Scilab Manual for
Radio Frequency Circuit Design
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Contents

List of Experiments

Experiment: 1

To design constant-k high pass filter.

Scilab code Solution 1.0 Experiment number 1

```
1  //AIM:To design constant−k high pass filter
2  //Software version Scilab 5.5.2
3  //OS Windows 7
4
5  clear;
6  clc;
7  //We will design constant−k T section high pass
       filter.
8  R0=600;//Nominal characteristic impedance in ohms.
9  disp('ohms',R0,'Considered value of nominal
       characteristic impedence : R0 = ')
10 fc=10^4;//Cutoff frequency in Hz.
11 L=(R0)/(4*%pi*fc);
12 disp('H',L,'L=')
13 C=1/(4*%pi*fc*R0);
14 disp('F',C,'C=')
15 //Each capacitor in the series arm of T section is 2
       C
16 twoC=2*C;
```

```scilab
17  disp('F',twoC,'2C=')
18
19  //(i): Computing Z0T:
20  //We will calculate the characteristic impedence and
        phase constant
21  // at (say) 25KHz
22  f=25*(10^3);
23  Z0T=R0*sqrt(1-((fc/f)^2));
24  disp('ohms',Z0T,'Z0T=')
25  b=2*asin(fc/f);//b=Beta
26  b_degrees=b*(180/%pi);
27  disp('degrees',b_degrees,'Beta=')
28
29  //(ii): Computing alpha:
30  f1=5*(10^3);
31  alpha=2*(acosh(fc/f1));
32  disp(alpha,'alpha=')
33
34  R01=sqrt(L/C);
35  disp('ohms',R01,'Calculated value of R0 = ')
36  if R01==R0 then
37      disp('Since the calculated value of the nominal
            characteristic impedence')
38      disp('is the same as the considered value of the
            nominal characteristic impedence,')
39      disp('our design is perfect')
40  else
41      disp('Design is not correct')
42  end
```

Experiment: 2

To design prototype Band Pass filter.

Scilab code Solution 2.0 Experiment number 2

```
1  //Aim:To design prototype Band Pass filter.
2  //Software version Scilab 5.5.2
3  //OS Windows 7
4
5  clear;
6  clc;
7  R0=600;//Nominal characteristic impedance in ohms.
8  disp('ohms',R0,'Considered value of nominal
       characteristic impedence : R0 = ')
9  fc=10^4;//Cutoff frequency in Hz.
10 f2=5000;//Upper cutoff frequency in Hz.
11 f1=2000;//Lower cutoff frequency in Hz.
12 L1=R0/(%pi*(f2-f1));
13 disp('H',L1,'L1=')
14 L=L1/2;
15 disp('H',L,'L1/2=')
16 C1=(f2-f1)/(4*%pi*R0*f1*f2);
17 disp('F',C1,'C1=')
18 C=2*C1;
```

```scilab
19  disp('F',C,'2*C1=')
20  L2=(R0*(f2-f1))/(4*%pi*f1*f2);
21  disp('H',L2,'L2=')
22  C2=1/(%pi*R0*(f2-f1));
23  disp('F',C2,'C2=')
24
25  //We will now check whether our design is correct or
        not
26  //For bandpass filter ,we have the relation :
27  // R0=sqrt(L2/C1)=sqrt(L1/C2)
28  //Let
29  R01=sqrt(L2/C1);
30  R02=sqrt(L1/C2);
31  disp('ohms',R01,'R01=')
32  disp('ohms',R02,'R02=')
33  if R01==R02 then
34      R0new=R01
35      disp('So, R01=R02')
36  else
37      disp('Design is not correct')
38  end
39  if R0new==R0 then
40      disp('Since R01=R02=R0 ,it indicates that the
            calculated values of the nominal
            characteristic impedence')
41      disp('are the same as the considered value of
            the nominal characteristic impedence ,')
42      disp('and so our design is perfect')
43  else
44      disp('Design is not correct')
45  end
```

Experiment: 3

Compute skin depth and ac & dc resistance of a wire at given frequency.

