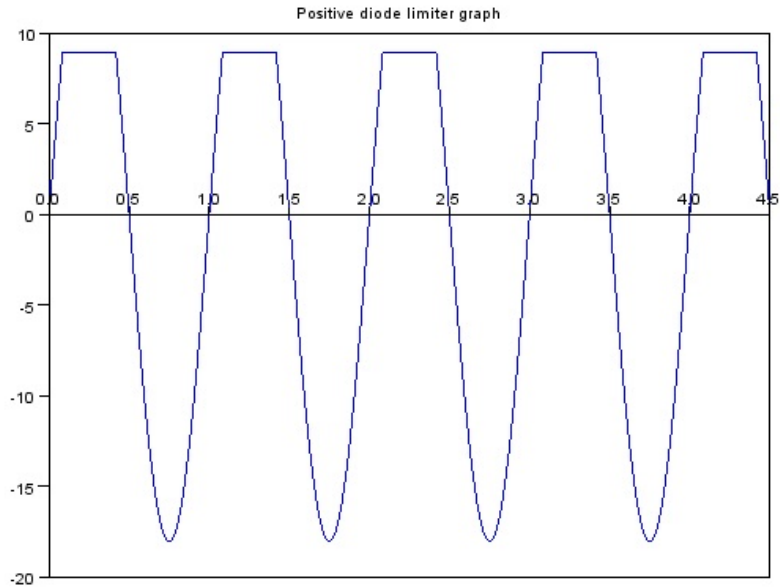


Figure 2.6: Positive diode limiter

Scilab code Exa 2.12 Positive diode limiter

```

1 //Ex2.12
2 //Positive diode limiter
3 //Let input wave be  $V_{in}=V_{p\_in}*\sin(2*\%pi*f*t)$ 
4 f=1; //let frequency be 1Hz
5 T=1/f;
6 V_p_in=18; //peak input voltage is 18V
7 V_supply=12;
8 R2=100;

```

```

9 R3=220;      //resistances in ohms
10 V_bias=V_supply*(R3/(R2+R3));
11 V=V_bias+0.7;    //waveform clipped at V
12 clf();
13 //let n be double the number of cycles of output
    wave shown in graph
14 for n=0:1:8
15     t=n*T/2:0.0005:T.*(n+1)/2;
16     V_in=V_p_in*sin(2*%pi*f.*t);
17     Vout=V_in;
18     if modulo(n,2)==0 then    //positive half, diode
        conucts till V
19         a=bool2s(Vout<V);
20         b=bool2s(Vout>V);
21         y=a.*Vout+V*b;
22     else                    //negative half cycle,
        output follows input
23         y=Vout;
24     end
25     plot(t,y)
26 end
27 xtitle('Positive diode limiter graph')
28 disp(V,'diode limiting the voltage at this voltage')

```

Scilab code Exa 2.13 Negative Clamper

```

1 //Ex2.13
2 //Negative Clamping circuit
3 //let input voltage be V_in=V_p_in*sin(2*%pi*f*t)
4 f=1;    //let frequency be 1Hz
5 T=1/f;
6 V_p_in=24;
7 V_DC=- (V_p_in-0.7);    //DC level added to output

```

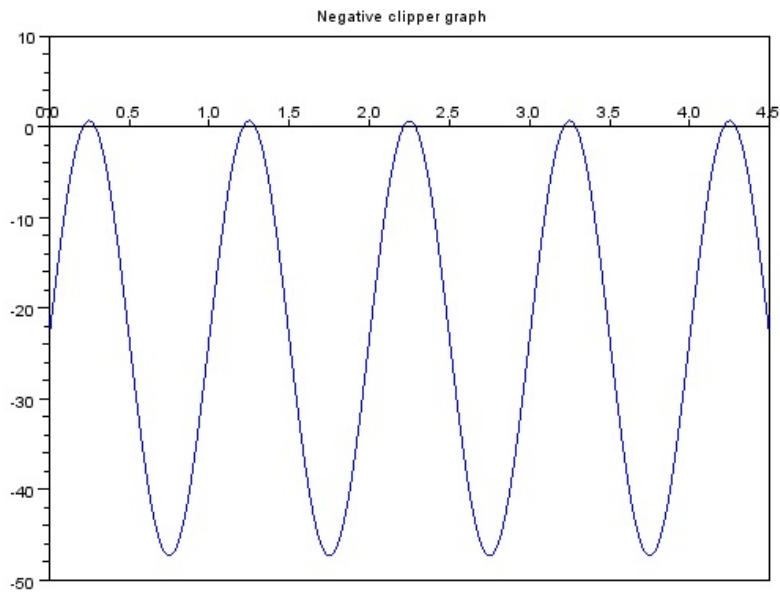


Figure 2.7: Negative Clamper

```
8 disp(V_DC, 'V_DC in volts= ')
9 for n=0:1:8
10     t=n*T/2:0.0005:T.*(n+1)/2;
11     V_in=V_p_in*sin(2*pi*f.*t);
12     Vout=V_DC+V_in;
13     plot(t,Vout)
14 end
15 xtitle('Negative clipper graph')
```

Chapter 3

Special purpose diodes

Scilab code Exa 3.1 Zener impedance

```
1 //ex3.1
2 del_V_Z=50*10^-3; //in volts , from graph
3 del_I_Z=5*10^-3; //in amperes , from rgraph
4 Z_Z=del_V_Z/del_I_Z;
5 disp(Z_Z, 'zener impedance in ohms')
```

Scilab code Exa 3.2 Zener Voltage

```
1 //ex3.2
2 I_ZT=37*10^-3; //IN AMPERES
3 V_ZT=6.8; //IN VOLTS
4 Z_ZT=3.5; //IN OHMS
5 I_Z=50*10^-3; //IN AMPERES
6 DEL_I_Z=I_Z-I_ZT;
7 DEL_V_Z=DEL_I_Z*Z_ZT;
8 V_Z=V_ZT+DEL_V_Z;
9 disp(V_Z, 'voltage across zener terminals (in volts)
when current is 50 mA')
```



```

10 I_Z=25*10^-3;    //IN AMPERES
11 DEL_I_Z=I_Z-I_ZT;
12 DEL_V_Z=DEL_I_Z*Z_ZT;
13 V_Z=V_ZT+DEL_V_Z;
14 disp(V_Z,'voltage across zener terminals (in volts)
    when current is 25 mA')

```

Scilab code Exa 3.3 Temperature coefficient

```

1 //ex3.3
2 V_Z=8.2;    //8.2 volt zener diode
3 TC=0.0005;    //Temperature coefficient (per degree
    celsius)
4 T1=60;    //Temperatures in celsius
5 T2=25;
6 DEL_T=T1-T2;
7 del_V_Z=V_Z*TC*DEL_T;
8 voltage=V_Z+del_V_Z;
9 disp(voltage,'zener voltage at 60 degree celsius')

```

Scilab code Exa 3.4 Zener power dissipation

```

1 //ex3.4
2 P_D_max=400*10^-3;    //power in watts
3 df=3.2*10^-3    //derating factor in watts per
    celsius
4 del_T=(90-50);    //in celsius, temperature
    difference
5 P_D_derated=P_D_max-df*del_T;
6 disp(P_D_derated,'maximum power dissipated at 90
    degree celsius')

```

Scilab code Exa 3.5 Zener voltage regulator

```
1 //ex3.5
2 V_Z=5.1;
3 I_ZT=49*10^-3;
4 I_ZK=1*10^-3;
5 Z_Z=7;
6 R=100;
7 P_D_max=1;
8 //At I_ZK, output voltage
9 V_out=V_Z-(I_ZT-I_ZK)*Z_Z;
10 V_IN_min=I_ZK*R+V_out;
11 I_ZM=P_D_max/V_Z;
12 //at I_ZM, output voltage
13 V_out=V_Z+(I_ZM-I_ZT)*Z_Z;
14 V_IN_max=I_ZM*R+V_out;
15 disp(V_IN_max, 'maximum input voltage in volts that
    can be regulated by the zener diode')
16 disp(V_IN_min, 'minimum input voltage in volts that
    can be regulated by the zener diode')
```

Scilab code Exa 3.6 Regulation Variable load

```
1 //ex3.6
2 V_Z=12;
3 V_IN=24;
4 I_ZK=1*10^-3;
5 I_ZM=50*10^-3;
6 Z_Z=0;
7 R=470;
8 //when I_L=0, I_Z is max and is equal to the total
    circuit current I_T
```

```

 9 I_T=(V_IN-V_Z)/R;
10 I_Z_max=I_T;
11 if I_Z_max<I_ZM then
12     I_L_min=0;
13 end
14 I_L_max=I_T-I_ZK;
15 R_L_min=V_Z/I_L_max;
16 disp(R_L_min,'minimum value of load resistance in
    ohms')
17 disp(I_L_min,'minimum curent in amperes')
18 disp(I_L_max,'maximum curent in amperes')

```

Scilab code Exa 3.7 Zener regulation

```

1 //ex3.7
2 V_IN=24;
3 V_Z=15;
4 I_ZK=0.25*10^-3;
5 I_ZT=17*10^-3;
6 Z_ZT=14;
7 P_D_max=1;
8 //output voltage at I_ZK
9 V_out_1=V_Z-(I_ZT-I_ZK)*Z_ZT;
10 disp(V_out_1,'output voltage in volts at I_ZK')
11 I_ZM=P_D_max/V_Z;
12 //output voltage at I_ZM
13 V_out_2=V_Z+(I_ZM-I_ZT)*Z_ZT;
14 disp(V_out_2,'output voltage in volts a I_ZM')
15 R=(V_IN-V_out_2)/I_ZM;
16 disp(R,'value of R in ohms for maximum zener current
    , no load')
17 disp('closest practical value is 130 ohms')
18 R=130;
19 //for minimum load resistance(max load current)
    zener current is minimum (I_ZK)

```

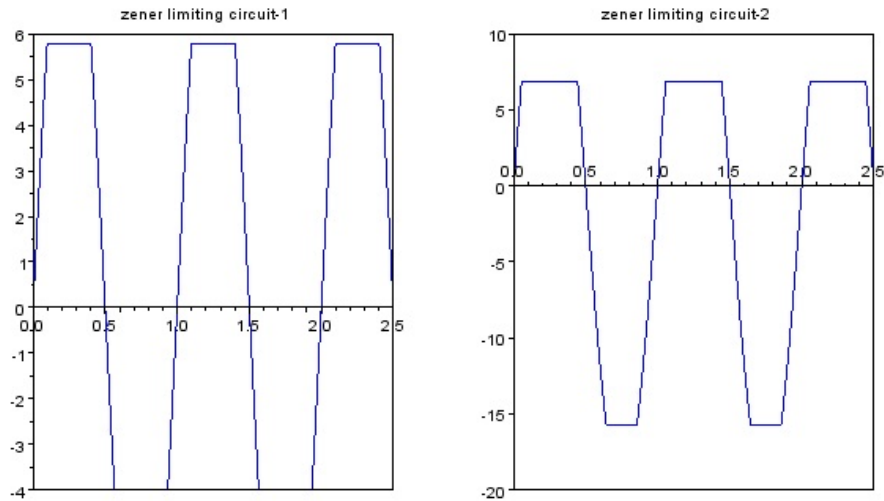


Figure 3.1: Zener limiting

```

20 I_T=(V_IN-V_out_1)/R;
21 I_L=I_T-I_ZK;
22 R_L_min=V_out_1/I_L;
23 disp(R_L_min,'minimum load resistance in ohms')

```

Scilab code Exa 3.8 Zener limiting

```

1 //Ex3.8
2 //let input wave be V_in=V_p_in*sin(2*%pi*f*t)
3 f=1; //Frequency is 1Hz
4 T=1/f;
5 V_p_in=10; //Peak input voltage
6 V_th=0.7; //forward biased zener
7 V_Z1=5.1;

```

```

8 V_Z2=3.3;
9 clf();
10 subplot(121)
11 //let n be double the number of cycles of output
    shown in graph
12 for n=0:1:4
13     t=T.*n/2:0.0005:T.*(n+1)/2    //time for each
        half cycle
14     V_in=V_p_in*sin(2*%pi*f.*t);
15     Vout=V_in;
16     if modulo(n,2)==0 then    //positive half,
        conducts till V_in=5.8V
17         a=bool2s(Vout<(V_Z1+V_th));
18         b=bool2s(Vout>(V_Z1+V_th));
19         y=a.*Vout+(V_Z1+V_th)*b;    //output follows
            input till 5.8V then is constant at 5.8V
20     else    //negative half,
        conducts till V_in=-4V
21         a=bool2s(Vout<-(V_Z2+V_th));
22         b=bool2s(Vout>-(V_Z2+V_th));
23         y=-(V_Z2+V_th)*a+b.*Vout;    //output
            follows input till -4V then stays
            constant at -4V
24     end
25     plot(t,y)
26 end
27 xtitle('zener limiting circuit-1')
28 disp((V_Z1+V_th),'max voltage in volts')
29 disp(-(V_Z2+V_th),'min voltage in volts')
30 subplot(122)
31 xtitle('zener limiting circuit-2')
32 V_p_in=20;
33 V_Z1=6.2;
34 V_Z2=15;
35 //let n be double the number of cycles of output
    shown in graph
36 for n=0:1:4
37     t=T.*n/2:0.0005:T.*(n+1)/2    //time for each

```

```

        half cycle
38     V_in=V_p_in*sin(2*%pi*f.*t);
39     Vout=V_in;
40     if modulo(n,2)==0 then //positive half,
        conducts till V_in=6.9V
41         a=bool2s(Vout<(V_Z1+V_th));
42         b=bool2s(Vout>(V_Z1+V_th));
43         y=a.*Vout+(V_Z1+V_th)*b; //output follows
            input till 6.9V then is constant at 6.9V
44     else //negative half,
        conducts till V_in=-15.7V
45         a=bool2s(Vout<-(V_Z2+V_th));
46         b=bool2s(Vout>-(V_Z2+V_th));
47         y=-(V_Z2+V_th)*a+b.*Vout; //output
            follows input till -15.7V then stays
            constant at -15.7V
48     end
49     plot(t,y)
50     end
51     disp((V_Z1+V_th),'max voltage in volts')
52     disp(-(V_Z2+V_th),'min voltage in volts')

```

Chapter 4

Bipolar Junction Transistors

Scilab code Exa 4.1 DC beta

```
1 //ex4.1
2 I_C=3.65*10^-3; //collector current in amperes
3 I_B=50*10^-6; //base current in amperes
4 B_DC=I_C/I_B;
5 I_E=I_B+I_C;
6 disp(B_DC, 'B_DC')
7 disp(I_E, 'emitter current in amperes')
```

Scilab code Exa 4.2 Current Voltage Analysis

```
1 //ex4.2
2 V_BE=0.7;
3 B_DC=150;
4 V_BB=5;
5 V_CC=10;
6 R_B=10*10^3;
7 R_C=100;
8 I_B=(V_BB-V_BE)/R_B;
```

```

9 I_C=B_DC*I_B;
10 I_E=I_C+I_B;
11 V_CE=V_CC-I_C*R_C;
12 V_CB=V_CE-V_BE;
13 disp(I_B,'base current in amperes')
14 disp(I_C,'collector current in amperes')
15 disp(I_E,'emitter current in amperes')
16 disp(V_CE,'collector to emitter voltage in volts')
17 disp(V_CB,'collector to base voltage in volts')

```

Scilab code Exa 4.3 Collector characteristic curve

```

1 //ex4.3
2 disp('cant be shown')

```

Scilab code Exa 4.4 DC loadline

```

1 //ex4.4
2 V_CE_sat=0.2;
3 V_BE=0.7;
4 V_BB=3;
5 V_CC=10;
6 B_DC=50;
7 R_B=10*10^3;
8 R_C=1*10^3;
9 I_C_sat=(V_CC-V_CE_sat)/R_C;
10 I_B=(V_BB-V_BE)/R_B;
11 I_C=B_DC*I_B;
12 if I_C>I_C_sat then
13     disp('transistor in saturation')
14 else
15     disp('transistor not in saturation')
16 end

```

Scilab code Exa 4.5 Transistor rating

```
1 //ex4.5
2 P_D_max=250*10^-3; //max power rating of
   transistor in watts
3 V_CE=6;
4 I_C=P_D_max/V_CE;
5 disp(I_C,'collector current that can be handled by
   the transistor(in amperes)')
```

Scilab code Exa 4.6 Maximum Transistor Rating

```
1 //ex4.6
2 P_D_max=800*10^-3;
3 V_BE=0.7;
4 V_CE_max=15;
5 I_C_max=100*10^-3;
6 V_BB=5;
7 B_DC=100;
8 R_B=22*10^3;
9 R_C=10^3;
10 I_B=(V_BB-V_BE)/R_B;
11 I_C=B_DC*I_B;
12 V_R_C=I_C*R_C; //voltage drop across R_C
13 V_CC_max=V_CE_max+V_R_C;
14 P_D=I_C*V_CE_max;
15 if P_D<P_D_max then
16     disp(V_CC_max,'V_CC in volts')
17     disp('V_CE_max will be exceeded first
   because entire supply voltage V_CC will be
   dropped across the transistor')
18 end
```

Scilab code Exa 4.7 Derating Power maximum

```
1 //ex4.7
2 df=5*10^-3; //derating factor in watts per degree
   celsius
3 T1=70;
4 T2=25;
5 P_D_max=1; //in watts
6 del_P_D=df*(T1-T2);
7 P_D=P_D_max-del_P_D;
8 disp(P_D, 'Power dissipated max at a temperature of
   70 degree celsius(in watts)')
```

Scilab code Exa 4.8 Transistor amplification

```
1 //ex4.8
2 R_C=1*10^3;
3 r_e=50;
4 V_b=100*10^-3;
5 A_v=R_C/r_e;
6 V_out=A_v*V_b;
7 disp(A_v, 'voltage gain')
8 disp(V_out, 'ac output voltage in volts')
```

Scilab code Exa 4.9 Collector in saturation

```
1 //ex4.9
2 V_CC=10;
3 B_DC=200;
```

```
4 R_C=10^3;
5 V_IN=0;
6 V_CE=V_CC;
7 disp(V_CE,'when V_IN=0, transistor acts as open
      switch(cut-off) and collector emitter voltage in
      volts is ')
8 //now when V_CE_sat is neglected
9 I_C_sat=V_CC/R_C;
10 I_B_min=I_C_sat/B_DC;
11 disp(I_B_min,'minimum value of base current in
      amperes to saturate transistor')
12 V_IN=5;
13 V_BE=0.7;
14 V_R_B=V_IN-V_BE; //voltage across base resistance
15 R_B_max=V_R_B/I_B_min;
16 disp(R_B_max,'maximum value of base resistance in
      ohms when input voltage is 5V')
```

Chapter 5

Transistor Bias Circuits

Scilab code Exa 5.1 DC bias

```
1 //ex5.1
2 V_BB=10;
3 V_CC=20;
4 B_DC=200;
5 R_B=47*10^3;
6 R_C=330;
7 V_BE=0.7;
8 I_B=(V_BB-V_BE)/R_B;
9 I_C=B_DC*I_B; //Q POINT
10 V_CE=V_CC-I_C*R_C; //Q POINT
11 I_C_sat=V_CC/R_C;
12 I_c_peak=I_C_sat-I_C;
13 I_b_peak=I_c_peak/B_DC;
14 disp(I_C,'q point of I_C in amperes')
15 disp(V_CE,'Q point of V_CE in volts')
16 disp(I_b_peak,'peak base current in amperes')
```

Scilab code Exa 5.2 Input resistance

```

1 //ex5.2
2 B_DC=125;
3 R_E=10^3;
4 R_IN_base=B_DC*R_E;
5 disp(R_IN_base, 'DC input resistance in ohms, looking
   in at the base of transistor')

```

Scilab code Exa 5.3 Voltage divider bias

```

1 //ex5.3
2 B_DC=100;
3 R1=10*10^3;
4 R2=5.6*10^3;
5 R_C=1*10^3;
6 R_E=560;
7 V_CC=10;
8 V_BE=0.7
9 R_IN_base=B_DC*R_E;
10 //We can neglect R_IN_base as it is equal to 10*R2
11 disp(R_IN_base, 'input resistance seen from base,
   which can be neglected as it is 10 times R2')
12 V_B=(R2/(R1+R2))*V_CC;
13 V_E=V_B-V_BE;
14 I_E=V_E/R_E;
15 I_C=I_E;
16 V_CE=V_CC-I_C*(R_C+R_E);
17 disp(V_CE, 'V_CE in volts')
18 disp(I_C, 'I_C in amperes')
19 disp('Since V_CE>0V, transistor is not in saturation
   ')

```

Scilab code Exa 5.4 Voltage bias PNP

```

1 //ex5.4
2 V_EE=10;
3 V_BE=0.7;
4 B_DC=150;
5 R1=22*10^3;
6 R2=10*10^3;
7 R_C=2.2*10^3;
8 R_E=1*10^3;
9 R_IN_base=B_DC*R_E; //R_IN_base>10*R2,so it can
    be neglected
10 disp(R_IN_base,'input resistance in ohms as seen
    from base. it can be neglected as it is greater
    than 10 times R2')
11 V_B=(R1/(R1+R2))*V_EE;
12 V_E=V_B+V_BE;
13 I_E=(V_EE-V_E)/R_E;
14 I_C=I_E;
15 V_C=I_C*R_C;
16 V_EC=V_E-V_C;
17 disp(I_C,'I_C collector current in amperes')
18 disp(V_EC,'V_EC emitter-collector voltage in Volts')

```

Scilab code Exa 5.5 PNP Transistor

```

1 //ex5.5
2 R1=68*10^3;
3 R2=47*10^3;
4 R_C=1.8*10^3;
5 R_E=2.2*10^3;
6 V_CC=-6;
7 V_BE=0.7;
8 B_DC=75;
9 R_IN_base=B_DC*R_E;
10 disp('input resistance as seen from base is not
    greater than 10 times R2 so it should be taken

```

```

        into account')
11 //R_IN_base in parallel with R2
12 V_B=((R2*R_IN_base)/(R2+R_IN_base)/(R1+(R2*R_IN_base
        )/(R2+R_IN_base)))*V_CC;
13 V_E=V_B+V_BE;
14 I_E=V_E/R_E;
15 I_C=I_E;
16 V_C=V_CC-I_C*R_C;
17 V_CE=V_C-V_E;
18 disp(I_C,'collector current in amperes')
19 disp(V_CE,'collector emitter voltage in volts')

```

Scilab code Exa 5.6 Qpoint base bias

```

1 //ex5.6
2 V_CC=12;
3 R_B=100*10^3;
4 R_C=560;
5 //FOR B_DC=85 AND V_BE=0.7V
6 B_DC=85;
7 V_BE=0.7;
8 I_C_1=B_DC*(V_CC-V_BE)/R_B;
9 V_CE_1=V_CC-I_C_1*R_C;
10 //FOR B_DC=100 AND V_BE=0.6V
11 B_DC=100;
12 V_BE=0.6;
13 I_C_2=B_DC*(V_CC-V_BE)/R_B;
14 V_CE_2=V_CC-I_C_2*R_C;
15 %_del_I_C=((I_C_2-I_C_1)/I_C_1)*100;
16 %_del_V_CE=((V_CE_2-V_CE_1)/V_CE_1)*100;
17 disp(%_del_I_C,'percent change in collector current'
        )
18 disp(%_del_V_CE,'percent change in collector emitter
        voltage')

```

Scilab code Exa 5.7 Emitter bias

```
1 //ex5.7
2 V_CC=20;
3 R_C=4.7*10^3;
4 R_E=10*10^3;
5 V_EE=-20;
6 R_B=100*10^3;
7 //FOR B_DC=85 AND V_BE=0.7V
8 B_DC=85;
9 V_BE=0.7;
10 I_C_1=(-V_EE-V_BE)/(R_E+(R_B/B_DC));
11 V_C=V_CC-I_C_1*R_C;
12 I_E=I_C_1;
13 V_E=V_EE+I_E*R_E;
14 V_CE_1=V_C-V_E;
15 disp(I_C_1)
16 disp(V_CE_1)
17 //FOR B_DC=100 AND V_BE=0.6V
18 B_DC=100;
19 V_BE=0.6;
20 I_C_2=(-V_EE-V_BE)/(R_E+(R_B/B_DC));
21 V_C=V_CC-I_C_2*R_C;
22 I_E=I_C_2;
23 V_E=V_EE+I_E*R_E;
24 V_CE_2=V_C-V_E;
25 disp(I_C_2)
26 disp(V_CE_2)
27 %_del_I_C=((I_C_2-I_C_1)/I_C_1)*100;
28 %_del_V_CE=((V_CE_2-V_CE_1)/V_CE_1)*100;
29 disp(%_del_I_C,'percent change in collector current
      ')
30 disp(%_del_V_CE,'percent change in collector emitter
      voltage')
```


31 //plz note that the answers differ because of the
number of places after the decimal that scilab
generates

Scilab code Exa 5.8 Q point

```
1 //ex5.8
2 V_CC=10;
3 B_DC=100;
4 R_C=10*10^3;
5 R_B=100*10^3;
6 V_BE=0.7;
7 I_C=(V_CC-V_BE)/(R_C+(R_B/B_DC));
8 V_CE=V_CC-I_C*R_C;
9 disp(I_C,'Q point of collector current in amperes')
10 disp(V_CE,'Q point of collector-emitter voltage in
    volts ' )
```

Chapter 6

BJT Amplifiers

Scilab code Exa 6.1 Linear amplifier

```
1 //ex6.1
2 disp('graph question , cannot be solved in scilab')
```

Scilab code Exa 6.2 AC Emitter resistance

```
1 //ex6.2
2 I_E=2*10^-3;
3 r_e=25*10^-3/I_E;
4 disp(r_e,'ac emitter resistance in ohms')
```

Scilab code Exa 6.3 Base voltage

```
1 //ex6.3
2 I_E=3.8*10^-3;
3 B_ac=160;
4 R1=22*10^3;
```

```

5 R2=6.8*10^3;
6 R_s=300;
7 V_s=10*10^-3;
8 r_e=25*10^-3/I_E;
9 R_in_base=B_ac*r_e;
10 R_in_tot=(R1*R2*R_in_base)/(R_in_base*R1+R_in_base*
    R2+R1*R2);
11 V_b=(R_in_tot/(R_in_tot+R_s))*V_s;
12 disp(V_b,'voltage at the base of the transistor in
    volts')

```

Scilab code Exa 6.4 Emitter bypass capacitor

```

1 //ex6.4
2 R_E=560;
3 f=2*10^3; //minimum value of frequency in hertz
4 X_C=R_E/10; //minimum value of capacitive
    reactance
5 C2=1/(2*%pi*X_C*f);
6 disp(C2,'value of bypass capacitor in farads')

```

Scilab code Exa 6.5 Effect bypass capacitor

```

1 //ex6.5
2 r_e=6.58; //from ex6.3
3 R_C=1*10^3;
4 R_E=560;
5 A_v=R_C/(R_E+r_e);
6 disp(A_v,'gain without bypass capacitor')
7 A_v=R_C/r_e;
8 disp(A_v,'gain in the presence of bypass capacitor')

```

Scilab code Exa 6.6 Gain with load

```
1 //ex6.6
2 R_C=10^3;
3 R_L=5*10^3;
4 r_e=6.58;
5 R_c=(R_C*R_L)/(R_C+R_L);
6 disp(R_c,'ac collector resistor in ohms')
7 A_v=R_c/r_e;
8 disp(A_v,'gain with load')
```

Scilab code Exa 6.7 Gain swamped amplifier

```
1 //ex6.7
2 R_C=3.3*10^3;
3 R_E1=330;
4 A_v=R_C/R_E1;
5 disp(A_v,'approximate voltage gain as R_E2 is
  bypassed by C2')
```

Scilab code Exa 6.8 Common emitter amplifier

```
1 //ex6.8
2 B_DC=150;
3 B_ac=175;
4 V_CC=10;
5 V_s=10*10^-3;
```