Scilab code Solution 3.0 Experiment number 3

```
1  //AIM: Compute  skin  depth  and  ac  &  dc  resistance  of
       a  wire  at  given  frequency.
2  //Software  version  Scilab  5.5.2
3  //OS  Windows  7
4
5  clc;
6  clear;
7  //Now  let  us  consder  1GHz  and  10GHz  be  the  given
       frequencies
8  //Let  the  kength  of  the  wire  be  10cm  with  a  diameter
       of  1mm
9  Length=10*(10^-2);//in  metres
10 a=0.5*(10^-3);//Since  diameter  is  1mm,so  the  radius
       'a'  will  be  0.5*10^-3  metres
11 sigmacu=64.516*10^6;//in  mho/metres
12 sigmaAl=40*10^6;//in  mho/metres
13 sigmaAu=48.544*10^6;//in  mho/metres
```

```scilab
14  //sigmacu,sigmaAl,sigmaAu are the conductivities of
        copper,aluminium
15  //and gold respectively.
16  //The formula for skin depth is 1/sqrt(%pi*f*mu0*
        sigma)
17  //Since we have to calculate the skin depth for 3
        values of frequency
18  // & 3 values of sigma,we will first calculate the
        value of
19  //1/sqrt(%pi*mu0) only which will be required for
        initial calculations
20  mu0=4*%pi*(10^(-7));//Standard value of permeability
        of free space (in H/m)
21  b=inv(sqrt(%pi*mu0));
22  //(i)At 1GHz
23  f1=1*(10^9);//in Hz
24  skindepthcu=b/(sqrt(f1*sigmacu));
25  skindepthAl=b/(sqrt(f1*sigmaAl));
26  skindepthAu=b/sqrt((f1*sigmaAu))
27  Rdccu=Length/(%pi*a*a*sigmacu)
28  RdcAl=Length/(%pi*a*a*sigmaAl);
29  RdcAu=Length/(%pi*a*a*sigmaAu);
30  Raccu=(Rdccu*a)/(2*skindepthcu);
31  RacAl=(RdcAl*a)/(2*skindepthAl);
32  RacAu=(RdcAu*a)/(2*skindepthAu);
33  disp("At 1GHz")
34  printf("Skindepth for Cu,Al,Au is as shown
        respectively=\n%g m\n%g m\n%g m\n",skindepthcu,
        skindepthAl,skindepthAu)
35  printf("DC resistance for Cu,Al,Au is as shown
        respectively=\n%g ohms\n%g ohms\n%g ohms\n",Rdccu
        ,RdcAl,RdcAu)
36  printf("AC resistance for Cu,Al,Au is as shown
        respectively=\n%g ohms\n%g ohms\n%g ohms\n",Raccu
        ,RacAl,RacAu)
37  //(ii)At 10GHz
38  f2=10*10^9;//in Hz
39  skindepthcu2=b/(sqrt(f2*sigmacu));
```

```
40  skindepthAl2=b/sqrt((f2*sigmaAl));
41  skindepthAu2=b/sqrt((f2*sigmaAu));
42  Raccu=Rdccu*a/(2*skindepthcu2);
43  RacAl=RdcAl*a/(2*skindepthAl2);
44  RacAu=RdcAu*a/(2*skindepthAu2);
45  disp("At 10GHz")
46  printf("skindepth for Cu,Al,Au is as shown
        respectively=\n%g m\n%g m\n%g m\n",skindepthcu2,
        skindepthAl2,skindepthAu2)
47  printf("AC resistance for Cu,Al,Au is as shown
        respectively=\n%g ohms\n%g ohms\n%g ohms",Raccu,
        RacAl,RacAu)
```

Experiment: 4

To design m-derived T and pi section low-pass filter.

Scilab code Solution 4.0 Experiment number 4

```
1  //Aim:To design m-derived T and pi section low-pass
      filter.
2  //Software version Scilab 5.5.2
3  //OS Windows 7
4
5  clear;
6  clc;
7  fc=1800;//fc is the cutoff frequency
8  f_infinity=2000;//f_infinity is the infinite
      attenuation frequency
9  R0=600;//R0 is the nominal characteristic impedence
10
11  //Computing the value of m:
12  m=sqrt(1-((fc/f_infinity)^2));
13  disp(m,'m=')
14  L=R0/(%pi*fc);//L is the series arm inductance
15  disp('H',L,'L=')
16  C=1/(%pi*R0*fc);//C is the shunt arm capacitance
17  disp('F',C,'C=')
```

```
18
19  //Computation of values of the elements for the T
        section
20  //of the m-derived filter:
21  a=(m*L/2);
22  disp('H',a,'mL/2=')
23  b=m*C;
24  disp('F',b,'mC=')
25  c=((1-(m^2))/(4*m))*L;
26  disp('H',c,'((1-(m^2))/(4*m)))*L=')
27
28  //Computation of the values of the elements for the
        pi-section
29  //of the m-derived filter :
30  d=(m*C)/2;
31  disp('F',d,'mC/2=')
32  e=m*L;
33  disp('H',e,'mL=')
34  f=((1-(m^2))/(4*m))*C;
35  disp('F',f,'((1-(m^2))/(4*m))*C=')
```

Experiment: 5

To design m-derived T and pi section high-pass filter.

Scilab code Solution 5.0 Experiment number 5

```
1  //Aim:To design m-derived T and pi section high-pass
       filter.
2  //Software version Scilab 5.5.2
3  //OS Windows 7
4
5  clear;
6  clc;
7  f_infinity=3.6*(10^3);//Frequency at infinite
       attenuation.
8  fc=4*(10^3);//Cut-off frequency.
9  R0=600;//Nominal characteristic impedance.
10
11 //Computing the values of m:
12 m=sqrt(1-((f_infinity/fc)^2));
13 disp(m,'m=')
14 C=1/(4*%pi*fc*R0);//C is the series arm capacitance.
15 disp('Farads',C,'C=')
16 L=R0/(4*%pi*fc);//L is the shunt arm inductance.
17 disp('Henry',L,'L=')
```

```scilab
18
19  //Computation of the values of the circuit elements
         for T−section
20  //of m−derived filter :
21  a=(2*C)/m;
22  disp('Farads',a,'2C/m=')
23  b=L/m;
24  disp('Henry',b,'L/m=')
25  c=((4*m)/(1-(m^2)))*C;
26  disp('Farads',c,'((4*m)/(1−(m^2)))*C=')
27  //Computation of the values of the circuit elements
         for pi−section
28  //of m−derived filter :
29  d=(2*L)/m;
30  disp('Henry',d,'2L/m=')
31  e=C/m;
32  disp('Farads',e,'C/m=')
33  f=((4*m)/(1-(m^2)))*L;
34  disp('Henry',f,'((4*m)/(1−(m^2)))*L=')
```

Experiment: 6

Compute width of trace,phase velocity and wavelegngth of microstripline

Scilab code Solution 6.0 Experiment number 6

```
1  //AIM:Compute width of trace ,phase velocity and
        wavelength of microstripline.
2  //Software version Scilab 5.5.2
3  //OS Windows 7
4
5  clc;
6  clear;
7  Zo=50;//Considered characteristic impedence Zo=50
        ohms
8  printf("Considered characteristic impedence=%g ohms\
        n\n",Zo)
9  //We know that ,for characteristic impedence of 50
        ohms ,the value of w/h is 1.9
10 mu0=4*%pi*(10^(-7));
11 epsilon0=8.85*(10^(-12));
12 Zf=sqrt(mu0/epsilon0);//in ohms
13 printf('Value of Zf=%g ohms\n\n',Zf)
```

```scilab
14  h=40;//in mil
15  f=2*10^9;//in Hz
16  //Er=epsilonr
17  Er=4.6;
18  //taking A=2*pi*(Zo/Zf)*(sqrt(Er+1/2))+((Er-1)/(Er
        +1))*(0.23+0.11/Er)
19  A=2*%pi*(Zo/Zf)*(sqrt((Er+1)/2))+((Er-1)/(Er+1))
        *(0.23+0.11/Er);
20  printf("Value of A=%g \n\n",A)
21  a=(8*exp(A))/(exp(2*A)-2);//a means the calculation
         of w/h
22  //Eeff=effective dielectric constant.
23  if a>1 then
24  Eeff=((Er+1)/2)+((Er-1)/2)*((1+12*(a^-1))^-0.5);
25  printf("Effective permittivity=%g\n\n",Eeff)
26  Zo1=Zf/(sqrt(Eeff)*(1.393+a+(2/3)*log(a+1.444)));
27  else
28  Eeff=((Er+1)/2)+((Er-1)/2)*(((1+12*(a^-1))^-0.5)
        +(0.04(1-a)^2));
29  printf("Effective permittivity=%g\n\n",Eeff)
30  Zo1=(Zf/(2*%pi*sqrt(Eeff)))*log((8*(a^-1))+(0.25*a))
        ;
31  end
32  Zo1=int(Zo1);
33  printf("Computed characteristic impedence,Zo1=%g
        ohms\n\n",Zo1)
34  if Zo1==Zo then
35      printf("The computed value of Zo1 is same as the
             considered value of Zo\n")
36      printf("Hence our design is correct.\n\n")
37  else
38      printf("Design is incorrect.\n\n")
39  end
40  w=a*h;
41  printf("Width of the trace=%g mils\n\n",w)
42  c=3*10^8;
43  vp=c/(sqrt(Eeff));
44  printf("Phase velocity=%g m/s\n\n",vp)
```

```
45  lambda=vp/f;
46  printf("Wavelength=%g m",lambda)
```

Experiment: 7

To design composite low-pass filter.