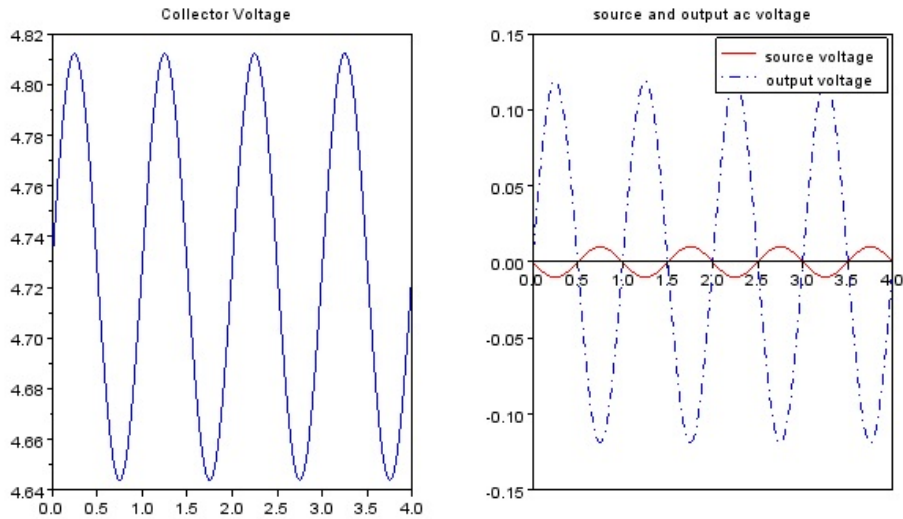


Figure 6.1: Common emitter amplifier

```

6 R_s=600;
7 R1=47*10^3;
8 R2=10*10^3;
9 R_E1=470;
10 R_E2=470;
11 R_C=4.7*10^3;
12 R_L=47*10^3;
13 R_IN_base=B_DC*(R_E1+R_E2);
14 //since R_IN_base is ten times more than R2,it can
    be neglected in DC voltage calculation
15 V_B=(R2/(R2+R1))*V_CC;
16 V_E=V_B-0.7;
17 I_E=V_E/(R_E1+R_E2);
18 I_C=I_E;
19 V_C=V_CC-I_C*R_C;
20 disp(V_C,'dc collector voltage in volts')
21 r_e=25*10^-3/I_E;
22 //base resistance

```

```

23 R_in_base=B_ac*(r_e+R_E1);
24 //total input resistance
25 R_in_tot=(R1*R2*R_in_base)/(R1*R2+R_in_base*R1+
    R_in_base*R2);
26 attenuation=R_in_tot/(R_s+R_in_tot);
27 //ac collector resistance
28 R_c=R_C*R_L/(R_C+R_L);
29 //voltage gain from base to collector
30 A_v=R_c/R_E1;
31 //overall voltage gain A_V
32 A_V=A_v*attenuation;
33 //rms voltage at collector V_c
34 V_c=A_V*V_s;
35 Max_V_c_p=V_C+sqrt(2)*V_c;
36 Min_V_c_p=V_C-sqrt(2)*V_c;
37 V_out_p=sqrt(2)*V_c;
38 //assume frequency to be 1Hz
39 f=1;
40 t=0:0.0005:4;
41 y=V_C+V_c*sin(2*pi*f.*t);
42 clf();
43 subplot(121)
44 xtitle('Collector Voltage')
45 plot(t,y)
46 subplot(122)
47 xtitle('source and output ac voltage')
48 x=-V_s*sin(2*f*pi.*t);
49 z=V_out_p*sin(2*pi*f.*t);
50 plot(t,x,'r')
51 plot(t,z,'-')
52 h1=legend(['source voltage';'output voltage'])

```

Scilab code Exa 6.9 Current gain

```
1 //ex6.9
```

```

2  R_E=10^3;
3  R_L=10^3;
4  R1=18*10^3;
5  R2=18*10^3;
6  B_ac=175;
7  V_CC=10;
8  V_BE=0.7;
9  V_in=1;
10 //ac emitter resistance R_e
11 R_e=(R_E*R_L)/(R_E+R_L);
12 //resistance from base R_in_base
13 R_in_base=B_ac*R_e;
14 //total input resistance R_in_tot
15 R_in_tot=(R1*R2*R_in_base)/(R1*R2+R1*R_in_base+R2*
    R_in_base);
16 disp(R_in_tot,'total input resistance in ohms')
17 V_E=((R2/(R1+R2))*V_CC)-V_BE;
18 I_E=V_E/R_E;
19 r_e=25*10^-3/I_E;
20 A_v=R_e/(r_e+R_e);
21 disp(A_v,'voltage gain')
22 //ac emitter current I_e
23 //V_e=A_v*V_b=1V
24 V_e=1;
25 I_e=V_e/R_e;
26 I_in=V_in/R_in_tot;
27 A_i=I_e/I_in; //current gain
28 disp(A_i,'current gain')
29 A_p=A_i; //power gain
30 //since R_L=R_E, one half of the total power is
    dissipated to R_L
31 A_p_load=A_p/2;
32 disp(A_p_load,'power gain delivered to load')

```

Scilab code Exa 6.10 Darlington emitter follower

```

1 //ex6.10
2 V_CC=12;
3 V_BE=0.7;
4 R_C=10^3;
5 r_e_ce=5; //for common emitter amplifier
6 R1=10*10^3;
7 R2=22*10^3;
8 R_E=22;
9 R_L=8;
10 B_DC=100;
11 B_ac=100;
12 V_B=((R2*B_DC^2*R_E/(R2+B_DC^2*R_E))/(R1+(R2*B_DC^2*
    R_E/(R2+B_DC^2*R_E))))*V_CC;
13 V_E=V_B-2*V_BE;
14 I_E=V_E/R_E;
15 r_e=25*10^-3/I_E; //for darlington emitter-
    follower
16 P_R_E=I_E^2*R_E; //power dissipated by R_E
17 P_Q2=(V_CC-V_E)*I_E //power dissipated by
    transistor Q2
18 R_e=R_E*R_L/(R_E+R_L); //ac emitter resistance of
    darlington emitter follower
19 R_in_tot=R1*R2*B_ac^2*(R_e+r_e)/(R1*R2+R1*B_ac^2*(
    r_e+R_e)+R2*B_ac^2*(r_e+R_e)); //total input
    resistance of darlington
20 R_c=R_C*R_in_tot/(R_C+R_in_tot); //effective ac
    resistance
21 A_v_CE=R_c/r_e_ce;
22 disp(A_v_CE,'voltage gain of common emitter
    amplifier')
23 A_v_EF=R_e/(r_e+R_e);
24 disp(A_v_EF,'voltage gain of darlington emitter
    follower')
25 A_v=A_v_CE*A_v_EF;
26 disp(A_v,'overall voltage gain')

```

Scilab code Exa 6.11 Common base amplifier

```
1 //ex6.11
2 B_DC=250;
3 R_C=2.2*10^3;
4 R_E=1*10^3;
5 R_L=10*10^3;
6 R1=56*10^3;
7 R2=12*10^3;
8 V_BE=0.7;
9 V_CC=10;
10 //since B_DC*R_E>>R2
11 V_B=(R2/(R1+R2))*V_CC;
12 V_E=V_B-V_BE;
13 I_E=V_E/R_E;
14 r_e=25*10^-3/I_E;
15 R_in=r_e; //input resistance
16 R_c=R_C*R_L/(R_C+R_L); //ac collector resistance
17 A_v=R_c/r_e;
18 //current gain is almost 1
19 //power gain is approximately equal to voltage gain
20 A_p=A_v;
21 A_i=1;
22 disp(R_in,'input resistance in ohms')
23 disp(A_v,'voltage gain')
24 disp(A_i,'current gain')
25 disp(A_p,'power gain')
```

Scilab code Exa 6.12 Voltage gain decibel

```
1 //ex6.12
2 A_v1=10;
```

```
3 A_v2=15;
4 A_v3=20;
5 A_v=A_v1*A_v2*A_v3;    //overall voltage gain
6 disp(A_v,'overall voltage gain')
7 A_v1_dB=gain_in_decibel_voltage(A_v1);
8 A_v2_dB=gain_in_decibel_voltage(A_v2);
9 A_v3_dB=gain_in_decibel_voltage(A_v3);
10 A_v_dB=A_v1_dB+A_v2_dB+A_v3_dB;
11 disp(A_v_dB,'total voltage gain in decibels')
```

Chapter 7

Field Effect Transistors

Scilab code Exa 7.1 cutoff FET

```
1 //ex7.1
2 V_GS_off=-4;
3 I_DSS=12*10^-3;
4 R_D=560;
5 V_P=-1*V_GS_off;
6 V_DS=V_P;
7 I_D=I_DSS;
8 V_R_D=I_D*R_D; //voltage across resistor
9 V_DD=V_DS+V_R_D;
10 disp(V_DD,'The value of V_DD required to put the
    device in the constant current area of operation
    of JFET')
```

Scilab code Exa 7.2 Drain current

```
1 //ex7.2
2 disp('The p-channel JFET requires a positive gate to
    source voltage. The more positive the voltage,
```

the lesser the drain current. Any further increase in V_{GS} keeps the JFET cut off, so I_D remains 0')

check Appendix [AP 6](#) for dependency:

value_of_I_D.sci

Scilab code Exa 7.3 JFET current voltage

```
1 //ex7.3
2 I_DSS=9*10^-3;
3 V_GS_off=-8;
4 V_GS=0;
5 I_D=value_of_I_D(9*10^-3,0,-8);
6 disp(I_D,'Value of I_D for V_GS=0V')
7 I_D=value_of_I_D(9*10^-3,-1,-8);
8 disp(I_D,'Value of I_D for V_GS=-1V')
9 I_D=value_of_I_D(9*10^-3,-4,-8);
10 disp(I_D,'Value of I_D for V_GS=-4V')
```

check Appendix [AP 6](#) for dependency:

value_of_I_D.sci

Scilab code Exa 7.4 JFET transconductance

```
1 //ex7.4
2 I_DSS=3*10^-3;
3 V_GS_off=-6;
4 y_fs_max=5000*10^-6;
5 V_GS=-4;
6 g_m0=y_fs_max;
7 g_m=g_m0*(1-(V_GS/V_GS_off));
```

```
8 I_D=value_of_I_D(3*10^-3,-4,-6)
9 disp(g_m,'forward transconductance in Siemens')
10 disp(I_D,'value of I D in amperes')
```

Scilab code Exa 7.5 JFET input resistance

```
1 V_GS=-20;
2 I_GSS=-2*10^-9;
3 R_IN=abs((-20/(2*10^-9)))
4 disp(R_IN,'Input Resistance in Ohms')
```

Scilab code Exa 7.6 Self bias

```
1 //ex7.5
2 V_DD=15;
3 V_G=0;
4 I_D=5*10^-3;
5 R_D=1*10^3;
6 R_G=10*10^6;
7 R_S=220;
8 V_S=I_D*R_S;
9 V_D=V_DD-I_D*R_D;
10 V_DS=V_D-V_S;
11 V_GS=V_G-V_S;
12 disp(V_DS,'Drain to source voltage in volts');
13 disp(V_GS,'Gate to source voltage in volts');
```

Scilab code Exa 7.7 Q point JFET

```
1 //ex7.6
```

```

2 I_D=6.25*10^-3;
3 V_GS=-5;
4 R_G=abs((V_GS/I_D))
5 disp(R_G,'Gate resistance in Ohms')

```

check Appendix [AP 6](#) for dependency:

value_of_I_D.sci

Scilab code Exa 7.8 Self bias Q point

```

1 //EX7.8
2 I_DSS=25*10^-3;
3 V_GS_off=15;
4 V_GS=5;
5 I_D=value_of_I_D(25*10^-3,5,15)
6 R_S=abs((V_GS/I_D))
7 disp(I_D,'Drain current in Amperes')
8 disp(R_S,'Source resistance in Ohms')

```

Scilab code Exa 7.9 Midpoint bias

```

1 //ex7.9
2 I_DSS=12*10^-3;
3 V_GS_off=-3;
4 V_DD=12;
5 V_D=6;
6 I_D=I_DSS/2; //MIDPOINT BIAS
7 V_GS=V_GS_off/3.4; //MIDPOINT BIAS
8 R_S=abs((V_GS/I_D))
9 R_D=(V_DD-V_D)/I_D
10 disp(R_S,'Source Resistance in Ohms')
11 disp(R_D,'Drain Resistance in Ohms')

```

Scilab code Exa 7.10 Graphical analysis

```
1 //ex7.10
2 R_S=680;
3 I_D=0;
4 V_GS=I_D*R_S; //FOR I_D=0A
5 disp(V_GS, 'V_GS in Volts , at I_D=0A')
6 I_DSS=4*10^-3;
7 I_D=I_DSS;
8 V_GS=I_D*R_S; //FOR I_D=4mA
9 disp(V_GS, 'V_GS in Volts , at I_D=4mA')
10 disp('Plotting load line using the values of V_GS at
      I_D=0 and 4mA, we find the intersection of load
      line with transfer characteristic to get Q-point
      values of V_GS=-1.5V and I_D=2.25mA')
```

Scilab code Exa 7.11 Voltage Divider bias

```
1 //ex7.11
2 V_DD=12;
3 V_D=7;
4 R_D=3.3*10^3;
5 R_S=2.2*10^3;
6 R_1=6.8*10^6;
7 R_2=1*10^6;
8 I_D=(V_DD-V_D)/R_D;
9 V_S=I_D*R_S;
10 V_G=(R_2/(R_1+R_2))*V_DD;
11 V_GS=V_G-V_S;
12 disp(I_D, 'Drain current in amperes')
13 disp(V_GS, 'Gate to source voltage in volts')
```

Scilab code Exa 7.12 Graph voltage divider

```
1 //ex7.12
2 R_1=2.2*10^6;
3 R_2=R_1;
4 V_DD=8;
5 R_S=3.3*10^3;
6 V_GS=(R_2/(R_1+R_2))*V_DD; //FOR I_D=0A
7 V_G=V_GS;
8 disp(V_GS,'V_GS in Volts , at I_D=0A')
9 I_D=(V_G-0)/R_S; //FOR V_GS=0V
10 disp(I_D,'I_D in Amperes , at V_GS=0V')
11 disp('Plotting load line using the value of V_GS=4V
    at I_D=0 and I_D=1.2mA at V_GS=0V, we find the
    intersection of load line with transfer
    characteristic to get Q-point values of V_GS=-1.8
    V and I_D=1.8mA')
```

check Appendix [AP 6](#) for dependency:

value_of_I_D.sci

Scilab code Exa 7.13 DMOSFET

```
1 //ex7.13
2 I_DSS=10*10^-3;
3 V_GS_off=-8;
4 V_GS=-3;
5 I_D=value_of_I_D(10*10^-3,-3,-8)
6 disp(I_D,'Drain current when V_GS=-3V in Amperes')
7 V_GS=3;
8 I_D=value_of_I_D(10*10^-3,3,-8)
9 disp(I_D,'Drain current when V_GS=3V in Amperes')
```

check Appendix [AP 5](#) for dependency:

value_of_K.sci

Scilab code Exa 7.14 EMOSFET

```
1 //EX7.14
2 I_D_on=500*10^-3;
3 V_GS=10;
4 V_GS_th=1;
5 K=value_of_K(500*10^-3,10,1)
6 V_GS=5;
7 I_D=K*(V_GS-V_GS_th)^2;
8 disp(I_D,'Drain current')
```