Scilab code Solution 7.0 Experiment number 7

```scilab
1  //Aim:To design composite low−pass filter.
2  //Software version Scilab 5.5.2
3  //OS Windows 7
4
5  clear;
6  clc;
7  R0=75;//R0 is the nominal impedence(in ohms).
8  fc=2*(10^6);//fc is the cut−off frequency in Hz.
9  f_infinity=2.05*(10^6);//f_infinity represents that
      the infinite attenuation.
10 //pole is placed at 2.05 MHz.
11
12 //Constant k section :
13 L=R0/(%pi*fc);
14 disp('H',L,'L=')
15 C=1/(%pi*R0*fc);
16 disp('F',C,'C=')
17
18 //m−derived section :
```

```
19  m=sqrt(1-((fc/f_infinity)^2));
20  disp(m,'m=')
21  a=(m*L)/2;
22  disp('H',a,'For m-derived section, mL/2=')
23  b=m*C;
24  disp('F',b,'For m-derived section, mC=')
25  c=((1-(m^2))/(4*m))*L;
26  disp('H',c,'For m-derived section, ((1-(m^2))/(4*m))
        )*L=')
27
28  //Matching sections: with m=0.6
29  //Let us call this new 'm' as 'm1'.
30  m1=0.6;
31  d=(m1*L)/2;
32  disp('H',d,'For matching section, m1L/2=')
33  e=(m1*C)/2;
34  disp('F',e,'For matching section, m1C/2=')
35  f=((1-(m1^2))/(2*m1))*L;
36  disp('H',f,'For matching section, ((1-(m1^2))/(2*m1)
        ))*L=')
```

Experiment: 8

To design composite high-pass filter.

Scilab code Solution 8.0 Experiment number 8

```
1  //Aim:To design composite high-pass filter.
2  //Software version Scilab 5.5.2
3  //OS Windows 7
4
5  clear;
6  clc;
7  R0=75;//R0 is the nominal impedence (in ohms)
8  fc=50*(10^3);//fc is the cut-off frequency (in Hz)
9  f_infinity=48*(10^3);
10
11  //Constant k section :
12  L=R0/(4*%pi*fc);
13  disp('H',L,'L=')
14  C=1/(4*%pi*R0*fc);
15  disp('F',C,'C=')
16  twoC=2*C;
17  disp('F',twoC,'2C=')
18
19  //m-derived section :
```

```
20
21  //Computing m
22  m=sqrt(1-((f_infinity/fc)^2));
23  disp(m,'m=')
24  a=(2*C)/m;
25  disp('F',a,'2C/m=')
26  b=L/m;
27  disp('H',b,'L/m=')
28  c=(4*m*C)/(1-(m^2));
29  disp('F',c,'(4*m*C)/(1-(m^2))=')
30
31  //Matching sections: with m=0.6
32  //Let us call this new 'm' as m1
33  m1=0.6;
34  d=(2*C)/m1;
35  disp('F',d,'2C/m1=')
36  e=(2*L)/m1;
37  disp('H',e,'2L/m1=')
38  f=(2*m1*C)/(1-(m1^2));
39  disp('F',f,'(2*m1*C)/(1-(m1^2))=')
40  //Some of the capacitors will be in series
41  C1=(d*twoC)/(d+twoC);
42  disp('F',C1,'C1=')
43  C2=(twoC*a)/(twoC+a);
44  disp('F',C2,'C2=')
45  C3=(a*d)/(a+d);
46  disp('F',C3,'C3=')
```

Experiment: 9

To design Butterworth low pass filter with 3dB ripple and plot response of filter.

Scilab code Solution 9.0 Experiment number 9

```
1  //AIM:To design Butterworth low pass filter with 3dB
       ripple and plot response of filter.
2  //Software version Scilab 5.5.2
3  //OS Windows 7
4
5  clc;
6  clear;
7  f=2;//f=normalized frequency.
8  IL=20;//IL is the insertion loss (in dB).
9  E=10^0.3-1;
10 N=0.5*(log(10^(0.1*IL)-1)/log((f)+log(E)));
11 A=N-int(N);
12 if(A>0)
13     N=int(N)+1;
14 end;
15 disp(N,"Order of filter=")
16 printf("values of filter element are\n")
```

```
17  for i=1:N
18      g(i)=2*sin(((((i*2)-1)*%pi)/(2*N));
19          printf("g(%g)=%g\n",i,g)
20  end
21
22  //IL=10log(1+(f)^2*N)
23  //Now ploting IL Vs normalized frequency graph.
24  f=0:0.1:5;
25  IL=10*log10(1+f.^(2*N));
26  title('Response of Butterworth low pass filter in
        terms of ''Insertion-loss(IL) versus frequency''
        ');
27  ylabel("IL in dB");
28  xlabel("normalized frequency");
29  plot2d(f,IL);
30  //representing values of IL in console.
31  f=0:0.5:5;
32  IL=10*log10(1+f.^(2*N));
33  disp(IL,"IL in dB",f,"normalized frequency")
```