Scilab code Exa 7.15 DMOSFET bias

```
1 //ex7.15
2 I_DSS=12*10^-3;
3 V_DD=18;
4 R_D=620;
5 I_D=I_DSS;
6 V_DS=V_DD-I_D*R_D;
7 disp(V_DS,'Drain to source voltage in volts')
```

check Appendix [AP 5](#) for dependency:

value_of_K.sci

Scilab code Exa 7.16 EMOSFET bias

```

1 //ex7.16
2 I_D_on=200*10^-3;
3 V_DD=24;
4 R_D=200;
5 V_GS=4;
6 V_GS_th=2;
7 R_1=100*10^3;
8 R_2=15*10^3;
9 K=value_of_K(200*10^-3,4,2)
10 V_GS=(R_2/(R_1+R_2))*V_DD;
11 I_D=K*(V_GS-V_GS_th)^2;
12 V_DS=V_DD-I_D*R_D;
13 disp(V_DS,'Drain to Source voltage in Volts')
14 disp(V_GS,'Gate to Source voltage in Volts')

```

Scilab code Exa 7.17 EMOSFET drain current

```

1 //EX7.17
2 V_GS_on=3;
3 V_GS=8.5; //DISPLAYED ON METER
4 V_DS=V_GS;
5 V_DD=15;
6 R_D=4.7*10^3;
7 I_D=(V_DD-V_DS)/R_D;
8 disp(I_D,'Drain current in Amperes')

```

Chapter 8

FET Amplifiers

Scilab code Exa 8.1 Voltage gain

```
1 //ex8.1
2 g_m=4*10^-3;
3 R_d=1.5*10^3;
4 A_v=g_m*R_d;
5 disp(A_v, 'Voltage gain')
```

Scilab code Exa 8.2 Rds effect

```
1 //ex8.2
2 r_ds=10*10^3;
3 R_d=1.5*10^3; //from previous question
4 g_m=4*10^-3; //from previous question
5 A_v=g_m*((R_d*r_ds)/(R_d+r_ds));
6 disp(A_v, 'Voltage gain')
```

Scilab code Exa 8.3 External source resistance

```

1 //ex8.3
2 R_s=560;
3 R_d=1.5*10^3;
4 g_m=4*10^-3;
5 A_v=(g_m*R_d)/(1+(g_m*R_s))
6 disp(A_v, 'Voltage gain')

```

Scilab code Exa 8.4 Unloaded amplifier

```

1 //ex8.4
2 V_DD=12;
3 V_in=100*10^-3;
4 R_D=3.3*10^3;
5 I_DSS=12*10^-3;
6 V_GS_off=-3;
7 R_S=910;
8 a=(R_S^2)/(V_GS_off^2); //we take V_GS_off
    positive so that we take current negative
9 b=(-1)*(((2*R_S)/(V_GS_off))-(1/I_DSS));
10 c=1;
11 p1=poly([c b a], 'x', 'c')
12 A=roots(p1)
13 I_D=(-1)*A(1); //make the value of current
    positive
14 V_D=V_DD-I_D*R_D;
15 V_GS=-I_D*R_S;
16 g_m0=(2*I_DSS)/(abs(V_GS_off));
17 g_m=g_m0*(1-(V_GS/V_GS_off));
18 V_out=g_m*R_D*V_in; //rms value
19 v_out=V_out*1.414*2; //peak to peak dc value
20 disp(v_out, 'output dc voltage (peak to peak) in
    volts')

```

Scilab code Exa 8.5 AC load effect

```
1 //ex8.5
2 R_D=3.3*10^3;
3 R_L=4.7*10^3;
4 R_d=(R_D*R_L)/(R_D+R_L);    //Equivalent drain
    resistance
5 g_m=3.25*10^-3;    //from previous question
6 V_in=100*10^-3;    //previous question
7 V_out=g_m*R_d*V_in;
8 disp(V_out, 'Output voltage rms value in Volts')
```

Scilab code Exa 8.6 Input resistance

```
1 //ex8.6
2 I_GSS=30*10^-9;
3 V_GS=10;
4 R_G=10*10^6;
5 R_IN_gate=V_GS/I_GSS;
6 R_in=(R_IN_gate*R_G)/(R_IN_gate+R_G);    //parallel
    combination
7 disp(R_in, 'Input resistance in ohms, as seen by
    signal source')
```

Scilab code Exa 8.7 DMOSFET amplifier

```
1 //ex8.7
2 I_DSS=200*10^-3;
3 g_m=200*10^-3;
4 V_in=500*10^-3;
5 V_DD=15;
6 R_D=33;
7 R_L=8.2*10^3;
```

```

8 I_D=I_DSS; // Amplifier is zero biased
9 V_D=V_DD-I_D*R_D;
10 R_d=(R_D*R_L)/(R_D+R_L);
11 V_out=g_m*R_d*V_in;
12 disp(V_D,'DC output voltage in Volts')
13 disp(V_out,'AC output voltage in volts')

```

Scilab code Exa 8.8 MOSFET Q points

```

1 //ex8.8
2 disp('Part A: Q point: V_GS=-2V I_D=2.5mA. At V_GS
   =-1V, I_D=3.4mA, At V_GS=-3V, I_D=1.8mA. So peak
   to peak drain current is the difference of the
   two drain currents=1.6mA')
3 disp('Part B: Q point: V_GS=0V I_D=4mA. At V_GS=1V,
   I_D=5.3mA, At V_GS=-1V, I_D=2.5mA. So peak to
   peak drain current is the difference of the two
   drain currents=2.8mA')
4 disp('Part C: Q point: V_GS=8V I_D=2.5mA. At V_GS=9V
   , I_D=3.9mA, At V_GS=7V, I_D=1.7mA. So peak to
   peak drain current is the difference of the two
   drain currents=2.2mA')

```

check Appendix [AP 5](#) for dependency:

value_of_K.sci

Scilab code Exa 8.9 EMOSFET amplifier

```

1 //ex8.9
2 R_1=47*10^3;
3 R_2=8.2*10^3;
4 R_D=3.3*10^3;

```

```

5 R_L=33*10^3;
6 I_D_on=200*10^-3;
7 V_GS=4;
8 V_GS_th=2;
9 g_m=23*10^-3;
10 V_in=25*10^-3;
11 V_DD=15;
12 V_GS=(R_2/(R_1+R_2))*V_DD;
13 K=value_of_K(200*10^-3,4,2);
14 I_D=K*(V_GS-V_GS_th)^2;
15 V_DS=V_DD-I_D*R_D;
16 R_d=(R_D*R_L)/(R_D+R_L);
17 V_out=g_m*V_in*R_d;
18 disp(V_DS,'Drain to source voltage in volts(V_DS)')
19 disp(I_D,'Drain current (I_D) inAmperes')
20 disp(V_GS,'Gate to source voltage (V_GS) in volts')
21 disp(V_out,'AC output voltage in volts')

```

Scilab code Exa 8.10 Common gate amplifier

```

1 //ex8.10
2 V_DD=-15; //p=channel MOSFET
3 g_m=2000*10^-6; //minimum value from datasheets
4 R_D=10*10^3;
5 R_L=10*10^3;
6 R_S=4.7*10^3;
7 R_d=(R_D*R_L)/(R_D+R_L); //effective drain
  resistance
8 A_v=g_m*R_d;
9 R_in_source=1/g_m;
10 R_in=(R_in_source*R_S)/(R_in_source+R_S); //
  signal souce sees R_S in parallel with input
  resistance at source terminal(R_in_source)
11 disp(A_v,'minimum voltage gain')
12 disp(R_in,'Input resistance seen from signal source')

```

in ohms ')

Chapter 9

Power Amplifiers

Scilab code Exa 9.1 classA power amplifier

```
1 //ex9.1
2 V_CC=15;
3 R_C=1*10^3;
4 R_1=20*10^3;
5 R_2=5.1*10^3;
6 R_3=5.1*10^3;
7 R_4=15*10^3;
8 R_E_1=47;
9 R_E_2=330;
10 R_E_3=16;
11 R_L=16; //SPEAKER IS THE LOAD;
12 B_ac_Q1=200;
13 B_ac_Q2=B_ac_Q1;
14 B_ac_Q3=50;
15 //R_c1=R_C || [ R_3 || R_4 || B_acQ2*B_ac_Q3*(R_E_3 || R_L) ]
    is ac collector resistance
16 R=(R_E_3*R_L)/(R_E_3+R_L);
17 R=B_ac_Q2*B_ac_Q3*R;
18 R=(R*R_4)/(R+R_4);
19 R=(R*R_3)/(R+R_3);
20 R_c1=(R*R_C)/(R_C+R); //ac collector resistance
```

```

21 //V_B=((R_2||(B_acQ1*(R_E_1+R_E_2)))/(R_1+(R_2||
    B_acQ1*(R_E_1+R_E_2)))*V_CC;
22 //This is the base voltage;
23 //LET R=(R_2||(B_acQ1*(R_E_1+R_E_2)))
24 R=(R_2*B_ac_Q1*(R_E_1+R_E_2))/(R_2+B_ac_Q1*(R_E_1+
    R_E_2));
25 V_B=R*V_CC/(R_1+R);
26 I_E=(V_B-0.7)/(R_E_1+R_E_2);
27 r_e_Q1=25*10^-3/I_E;
28 A_v1=(-1)*(R_c1)/(R_E_1+r_e_Q1); //voltage gain
    of 1st stage
29 //total input resistance of 1st stage is R_in_tot_1=
    R_1||R_2||B_ac_Q1*(R_E_1+r_e_Q1);
30 R_in_tot_1=(R_1*(R_2*B_ac_Q1*(R_E_1+r_e_Q1)/(R_2+
    B_ac_Q1*(R_E_1+r_e_Q1)))/(R_1+(R_2*B_ac_Q1*(
    R_E_1+r_e_Q1)/(R_2+B_ac_Q1*(R_E_1+r_e_Q1))));
31 A_v2=1; //gain of darlington voltage-follower
32 A_v_tot=A_v1*A_v2; //total gain
33 A_p=(A_v_tot^2)*(R_in_tot_1/R_L); //power gain
34 disp(A_v_tot,'Voltage gain')
35 disp(A_p,'Power gain')

```

Scilab code Exa 9.2 class A efficiency

```

1 //ex9.2
2 V_in=176*10^-3;
3 R_in=2.9*10^3; //total input resistance from
    previous question
4 A_p=42429; //power gain from previous question
5 V_CC=15;
6 I_CC=0.6; //emitter current
7 P_in=V_in^2/R_in;
8 P_out=P_in*A_p;
9 P_DC=I_CC*V_CC;
10 eff=P_out/P_DC;

```

```
11 disp(eff, 'efficiency ')
```

Scilab code Exa 9.3 class AB pushpull

```
1 //ex9.3
2 V_CC=20;
3 R_L=16;
4 V_out_peak=V_CC;
5 I_out_peak=V_CC/R_L;
6 disp(V_out_peak, 'ideal maximum peak output voltage
   in volts')
7 disp(I_out_peak, 'ideal maximum current in amperes')
```

Scilab code Exa 9.4 Single supply pushpull

```
1 //ex9.4
2 V_CC=20;
3 R_L=16;
4 V_out_peak=V_CC/2;
5 I_out_peak=V_out_peak/R_L;
6 disp(V_out_peak, 'ideal maximum output peak voltage
   in volts')
7 disp(I_out_peak, 'ideal maximum current in amperes')
```

Scilab code Exa 9.5 Power of amplifier

```
1 //ex9.5
2 V_CC=20;
3 R_L=8;
4 B_ac=50;
```

```

5  r_e=6;
6  V_out_peak=V_CC/2;
7  V_CEQ=V_out_peak;
8  I_out_peak=V_CEQ/R_L;
9  I_c_sat=I_out_peak;
10 P_out=0.25*I_c_sat*V_CC;
11 P_DC=(I_c_sat*V_CC)/%pi;
12 R_in=B_ac*(r_e+R_L);
13 disp(P_out, 'maximum ac output power in Watts');
14 disp(P_DC, 'maximum DC output power in Watts');
15 disp(R_in, 'input resistance in ohms');

```

Scilab code Exa 9.6 MOSFET pushpull amplifier

```

1  //ex9.6
2  V_DD=24;
3  V_in=100*10^-3;
4  R1=440;
5  R2=5.1*10^3;
6  R3=100*10^3;
7  R4=10^3;
8  R5=100;
9  R7=15*10^3;
10 R_L=33;
11 V_TH_Q1=2;
12 V_TH_Q2=-2;
13 I_R1=(V_DD-(-V_DD))/(R1+R2+R3);
14 V_B=V_DD-I_R1*(R1+R2); //BASE VOLTAGE
15 V_E=V_B+0.7; //EMITTER VOLTAGE
16 I_E=(V_DD-V_E)/(R4+R5); //EMITTER CURRENT
17 V_R6=V_TH_Q1-V_TH_Q2; //VOLTAGE DROP ACROSS R6
18 I_R6=I_E;
19 R6=V_R6/I_R6;
20 r_e=25*10^-3/I_E; //UNBYPASSED EMITTER RESISTANCE
21 A_v=R7/(R5+r_e); //VOLTAGE GAIN

```

```

22 V_out=A_v*V_in;
23 P_L=V_out^2/R_L;
24 disp(R6,'value of resistance R6 in ohms fot AB
      operation ')
25 disp(P_L,'power across load in watts')

```

Scilab code Exa 9.7 class C amplifier

```

1 //ex9.7
2 f=200*10^3; //frequency in hertz
3 I_c_sat=100*10^-3;
4 V_ce_sat=0.2;
5 t_on=1*10^-6;
6 T=1/f; //time period of signal
7 P_D_avg=(t_on/T)*I_c_sat*V_ce_sat;
8 disp(P_D_avg,'average power dissipation in Watts')

```

Scilab code Exa 9.8 class C efficiency

```

1 //ex9.8
2 P_D_avg=4*10^-3; //from previous question
3 V_CC=24;
4 R_c=100;
5 P_out=(0.5*V_CC^2)/R_c;
6 n=(P_out)/(P_out+P_D_avg); //n is efficiency
7 disp(n,'efficiency')

```

Chapter 10

Amplifier Frequency Response

check Appendix [AP 4](#) for dependency:

```
gain_in_decibel_power.sci
```

check Appendix [AP 3](#) for dependency:

```
gain_in_decibel_voltage.sci
```

Scilab code Exa 10.1 Gain in decibel

```
1 //ex10.1
2 //P out/P in=250;
3 A_p_dB=gain_in_decibel_power(250)
4 disp(A_p_dB,'Power gain when power gain is 250')
5 A_p_dB=gain_in_decibel_power(100)
6 disp(A_p_dB,'Power gain when power gain is 100')
7 A_v_dB=gain_in_decibel_voltage(10)
8 disp(A_v_dB,'Voltage gain when voltage gain is 10')
9 A_v_dB=gain_in_decibel_power(0.5)
10 disp(A_v_dB,'Power gain when voltage gain is 0.5')
11 A_v_dB=gain_in_decibel_voltage(0.707)
12 disp(A_v_dB,'Voltage gain when voltage gain is 0.707
    ')
```

Scilab code Exa 10.2 Critical frequency

```
1 //ex10.2
2 //input voltage=10V
3 //at -3dB voltage gain from table is 0.707
4 v_out=0.707*10;
5 disp(v_out,'output voltage in volts at -3dB gain')
6 //at -6dB voltage gain from table is 0.5
7 v_out=0.5*10;
8 disp(v_out,'output voltage in volts at -6dB gain')
9 //at -12dB voltage gain from table is 0.25
10 v_out=0.25*10;
11 disp(v_out,'output voltage in volts at -12dB gain')
12 //at -24dB voltage gain from table is 0.0625
13 v_out=0.0625*10;
14 disp(v_out,'output voltage in volts at -24dB gain')
```

Scilab code Exa 10.3 Lower critical frequency

```
1 //ex10.3
2 R_in=1*10^3;
3 C1=1*10^-6;
4 A_v_mid=100; //mid range voltage gain
5 f_c=1/(2*pi*R_in*C1);
6 //at f_c, capacitive reactance is equal to
   resistance(X_C1=R_in)
7 attenuation=0.707;
8 //A_v is gain at lower critical frequency
9 A_v=0.707*A_v_mid;
10 disp(f_c,'lower critical frequency in hertz')
11 disp(attenuation,'attenuation at lower critical
   frequency')
```

```
12 disp(A_v, 'gain at lower critical frequency')
```

Scilab code Exa 10.4 Voltage gains

```
1 //ex10.4
2 A_v_mid=100;
3 //At 1Hz frequency, voltage gain is 3 dB less than at
   midrange. At -3dB, the voltage is reduced by a
   factor of 0.707
4 A_v=0.707*A_v_mid;
5 disp(A_v, 'actual voltage gain at 1Hz frequency')
6 //At 100Hz frequency, voltage gain is 20 dB less than
   at critical frequency (f_c). At -20dB, the
   voltage is reduced by a factor of 0.1
7 A_v=0.1*A_v_mid;
8 disp(A_v, 'actual voltage gain at 100Hz frequency')
9 //At 10Hz frequency, voltage gain is 40 dB less than
   at critical frequency (f_c). At -40dB, the
   voltage is reduced by a factor of 0.01
10 A_v=0.01*A_v_mid;
11 disp(A_v, 'actual voltage gain at 10Hz frequency')
```

Scilab code Exa 10.5 Output RC circuit

```
1 //ex10.5
2 R_C=10*10^3;
3 C3=0.1*10^-6;
4 R_L=10*10^3;
5 A_v_mid=50;
6 f_c=1/(2*pi*(R_L+R_C)*C3);
7 disp(f_c, 'lower critical frequency in hertz')
8 //at midrange capacitive reactance is zero
9 X_C3=0;
```



```

10 attenuation=R_L/(R_L+R_C);
11 disp(attenuation,'attenuation at midrange frequency'
    )
12 //at critical frequency, capacitive reactance equals
    total resistance
13 X_C3=R_L+R_C;
14 attenuation=R_L/(sqrt((R_C+R_L)^2+X_C3^2));
15 disp(attenuation,'attenuation at critical frequency'
    )
16 A_v=0.707*A_v_mid;
17 disp(A_v,'gain at critical frequency')

```

Scilab code Exa 10.6 Bypass RC circuit BJT

```

1 //ex10.6
2 B_ac=100;
3 r_e=12;
4 R1=62*10^3;
5 R2=22*10^3;
6 R_S=1*10^3;
7 R_E=1*10^3;
8 C2=100*10^-6;
9 //Base circuit impedance= parallel combination of R1
    , R2, R_S
10 R_th=(R1*R2*R_S)/(R1*R2+R2*R_S+R_S*R1);
11 //Resistance looking at emitter
12 R_in_emitter=r_e+(R_th/B_ac);
13 //resistance of equivalent bypass RC is parallel
    combination of R_E, R_in_emitter
14 R=(R_in_emitter*R_E)/(R_E+R_in_emitter);
15 f_c=1/(2*pi*R*C2);
16 disp(f_c,'critical frequency of bypass RC circuit in
    hertz')

```

Scilab code Exa 10.7 input RC circuit FET

```
1 //ex10.7
2 V_GS=-10;
3 I_GSS=25*10^-9;
4 R_G=10*10^6;
5 C1=0.001*10^-6;
6 R_in_gate=abs((V_GS/I_GSS));
7 R_in=(R_in_gate*R_G)/(R_G+R_in_gate);
8 f_c=1/(2*%pi*R_in*C1);
9 disp(f_c,'critical frequency in hertz')
```

Scilab code Exa 10.8 Low frequency response FET

```
1 //ex10.8
2 V_GS=-12;
3 I_GSS=100*10^-9;
4 R_G=10*10^6;
5 R_D=10*10^3;
6 C1=0.001*10^-6;
7 C2=0.001*10^-6;
8 R_in_gate=abs((V_GS/I_GSS));
9 R_in=(R_in_gate*R_G)/(R_G+R_in_gate);
10 R_L=R_in; //according to question
11 f_c_input=1/(2*%pi*R_in*C1);
12 disp(f_c_input,'critical frequency of input RC
    circuit in hertz')
13 f_c_output=1/(2*%pi*(R_D+R_L)*C2)
14 disp(f_c_output,'critical frequency of output RC
    circuit in hertz')
```

Scilab code Exa 10.9 Low frequency response BJT

```
1 //ex10.9
2 B_ac=100;
3 r_e=16;
4 R1=62*10^3;
5 R2=22*10^3;
6 R_S=600;
7 R_E=1*10^3;
8 R_C=2.2*10^3;
9 R_L=10*10^3;
10 C1=0.1*10^-6;
11 C2=10*10^-6;
12 C3=0.1*10^-6;
13 //input RC circuit
14 R_in=(B_ac*r_e*R1*R2)/(B_ac*r_e*R1+B_ac*r_e*R2+R1*R2
    );
15 f_c_input=1/(2*%pi*(R_S+R_in)*C1);
16 disp(f_c_input,'input frequency in hertz')
17 //For bypass circuit; Base circuit impedance=
    parallel combination of R1, R2, R_S
18 R_th=(R1*R2*R_S)/(R1*R2+R2*R_S+R_S*R1);
19 //Resistance looking at emitter
20 R_in_emitter=r_e+(R_th/B_ac);
21 //resistance of equivalent bypass RC is parallel
    combination of R_E, R_in_emitter
22 R=(R_in_emitter*R_E)/(R_E+R_in_emitter);
23 f_c_bypass=1/(2*%pi*R*C2);
24 disp(f_c_bypass,'critical frequency of bypass RC
    circuit in hertz')
25 f_c_output=1/(2*%pi*(R_C+R_L)*C3)
26 disp(f_c_output,'output frequency circuit in hertz')
27 R_c=R_C*R_L/(R_C+R_L);
28 A_v_mid=R_c/r_e;
```

```

29 attenuation=R_in/(R_in+R_S);
30 A_v=attenuation*A_v_mid;    //overall voltage gain
31 A_v_mid_dB=20*log10(A_v);
32 disp(A_v_mid_dB,'overall voltage gain in dB')

```

Scilab code Exa 10.10 input RC circuit BJT

```

1 //ex10.10
2 B_ac=125;
3 C_be=20*10^-12;
4 C_bc=2.4*10^-12;
5 R1=22*10^3;
6 R2=4.7*10^3;
7 R_E=470;
8 R_S=600;
9 R_L=2.2*10^3;
10 V_CC=10;
11 V_B=(R2/(R1+R2))*V_CC;
12 V_E=V_B-0.7;
13 I_E=V_E/R_E;
14 r_e=25*10^-3/I_E;
15 //total resistance of input circuit is parallel
    combination of R1,R2,R_s,B_ac*r_e
16 R_in_tot=B_ac*r_e*R1*R2*R_S/(B_ac*r_e*R1*R2+B_ac*r_e
    *R1*R_S+B_ac*r_e*R2*R_S+R1*R2*R_S);
17 R_c=R_C*R_L/(R_C+R_L)
18 A_v_mid=R_c/r_e;
19 C_in_Miller=C_bc*(A_v_mid+1)
20 C_in_tot=C_in_Miller+C_be;
21 f_c=1/(2*pi*R_in_tot*C_in_tot);
22 disp(R_in_tot,'total resistance of circuit in ohms'
    )
23 disp(C_in_tot,'total capacitance in farads')
24 disp(f_c,'critical frequency in hertz')

```

Scilab code Exa 10.11 Critical frequency BJT output

```
1 //ex10.11
2 C_bc=2.4*10^-12; //from previous question
3 A_v=99; //from previous question
4 R_C=2.2*10^3;
5 R_L=2.2*10^3;
6 R_c=R_C*R_L/(R_C+R_L);
7 C_out_Miller=C_bc*(A_v+1)/A_v;
8 f_c=1/(2*pi*R_c*C_bc); //C_bc is almost equal to
   C_in_Miller
9 disp(R_c,'equivalent resistance in ohms')
10 disp(C_out_Miller,'equivalent capacitance in farads'
   )
11 disp(f_c,'critical frequency in hertz')
```

Scilab code Exa 10.12 FET capacitors

```
1 //ex10.12
2 C_iss=6*10^-12;
3 C_rss=2*10^-12;
4 C_gd=C_rss;
5 C_gs=C_iss-C_rss;
6 disp(C_gd,'gate to drain capacitance in farads')
7 disp(C_gs,'gate to source capacitance in farads')
```

Scilab code Exa 10.13 Critical frequency FET input

```
1 //ex10.13;
```

```

2 C_iss=8*10^-12;
3 C_rss=3*10^-12;
4 g_m=6500*10^-6;    //in Siemens
5 R_D=1*10^3;
6 R_L=10*10^6;
7 R_s=50;
8 C_gd=C_rss;
9 C_gs=C_iss-C_rss;
10 R_d=R_D*R_L/(R_D+R_L);
11 A_v=g_m*R_d;
12 C_in_Miller=C_gd*(A_v+1);
13 C_in_tot=C_in_Miller+C_gs;
14 f_c=1/(2*%pi*C_in_tot*R_s);
15 disp(f_c,'critical frequency of input RC circuit in
    hertz ')

```

Scilab code Exa 10.14 Critical frequency FET input

```

1 //ex10.14
2 C_gd=3*10^-12;    //from previous question
3 A_v=6.5;    //from previous question
4 R_d=1*10^3;    //from previous question
5 C_out_Miller=C_gd*(A_v+1)/A_v;
6 f_c=1/(2*%pi*R_d*C_out_Miller);
7 disp(f_c,'critical frequency of the output circuit
    in hertz ')

```

Scilab code Exa 10.15 Bandwidth

```

1 //ex10.15
2 f_cu=2000;
3 f_cl=200;
4 BW=f_cu-f_cl;

```

```
5 disp(BW, 'bandwidth in hertz')
```

Scilab code Exa 10.16 Bandwidth transistor

```
1 //ex10.16;
2 f_T=175*10^6; //in hertz
3 A_v_mid=50;
4 BW=f_T/A_v_mid;
5 disp(BW, 'bandwidth in hertz')
```

Scilab code Exa 10.17 Bandwidth 2stage amplifier

```
1 //ex10.17
2 f_cl=1*10^3; //lower critical frequency of 2nd
   stage in hertz
3 f_cu=100*10^3; //upper critical frequency of 1st
   stage in hertz
4 BW=f_cu-f_cl;
5 disp(BW, 'bandwidth in hertz')
```

Scilab code Exa 10.18 Bandwidth 2stage amplifier

```
1 //ex10.18
2 n=2; //n is the number of stages of amplifier
3 f_cl=500;
4 f_cu=80*10^3;
5 f_cl_new=f_cl/(sqrt(2^(1/n)-1));
6 f_cu_new=f_cu*(sqrt(2^(1/n)-1));
7 BW=f_cu_new-f_cl_new;
8 disp(BW, 'bandwidth in hertz')
```

Chapter 11

Thyristors and Other Devices

Scilab code Exa 11.1 Four layer diode

```
1 //ex11.1
2 V_AK=20; //VOLTAGE ACROSS ANODE
3 I_A=1*10^-6;
4 R_AK=V_AK/I_A;
5 disp(R_AK, 'RESISTANCE IN OHMS')
```

Scilab code Exa 11.2 Anode current

```
1 //ex11.2
2 R_S=10^3;
3 V_BIAS=110;
4 V_BE=0.7;
5 V_CE_sat=0.1;
6 V_A=V_BE+V_CE_sat; //VOLTAGE ACROSS ANODE
7 V_R_s=V_BIAS-V_A; //VOLTAGE ACROSS R_S
8 I_A=V_R_s/R_S;
9 disp(I_A, 'Anode current in amperes')
```

Scilab code Exa 11.3 Unijunction transistor

```
1 //ex11.3
2 n=0.6;
3 V_BB=20;
4 V_pn=0.7;
5 V_P=n*V_BB+V_pn;
6 disp(V_P,'peak point emitter voltage in volts')
```

Scilab code Exa 11.4 turn on off UJT

```
1 //ex11.4
2 V_BB=30;
3 V_P=14;
4 I_P=20*10^-6;
5 V_V=1;
6 I_V=10*10^-3;
7 x=(V_BB-V_P)/I_P;
8 y=(V_BB-V_V)/I_V;
9 disp('ohms',x,'R1 should be less than',)
10 disp('ohms',y,'R1 should be more than')
```