Experiment: 10

To design Low pass Chebychev filter and plot response.

Scilab code Solution 10.0 Experiment number 10

```
1 //AIM:To design Low pass Chebyshev filter and plot
      response.
2 //Software version Scilab 5.5.2
3 //OS Windows 7
4
5 clc;
6 clear;
7 //ripple
8 rp=6;//ripple in dB.
9 ohm=2;//ohm=normalized frequency.
10 IL=50;//IL is the insertion loss (in dB).
11 a=sqrt(10^(rp/10)-1)
12 //To optain order of filter N
13 // Using equation IL=10*log(1+a^2*(T^2(    )))
14 num=acosh(sqrt((10^(0.1*IL)-1)/(a^2)))
15 dem=acosh(ohm)
16 N=num/dem
17 x=N-int(N)
18 if(x>0);
```

```
19      N=int(N)+1;
20  end
21  disp(N,"Order of filter=");
22  ohm=0:0.01:1;
23  T=cos(N*(acos(ohm)));
24  IL=10*log10(1+(T.^2).*a^2);
25  title('Response of low pass Chebychev filter');
26  ylabel("IL in dB");
27  xlabel("normalized frequency");
28  plot2d(ohm,IL);
29  ohm=0:0.1:1;
30  T=cos(N*(acos(ohm)));
31  IL=10*log10(1+(T.^2).*a^2);
32  disp(IL,"IL in dB",ohm,"normalized frequency");
```

Experiment: 11

To convert low- pass filter to high- pass ,band -pass and band-stop.

Scilab code Solution 11.0 Experiment number 11

```
1 //Aim:To convert  low- pass  filter  to high- pass ,
      band -pass  and band-stop.
2 //Software  version  Scilab  5.5.2
3 //OS Windows 7
4
5 clc;
6 clear;
7 //we are considering order  of filter  as 5 hence
      there  will  be three
8 //inductors  and two capacitors
9 L=[1.7058 2.5408 1.7058]
10 c=[1.2296 1.2296]
11 fc=60*10^6
12 wc=2*%pi*fc
13 fu=2*10^9
14 wu=2*%pi*fu
15 fl=1.9*10^9
```

```
16  wl=2*%pi*fl
17  wd=wu-wl;
18  wo=sqrt(wu*wl)
19  del=wd/wo;
20  //high pass filter.
21  disp("Converting values to High pass filter")
22  disp("Here inductor is converted into cpacitor &
        cpacitor is converted into inductor")
23  disp("For capacitor")
24  c1=(L*wc).^-1;
25  disp(c1)
26  disp("For inductor")
27  L1=(wc*c).^-1;
28  disp(L1)
29  //band pass filter
30  disp("Converting values to band pass filter")
31  disp("Here inductor is coverted into series
        inductance and cpacitance value are as follows")
32  disp("For inductor")
33  L2=L*(del*wo).^-1;
34  disp(L2)
35  disp("For capacitor")
36  c2=((L*wo).^-1)*del;
37  disp(c2)
38  disp("Here capacitor is coverted into serice
        inductance and cpacitance value are as follows")
39  disp("For inductor")
40  L2=del/(wo*c);
41  disp(L2)
42  disp("For capacitor")
43  c2=c/(wo*del);
44  disp(c2)
45  //band stop filter.
46  disp("Convertion values of band stop filter")
47  disp("Here inductor is coverted into parallel
        inductance and cpacitance value are as follows")
48  disp("For inductor")
49  L3=(L*del)/wo;
```

```
50  disp(L3)
51  disp("For capacitor")
52  c3=(wo*L*del).^-1;
53  disp(c3)
54  disp("Here capacitance is coverted into serice
        inductance and cpacitance value are as follows")
55  disp("For inductor")
56  L3=(wo*c*del).^-1;
57  disp(L3)
58  disp("For capacitor")
59  c3=(c*del)/wo;
60  disp(c3)
```