Scilab code Exa 11.5 Critical angle

```
1 //ex11.5
2 n2=1.3; //cladding index
3 n1=1.35; //core index
4 theta=acos(n2/n1);
5 t=theta*180/%pi;
6 disp(t,'critical angle in degrees')
```


Chapter 12

The Operational Amplifier

Scilab code Exa 12.1 CMRR opamp

```
1 //ex12.1
2 A_ol=100000; //open loop voltage gain
3 A_cm=0.2; //common mode gain
4 CMRR=A_ol/A_cm;
5 CMRR_dB=20*log10(CMRR);
6 disp(CMRR, 'CMRR')
7 disp(CMRR_dB, 'CMRR in decibels')
```

Scilab code Exa 12.2 Slew rate

```
1 //ex12.2
2 del_t=1; // in microseconds
3 //lower limit is -9V and upper limit is 9V from the
  graph
4 del_V_out=9-(-9);
5 slew_rate=del_V_out/del_t;
6 disp(slew_rate, 'slew rate in volts per microseconds')
  )
```

Scilab code Exa 12.3 Non inverting amplifier

```
1 //ex12.3
2 R_f=100*10^3;
3 R_i=4.7*10^3;
4 A_cl_NI=1+(R_f/R_i);
5 disp(A_cl_NI,'closed loop voltage gain')
```

Scilab code Exa 12.4 Inverting amplifier

```
1 //ex12.4
2 R_i=2.2*10^3;
3 A_cl=-100; //closed loop voltage gain
4 R_f=abs(A_cl)*R_i;
5 disp(R_f,'value of R_f in ohms')
```

Scilab code Exa 12.5 Impedance noninverting amplifier

```
1 //ex12.5
2 Z_in=2*10^6;
3 Z_out=75;
4 A_ol=200000;
5 R_f=220*10^3;
6 R_i=10*10^3;
7 B=R_i/(R_i+R_f); //B is attenuation
8 Z_in_NI=(1+A_ol*B)*Z_in;
9 Z_out_NI=Z_out/(1+A_ol*B);
10 A_cl_NI=1+(R_f/R_i);
11 disp(Z_in_NI,'input impedance in ohms')
```

```
12 disp(Z_out_NI, 'output impedance in ohms')
13 disp(A_cl_NI, 'closed loop voltage gain')
```

Scilab code Exa 12.6 Voltage follower impedance

```
1 //ex12.6
2 B=1; //voltage follower configuration
3 A_ol=200000;
4 Z_in=2*10^6;
5 Z_out=75;
6 Z_in_VF=(1+A_ol)*Z_in;
7 Z_out_VF=Z_out/(1+A_ol);
8 disp(Z_in_VF, 'input impedance in ohms')
9 disp(Z_out_VF, 'output impedance in ohms')
```

Scilab code Exa 12.7 Impedance inverting amplifier

```
1 //ex12.7
2 R_i=1*10^3;
3 R_f=100*10^3;
4 Z_in=4*10^6;
5 Z_out=50;
6 A_ol=50000;
7 B=R_i/(R_i+R_f); //attenuation
8 Z_in_I=R_i; //almost equal to R_i
9 Z_out_I=Z_out/(1+(A_ol*B));
10 A_cl_I=-R_f/R_i;
11 disp(Z_in_I, 'input impedance in ohms')
12 disp(Z_out_I, 'output impedance in ohms')
13 disp(A_cl_I, 'closed loop voltage gain')
```

check Appendix [AP 2](#) for dependency:

open_loop_gain.sci

Scilab code Exa 12.8 Open Loop gain

```
1 //ex12.8
2 f_c_ol=100;
3 A_ol_mid=100000;
4 f=0;
5 A_ol=open_loop_gain(A_ol_mid,f,f_c_ol)
6 disp(A_ol,'open loop gain when f=0Hz');
7 f=10;
8 A_ol=open_loop_gain(A_ol_mid,f,f_c_ol)
9 disp(A_ol,'open loop gain when f=10Hz')
10 f=100;
11 A_ol=open_loop_gain(A_ol_mid,f,f_c_ol)
12 disp(A_ol,'open loop gain when f=100Hz')
13 f=1000;
14 A_ol=open_loop_gain(A_ol_mid,f,f_c_ol)
15 disp(A_ol,'open loop gain when f=1000Hz')
```

check Appendix [AP 1](#) for dependency:

phase_shift.sci

Scilab code Exa 12.9 phase RC lag

```
1 //ex12.9
2 f_c=100;
3 f=1;
4 theta=phase_shift(f,f_c);
5 disp(theta,'phase lag when f=1Hz (in degrees)')
6 f=10;
7 theta=phase_shift(f,f_c);
```

```

8 disp(theta,'phase lag when f=10Hz (in degrees)')
9 f=100;
10 theta=phase_shift(f,f_c);
11 disp(theta,'phase lag when f=100Hz (in degrees)')
12 f=1000;
13 theta=phase_shift(f,f_c);
14 disp(theta,'phase lag when f=1000Hz (in degrees)')
15 f=10000;
16 theta=phase_shift(f,f_c);
17 disp(theta,'phase lag when f=10000Hz (in degrees)')

```

check Appendix [AP 1](#) for dependency:

phase_shift.sci

Scilab code Exa 12.10 Gain and phase lag

```

1 //ex12.10
2 A_v1=40; //all gains are in decibels
3 A_v2=32;
4 A_v3=20;
5 f_c1=2*10^3;
6 f_c2=40*10^3;
7 f_c3=150*10^3;
8 f=f_c1;
9 A_ol_mid=A_v1+A_v2+A_v3;
10 theta_1=phase_shift(f,f_c1);
11 theta_2=phase_shift(f,f_c2);
12 theta_3=phase_shift(f,f_c3);
13 theta_tot=theta_1+theta_2+theta_3;
14 disp(A_ol_mid,'open loop midrange gain in decibels')
15 disp(theta_tot,'total phase lag in degrees')

```

Scilab code Exa 12.11 Closed loop bandwidth

```
1 //ex12.11
2 A_ol_mid=150000; //open loop midrange gain
3 B=0.002; //feedback attenuation
4 BW_ol=200; //open loop bandwidth
5 BW_cl=BW_ol*(1+B*A_ol_mid);
6 disp(BW_cl, 'closed loop bandwidth in hertz')
```

Scilab code Exa 12.12 Amplifier bandwidth

```
1 //ex12.12
2 BW=3*10^6; //unity gain bandwidth
3 A_ol=100; //open loop gain
4 disp("non-inverting amplifier")
5 R_f=220*10^3;
6 R_i=3.3*10^3;
7 A_cl=1+(R_f/R_i); //closed loop gain
8 BW_cl=BW/A_cl;
9 disp(BW_cl, 'closed loop bandwidth in hertz')
10 disp("inverting amplifier")
11 R_f=47*10^3;
12 R_i=1*10^3;
13 A_cl=-R_f/R_i;
14 BW_cl=BW/(abs(A_cl));
15 disp(BW_cl, 'closed loop bandwidth in hertz')
```

Chapter 13

Basic Opamp Circuits

Scilab code Exa 13.1 Comparator

```
1 //ex13.1
2 R2=1*10^3;
3 R1=8.2*10^3;
4 V=15;
5 V_REF=R2*V/(R1+R2);
6 disp(V_REF, 'V_REF in volts')
7 V_max=12; //maximum output level of op-amp
8 V_min=-12; //minimum output voltage of comparator
9 f=1; //assume frequency of input wave to be 1
   hertz
10 t=0:0.001:3;
11 V_in=5*sin(2*%pi*f.*t)
12 clf();
13 subplot(121)
14 xtitle('Input to comparator-1')
15 plot(t,V_in)
16 subplot(122)
17 xtitle('Output of Comparator-1')
18 a=boole2s(V_in>=V_REF)
```

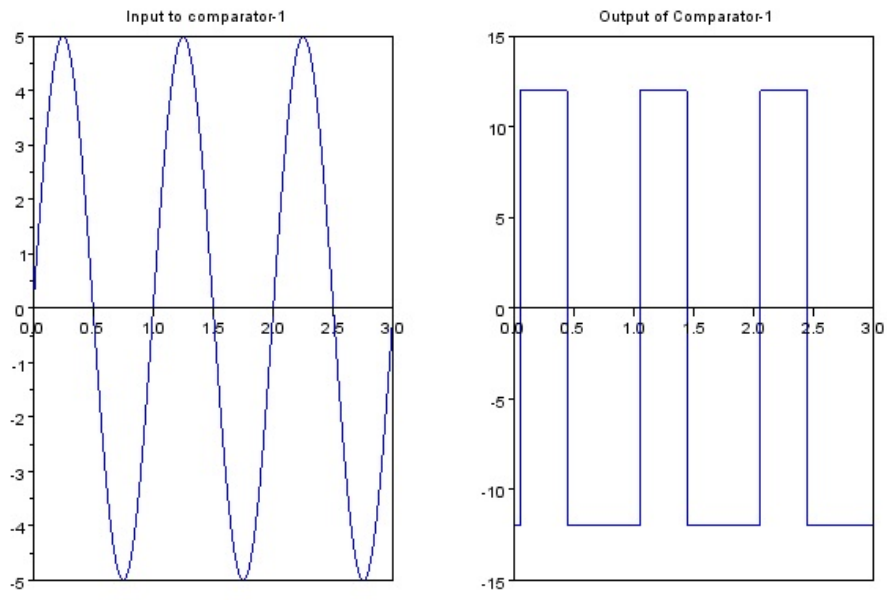


Figure 13.1: Comparator

```

19 b=~a;
20 y=V_max*a+V_min*b;
21 plot(t,y)
22 disp(V_max,'max output voltage in volts')
23 disp(V_min,'min output voltage in volts')

```

Scilab code Exa 13.2 Trigger points

```

1 //ex13.2
2 R1=100*10^3;
3 R2=R1;
4 V_out_max=5;
5 V_UTP=R2*V_out_max/(R1+R2);
6 V_LTP=-V_out_max*R2/(R1+R2);
7 disp(V_UTP,'upper trigger point in volts')
8 disp(V_LTP,'lower trigger point in volts')

```

Scilab code Exa 13.3 Comparator hysteresis Zener bounding

```

1 //ex13.3
2 R1=100*10^3;
3 R2=47*10^3;
4 V_R1=4.7+0.7; //one zener is always forward
   biased with forward voltage 0.7V
5 //V_R1 can be positive or negative
6 I_R1=V_R1/R1;
7 I_R2=I_R1;
8 V_R2=R2*I_R2;
9 V_out=V_R1+V_R2; //positive or negative
10 V_UTP=R2*V_out/(R1+R2);
11 V_LTP=-V_out*R2/(R1+R2);

```

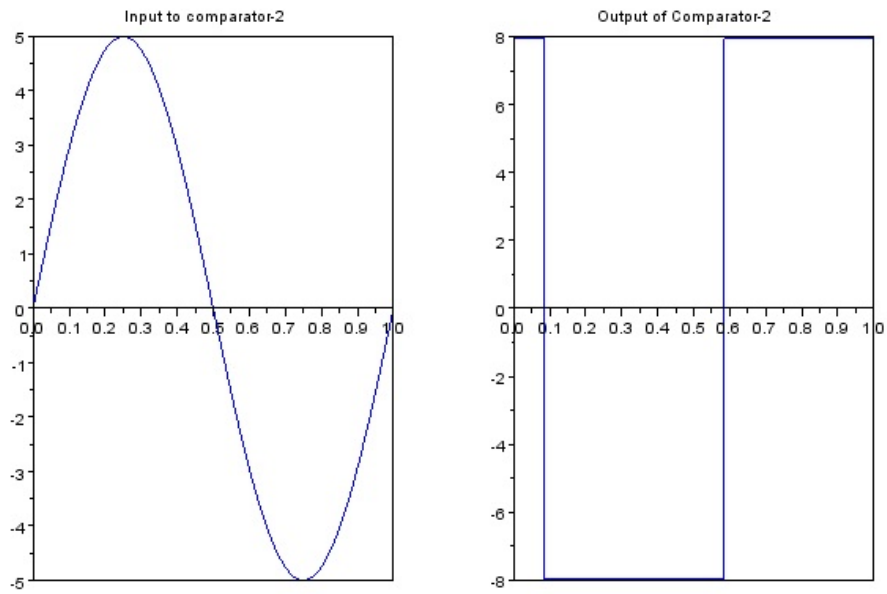


Figure 13.2: Comparator hysteresis Zener bounding

```

12 f=1;      //assume frequency of input as 1 Hertz
13 t=0:0.001:1;
14 T=1/f;
15 V_in=5*sin(2*%pi*f.*t)
16 subplot(121)
17 xtitle('Input to comparator-2')
18 plot(t,V_in)
19 subplot(122)
20 xtitle('Output of Comparator-2')
21 t1=(1/(2*%pi*f))*asin((V_UTP/5))
22 a=bool2s(t<t1)
23 b=bool2s(t>((T/2)+t1))
24 a=bool2s(a|b)
25 b=~a;
26 y=V_out*a-V_out*b;
27 plot(t,y)
28 disp(V_out,'max output voltage in volts')
29 disp(-V_out,'min output voltage in volts')

```

Scilab code Exa 13.4 Summing amplifier unity gain

```

1 //ex13.4
2 V_IN1=3;
3 V_IN2=1;
4 V_IN3=8;
5 //all resistors are of equal value so weight of each
   input is 1
6 V_OUT=-(V_IN1+V_IN2+V_IN3);
7 disp(V_OUT,'output voltage in volts')

```

Scilab code Exa 13.5 Summing amplifier

```

1 //ex13.5

```

```

2 R_f=10*10^3;
3 R1=1*10^3;
4 R2=R1;
5 R=R1;
6 V_IN1=0.2;
7 V_IN2=0.5;
8 V_OUT=-(R_f/R)*(V_IN1+V_IN2);
9 disp(V_OUT,'output voltage of the summing amplifier
    in volts')

```

Scilab code Exa 13.6 Averaging amplifier

```

1 //ex13.6
2 R_f=25*10^3;
3 R1=100*10^3;
4 R2=R1;
5 R3=R1;
6 R4=R1;
7 R=R1;
8 V_IN1=1;
9 V_IN2=2;
10 V_IN3=3;
11 V_IN4=4;
12 V_OUT=-(R_f/R)*(V_IN1+V_IN2+V_IN3+V_IN4);
13 disp(V_OUT,'output voltage in volts')
14 V_IN_avg=(V_IN1+V_IN2+V_IN3+V_IN4)/4;
15 if abs(V_OUT)==V_IN_avg then
16     disp('the amplifier produces an output whose
        magnitude is the mathematical average of the
        input voltages')
17 end

```

Scilab code Exa 13.7 Scaling adder

```

1 //ex13.4
2 V_IN1=3;
3 V_IN2=2;
4 V_IN3=8;
5 R_f=10*10^3;
6 R1=47*10^3;
7 R2=100*10^3;
8 R3=10*10^3;
9 weight_of_input1=R_f/R1;
10 weight_of_input2=R_f/R2;
11 weight_of_input3=R_f/R3;
12 V_OUT=-(weight_of_input1*V_IN1+weight_of_input2*
           V_IN2+weight_of_input3*V_IN3);
13 disp(weight_of_input1, 'weight_of_input1 ')
14 disp(weight_of_input2, 'weight_of_input2 ')
15 disp(weight_of_input3, 'weight_of_input3 ')
16 disp(V_OUT, 'output voltage in volts ')

```

Scilab code Exa 13.8 Opamp integrator

```

1 //ex13.8
2 R_i=10*10^3;
3 C=0.01*10^-6;
4 V_in=2.5-(-2.5);
5 PW=100*10^-6; //pulse width
6 T=2*PW;
7 A=2.5;
8 op_change_cap_charge=-V_in/(R_i*C);
9 op_change_cap_discharge=V_in/(R_i*C);
10 disp(op_change_cap_charge, 'rate of change of output
    voltage with respect to time when capacitor is
    charging (in Volts per sec)')
11 disp(op_change_cap_discharge, 'rate of change of

```

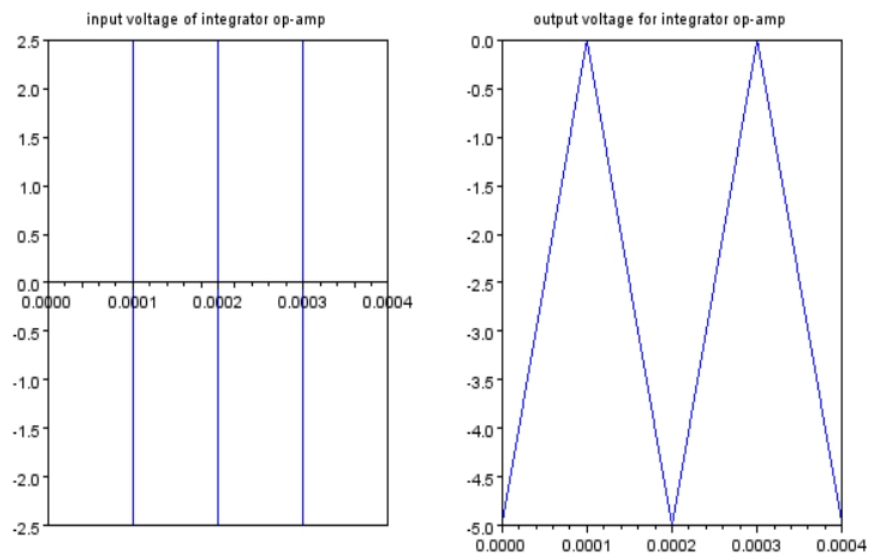


Figure 13.3: Opamp integrator


```

    output voltage with respect to time when
    capacitor is discharging (in Volts per sec)')
12 del_V_OUT=op_change_cap_discharge*PW;
13 disp(-del_V_OUT,'when input is positive , the slope
    is negative , when input is negative , the slope
    is negative. So, the output is a triangular wave
    varying from zero to')
14 subplot(121)
15 xtitle('input voltage of op-amp differentiator')
16 t=0:10^-7:2*T;
17 a=bool2s(t>=T/2 & t<=T)
18 b=bool2s(t>=1.5*T & t<=2*T)
19 a=bool2s(a|b)
20 b=~a;
21 y=-A*b+A*a;
22 plot(t,y)
23 subplot(122)
24 xtitle('output voltage of op-amp diferentiator')
25 x=[];
26 A=del_V_OUT;
27 for t=0:10^-7:2*T
28     tcor = t- floor(t/T)*T;
29     if tcor >= 0 & tcor < (T/2) then
30         x_temp = -A +(2*A/T)*tcor;
31     end;
32     if tcor >= (T/2) & tcor <T then
33         x_temp = A - (2*A/T)*tcor;
34     end
35     x = [x, x_temp];
36 end;
37 t=0:10^-7:2*T;
38 plot(t,x)

```

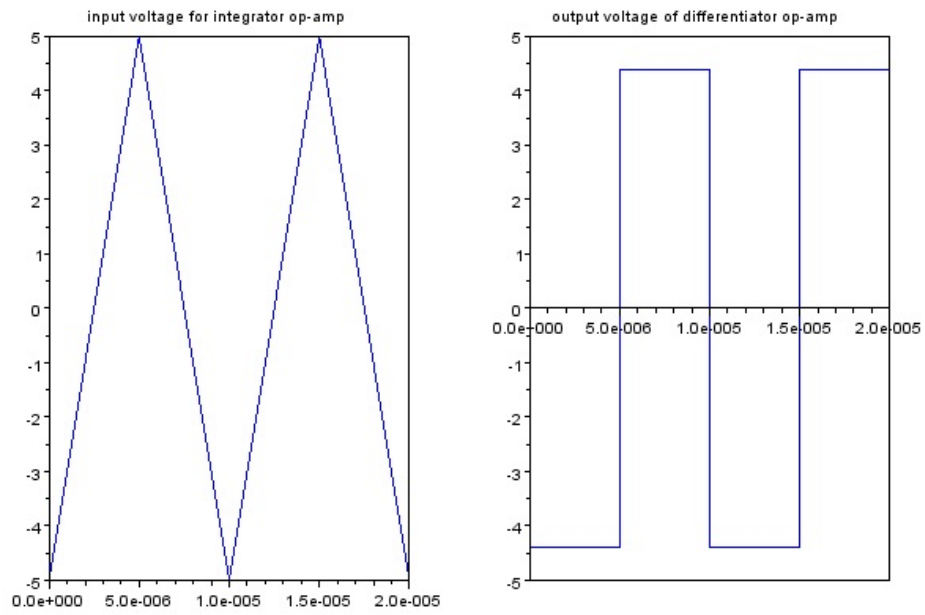


Figure 13.4: Opamp differentiator

Scilab code Exa 13.9 Opamp differentiator

```
1 //ex13.9
2 R_f=2.2*10^3;
3 C=0.001*10^-6;
4 Vc=5-(-5);
5 A=5;
6 time_const=R_f*C;
7 T=10*10^-6;
8 t=T/2;
9 slope=Vc/t;
10 V_out=slope*time_const; //V_out is negative when
    input is positive and V_out is positive when
    input is negative
11 disp(V_out,'output voltage in volts is a square wave
    with peak voltages positive and negative of')
12 subplot(121)
13 xtitle('input voltage for integrator op-amp')
14 x=[];
15 for t=0:10^-8:2*T
16     tcor = t- floor(t/T)*T;
17     if tcor >= 0 & tcor < (T/2) then
18         x_temp = -A +(4*A/T)*tcor;
19     end;
20     if tcor >= (T/2) & tcor <T then
21         x_temp = 3*A - (4*A/T)*tcor;
22     end
23     x = [x, x_temp];
24 end;
25 t=0:10^-8:2*T;
26 plot(t,x)
27 subplot(122)
28 xtitle('output voltage of differentiator op-amp')
29 a=bool2s(t>=T/2 & t<=T)
30 b=bool2s(t>=1.5*T & t<=2*T)
31 a=bool2s(a|b)
32 b=~a;
33 y=V_out*a-V_out*b;
```

```
34 plot(t,y)
35 disp(V_out,'max output voltage in volts')
36 disp(-V_out,'min output voltage in volts')
```

Chapter 14

Special Purpose Opamp Circuits

Scilab code Exa 14.1 Gain setting resistor

```
1 //ex14.1
2 R1=25*10^3;
3 R2=R1;
4 A_cl=500; //closed loop voltage gain
5 R_G=2*R1/(A_cl-1);
6 disp(R_G,'value of the external gain setting
   resistor in ohms')
```

Scilab code Exa 14.2 Voltage gain Instrumentation amplifier

```
1 //ex14.2
2 R1=25.25*10^3; //internal resistors
3 R2=R1;
4 R_G=510;
5 A_v=(2*R1/R_G)+1;
6 disp(A_v,'voltage gain')
```

```
7 BW=60*103;
8 disp(BW, 'bandwidth from graph, in hertz')
```

Scilab code Exa 14.3 Isolation amplifier

```
1 //ex14.3
2 disp("cannot be shown in scilab")
```

Scilab code Exa 14.4 Voltage gain Isolation amplifier

```
1 //ex14.4
2 R_f1=22*103;
3 R_i1=2.2*103;
4 R_f2=47*103;
5 R_i2=10*103;
6 A_v1=(R_f1/R_i1)+1; //voltage gain of input stage
7 A_v2=(R_f2/R_i2)+1; //voltage gain of output
   stage
8 A_v=A_v1*A_v2;
9 disp(A_v, 'total voltage gain of the isolation
   amplifier')
```

Scilab code Exa 14.5 Transconductance OTA

```
1 //ex14.5
2 g_m=1000*10-6;
3 V_in=25*10-3;
4 I_out=g_m*V_in;
5 disp(I_out, 'output current in amperes')
```

Scilab code Exa 14.6 Voltage gain OTA

```
1 //ex14.6
2 V_BIAS=9;
3 V=V_BIAS;
4 R_BIAS=33*10^3;
5 R_L=10*10^3;
6 K=16; //in microSiemens per microAmpere
7 I_BIAS=(V_BIAS-(-V)-1.4)/R_BIAS;
8 g_m=K*I_BIAS;
9 A_v=g_m*R_L;
10 disp(A_v, 'voltage gain')
```

Scilab code Exa 14.7 Output OTA amplitude modulator

```
1 //ex14.7
2 V_MOD_max=10;
3 V_MOD_min=1;
4 V=9;
5 V_in=50*10^-3;
6 R_BIAS=56*10^3;
7 R_L=10*10^3;
8 K=16; //in microSiemens per microAmpere
9 I_BIAS_max=(V_MOD_max-(-V)-1.4)/R_BIAS;
10 g_m_max=K*I_BIAS_max;
11 A_v_max=g_m_max*R_L;
12 V_out_max=A_v_max*V_in;
13 I_BIAS_min=(V_MOD_min-(-V)-1.4)/R_BIAS;
14 g_m_min=K*I_BIAS_min;
15 A_v_min=g_m_min*R_L;
```

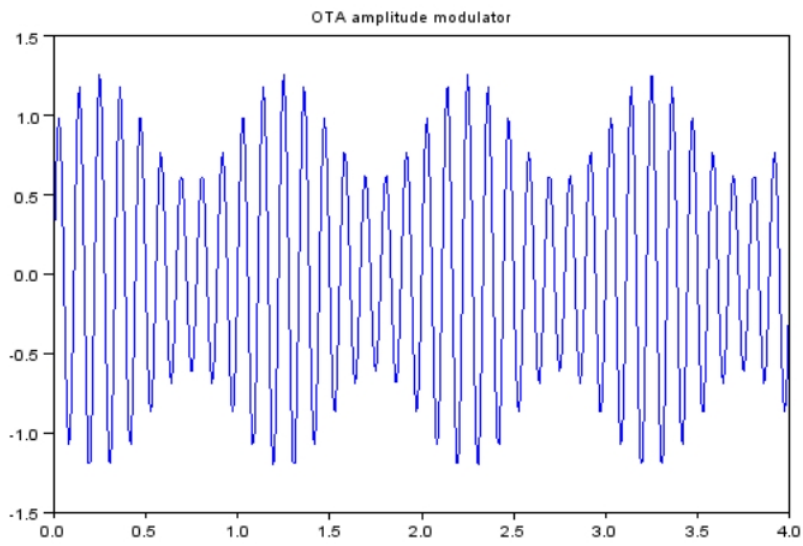


Figure 14.1: Output OTA amplitude modulator


```

16 V_out_min=A_v_min*V_in;
17 t=0:0.01:4;
18 f=1; //assume frequency 1 hertz
19 y=((V_out_max/4-V_out_min/4)*sin(2*pi*f.*t)+(
    V_out_min/2+V_out_max/2)/2).*sin(2*9*pi*f.*t);
20 plot(t,y)
21 xtitle('OTA amplitude modulator')

```

Scilab code Exa 14.8 Output log amplifier

```

1 //ex14.8
2 V_in=2;
3 I_R=50*10^-9;
4 R1=100*10^3;
5 //voltage output for log amplifier
6 V_OUT=-0.025*log(V_in/(I_R*R1));
7 disp(V_OUT,'output voltage in volts')

```

Scilab code Exa 14.9 Transistor log amplifier

```

1 //ex14.9
2 V_in=3;
3 I_EB0=40*10^-9;
4 R1=68*10^3;
5 //voltage output for log amplifier
6 V_OUT=-0.025*log(V_in/(I_EB0*R1));
7 disp(V_OUT,'output voltage in volts')

```

Scilab code Exa 14.10 Antilog amplifier

```
1 //ex14.10
2 I_EB0=40*10^-9;
3 V_in=175.1*10^-3;
4 R_f=68*10^3;
5 V_OUT=-I_EB0*R_f*exp(V_in/0.025);
6 disp(V_OUT,'output voltage in volts')
```

Chapter 15

Active Filters

Scilab code Exa 15.1 Band pass filter

```
1 //EX15.1
2 f0=15*10^3; //center frequency in hertz
3 BW=1*10^3;
4 Q=f0/BW;
5 if Q>10 then
6     disp(Q,'narrow band filter')
7 end
```

Scilab code Exa 15.2 Butterworth response

```
1 //ex15.2
2 R2=10*10^3;
3 R1=0.586*R2; //FOR BUTTERWORTH RESPONSE
4 disp(R1,'R1 in ohms')
5 disp('5.6 kilo ohm will be ideally close to maximally
    flat butterworth response')
```

Scilab code Exa 15.3 Sallen Key lowpass filter

```
1 //ex15.3
2 R_A=1*10^3;
3 R2=1*10^3;
4 R_B=R_A;
5 R=R_A;
6 C_A=0.022*10^-6;
7 C_B=C_A;
8 C=C_A;
9 f_c=1/(2*%pi*R*C); //critical frequency
10 R1=0.586*R2; //for butterworth response
11 disp(f_c,'critical frequency in hertz')
12 disp(R1,'value of R1 in ohms')
```

Scilab code Exa 15.4 4 pole filter

```
1 //ex15.4
2 f_c=2860;
3 R=1.8*10^3;
4 C=1/(2*%pi*f_c*R);
5 R2=R;
6 R1=0.152*R2; //BUTTERWORTH RESPONSE IN FIRST
   STAGE
7 R4=R;
8 R3=1.235*R4; //BUTTERWORTH RESPONSE IN SECOND
   STAGE
9 disp(C,'capacitance in farads');
10 disp(R1,'R1 in ohms for butterworth response in
   first stage')
11 disp(R3,'R3 in ohms for butterworth response in
   second stage')
```

Scilab code Exa 15.5 Sallen Key highpass filter

```
1 //ex15.5
2 f_c=10*10^3; //critical frequency in hertz
3 R=33*10^3; //Assumption
4 R2=R;
5 C=1/(2*%pi*f_c*R);
6 R1=0.586*R2; //for butterworth response
7 disp(C, 'Capacitance in Farads')
8 disp(R1, 'R1 in ohms taking R2=33kilo-ohms')
9 R1=3.3*10^3; //Assumption
10 R2=R1/0.586; //butterworth response
11 disp(R2, 'R2 in ohms taking R1=3.3kilo-ohms')
```

Scilab code Exa 15.6 Cascaded filter

```
1 //ex15.6
2 R1=68*10^3;
3 R2=180*10^3;
4 R3=2.7*10^3;
5 C=0.01*10^-6;
6 f0=(sqrt((R1+R3)/(R1*R2*R3)))/(2*%pi*C);
7 A0=R2/(2*R1);
8 Q=%pi*f0*C*R2;
9 BW=f0/Q;
10 disp(f0, 'center frequency in hertz')
11 disp(A0, 'maximum gain')
12 disp(BW, 'bandwidth in hertz')
```

Scilab code Exa 15.7 State variable filter

```
1 //ex15.7
2 R4=10^3;
```

```

3 C1=0.022*10^-6;
4 R7=R4;
5 C2=C1;
6 R6=R4;
7 R5=100*10^3;
8 f_c=1/(2*%pi*R4*C1); //critical frequency in
    hertz for each integrator
9 f0=f_c //center frequency
10 Q=(1+(R5/R6))/3;
11 BW=f0/Q;
12 disp(f0,'center frequency in hertz')
13 disp(Q,' value of Q')
14 disp(BW,'bandwidth in hertz')

```

Scilab code Exa 15.8 Band stop filter

```

1 //ex15.8
2 R4=12*10^3;
3 C1=0.22*10^-6;
4 R7=R4;
5 C2=C1;
6 R6=3.3*10^3;
7 Q=10;
8 f0=1/(2*%pi*R7*C2);
9 R5=(3*Q-1)*R6;
10 disp(f0,'center frequency in hertz')
11 disp(R5,'R5 in ohms')
12 disp('Nearest value is 100 kilo-ohms')

```

Chapter 16

Oscillators

Scilab code Exa 16.1 Wien bridge oscillator

```
1 //ex16.1
2 R1=10*10^3;
3 R2=R1;
4 R=R1;
5 C1=0.01*10^-6;
6 C2=C1;
7 C=C1;
8 R3=1*10^3;
9 r_ds=500;
10 f_r=1/(2*%pi*R*C);
11 disp(f_r,'resonant frequency of the Wein-bridge
    oscillator in Hertz')
12 //closed loop gain A_v=3 to sustain oscillations
13 A_v=3;
14 //A_v=(R_f+R_i)+1 where R_i is composed of R3 and
    r_ds
15 R_f=(A_v-1)*(R3+r_ds);
16 disp(R_f,'value of R_f in ohms')
```

Scilab code Exa 16.2 Phase shift oscillator

```
1 //ex16.2
2 A_cl=29;      // A_cl=R_f/R_i;
3 R3=10*10^3;
4 R_f=A_cl*R3;
5 disp(R_f, 'value of R_f in ohms')
6 //let R1=R2=R3=R and C1=C2=C3=C
7 R=R3;
8 C3=0.001*10^-6;
9 C=C3;
10 f_r=1/(2*pi*sqrt(6)*R*C);
11 disp(f_r, 'frequency of oscillation in Hertz')
```

Scilab code Exa 16.3 FET Colpitts oscillator

```
1 //ex16.3
2 C1=0.1*10^-6;
3 C2=0.01*10^-6;
4 L=50*10^-3;   //in Henry
5 C_T=C1*C2/(C1+C2); //total capacitance
6 f_r=1/(2*pi*sqrt(L*C_T));
7 disp(f_r, 'frequency of oscillation in Hertz when Q
   >10')
8 Q=8;         //when Q drops to 8
9 f_r=(1/(2*pi*sqrt(L*C_T)))*sqrt(Q^2/(1+Q^2));
10 disp(f_r, 'frequency of oscillation in hertz when Q=8
   ')
```

Scilab code Exa 16.4 Triangular wave oscillator

```
1 //ex16.4
2 R1=10*10^3;
```

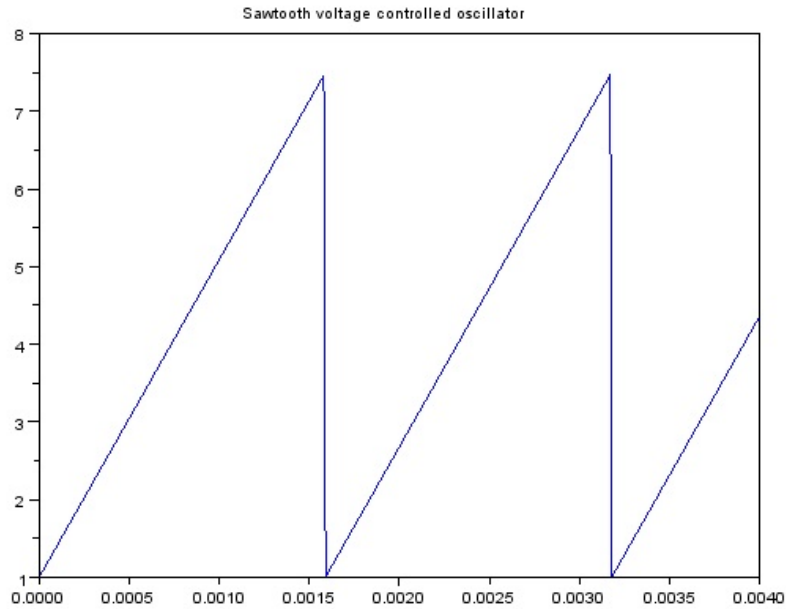



Figure 16.1: Sawtooth VCO

```

3 R2=33*103;
4 R3=10*103;
5 C=0.01*10-6;
6 f_r=(1/(4*R1*C))*(R2/R3);
7 disp(f_r,'frequency of oscillation in hertz')
8 //the value of R1 when frequency of oscillation is
   20 kHz
9 f=20*103;
10 R1=(1/(4*f*C))*(R2/R3);
11 disp(R1,'value of R1 in ohms to make frequency 20
   kiloHertz ')

```

Scilab code Exa 16.5 Sawtooth VCO

```
1 //ex16.5
2 V=15;
3 C=0.0047*10^-6;
4 R3=10*10^3;
5 R4=R3;
6 R2=10*10^3;
7 R1=68*10^3;
8 R_i=100*10^3;
9 V_G=R4*V/(R3+R4); //gate voltage at which PUT
    turns on
10 V_p=V_G; //neglecting 0.7V, this the peak voltage
    of sawtooth wave
11 disp(V_p,'neglecting 0.7V, this the peak voltage of
    sawtooth wave in volts')
12 V_F=1; //minimum peak value of sawtooth wave
13 V_pp=V_p-V_F;
14 disp(V_pp,'peak to peak amplitude of the sawtooth
    wave in volts')
15 V_IN=-V*R2/(R1+R2);
16 f=(abs(V_IN)/(R_i*C))*(1/(V_pp));
17 disp(f,'frequency of the sawtooth wave')
18 T=1/f;
19 xtitle('Sawtooth voltage controlled oscillator')
20 x=[];
21 for t=0:1*10^-5:4*10^-3
22     tcor = t- floor(t/T)*T;
23         x_temp = (V_pp/T)*tcor + 1;
24     x = [x, x_temp];
25     end;
26     t=0:1*10^-5:4*10^-3
27     plot(t,x)
```

Scilab code Exa 16.6 555 timer

```
1 //ex16.6
2 R1=2.2*10^3;
3 R2=4.7*10^3;
4 C_ext=0.022*10^-6;
5 f_r=1.44/((R1+2*R2)*C_ext);
6 disp(f_r,'frequency of the 555 timer in hertz')
7 duty_cycle=((R1+R2)/(R1+2*R2))*100;
8 disp(duty_cycle,'duty cycle in percentage')
```

Chapter 17

Voltage Regulators

Scilab code Exa 17.1 Percentage line regulation

```
1 //Ex17.1
2 Del_V_out=0.25;
3 V_out=15;
4 Del_V_in=5;    //All voltages in Volts
5 line_regulation=((Del_V_out/V_out)/Del_V_in)*100;
6 disp(line_regulation,'line regulation in %/V')
```

Scilab code Exa 17.2 Load regulation percentage

```
1 //Ex17.2
2 V_NL=12;    //No load output voltage in Volts
3 V_FL=11.9;  //Full load output voltage in Volts
4 I_F=10;    //Full load current in milli-Amperes
5 load_regulation=((V_NL-V_FL)/V_FL)*100;
6 load_reg=load_regulation/I_F;
7 disp('load regulation as percentage change from no
      load to full load')
8 disp(load_regulation)
```

```
9 disp('load regulation as percentage change per
      milliampere')
10 disp(load_reg);
```

Scilab code Exa 17.3 Series regulator

```
1 //Ex17.3
2 //All voltages are in Volts and Resistances in Ohms
3 V_REF=5.1 //Zener voltage
4 R2=10*10^3;
5 R3=10*10^3;
6 V_out=(1+(R2/R3))*V_REF;
7 disp(V_out,'output voltage in volts')
```

Scilab code Exa 17.4 Overload protection

```
1 //Ex-17.4
2 R4=1; //Resistance in Ohms
3 I_L_max=0.7/R4;
4 disp(I_L_max,'maximum current provided to load(in
      amperes)')
```

Scilab code Exa 17.5 Shunt regulator

```
1 //Ex17.5
2 V_IN=12.5; //maximum input voltage in volts
3 R1=22; //In Ohms
4 //Worst case of power dissipation is when V_OUT=0V
5 V_OUT=0;
6 V_R1=V_IN-V_OUT; //Voltage across R1
```

```

7 P_R1=(V_R1*V_R1)/R1;    //maximum power dissipated
    by R1
8 disp(P_R1,'maximum power dissipated by R1 in WATTS')

```

Scilab code Exa 17.6 Positive linear voltage regulator

```

1 //Ex17.6
2 disp('SAME AS EX-2.8 in CHAPTER-2')

```

Scilab code Exa 17.7 External pass filter

```

1 //Ex17.7
2 I_max=700*10^-3;    //in Amperes
3 R_ext=0.7/I_max;
4 disp(R_ext,'value of resistor in Ohms for which max
    current is 700mA')

```

Scilab code Exa 17.8 Power rating 7824

```

1 //Ex17.8
2 V_OUT=24;    //Output voltage in Volts
3 R_L=10;    //Load resistance in Ohms
4 V_IN=30;    //Input voltage in Volts
5 I_max=700*10^-3;    //maximum interal current in
    Amperes
6 I_L=V_OUT/R_L;    //load current in amperes
7 I_ext=I_L-I_max;    //current through the external
    pass transistor in Amperes
8 P_ext_Qext=I_ext*(V_IN-V_OUT);    //power dissipated

```

```
9 disp(P_ext_Qext, 'power dissiated (in WATTS) by the
   external pass transistor')
10 disp('For safety purpose, we choose a power
   transistor with rating more than this, say 15W')
```

Scilab code Exa 17.9 Current regulator

```
1 //Ex17.9
2 V_out=5; //7805 gives output voltage of 5V
3 I_L=1; //constant current of 1A
4 R1=V_out/I_L;
5 disp(R1, 'The value of current-setting resistor in
   ohms is')
```

Chapter 18

Programmable Analog Arrays

Scilab code Exa 18.1 Switching capacitor

```
1 //Ex18.1
2 C=1000*10^-12;    //Switch capacitor value in
   farads
3 R=1000;          //resistance in ohms
4 T=R*C;          //Time period
5 f=1/T;          //Frequency at which switch should operate
6 disp(f, 'Frequency at which each switch should
   operate(in hertz)' )
7 disp('Duty cycle should be 50%')
```

Appendix

Scilab code AP 1 Phase shift in degrees

```
1 function theta=phase_shift(f,f_c)
2     theta_rad=-atan((f/f_c))
3     theta=theta_rad*180/%pi;
4 endfunction
```

Scilab code AP 2 Open loop gain

```
1 function A_ol=open_loop_gain(A_ol_mid,f,f_c_ol)
2     A_ol=A_ol_mid/(sqrt(1+(f/f_c_ol)^2))
3 endfunction
```

Scilab code AP 3 Voltage gain in decibel

```
1 function A_v_dB=gain_in_decibel_voltage(A_v)
2     A_v_dB=20*log10(A_v)
3 endfunction
```

Scilab code AP 4 Power gain in decibel

```
1 function A_p_dB=gain_in_decibel_power(A_p)
2     A_p_dB=10*log10(A_p)
3 endfunction
```

Scilab code AP 5 value of K

```
1 //VALUE OF K
```

```
2 function [k]=value_of_K(I_D_on,V_GS,V_GS_th)
3     k=I_D_on/((V_GS-V_GS_th)^2)
4 endfunction
```

Scilab code AP 6 Drain current value

```
1 //value of I_D
2 function [i_d]= value_of_I_D(I_DSS,V_GS,V_GS_off)
3     i_d=I_DSS*(1-(V_GS/V_GS_off))^2;
4 endfunction
```
