Scilab Manual for Radio Frequency Circuit Design by Prof Rajiv Tawde Others Padmabhushan Vasantdada Patil Pratishthan's College of Engineering/Mumbai University[1]

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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

```
//AIM:To design constant-k high pass filter
//Software version Scilab 5.5.2
//OS Windows 7

clear;
clc;
//We will design constant-k T section high pass filter.
R0=600;//Nominal characteristic impedance in ohms.
disp('ohms',R0,'Considered value of nominal characteristic impedence : R0 = ')
fc=10^4;//Cutoff frequency in Hz.
L=(R0)/(4*%pi*fc);
disp('H',L,'L=')
C=1/(4*%pi*fc*R0);
disp('F',C,'C=')
//Each capacitor in the series arm of T section is 2 C
twoC=2*C;
```

```
disp('F',twoC,'2C=')

//(i): Computing Z0T:
//We will calculate the characteristic impedence and
    phase constant
// at (say) 25KHz
f=25*(10^3);
Z0T=R0*sqrt(1-((fc/f)^2));
disp('ohms',Z0T,'Z0T=')
b=2*asin(fc/f);//b=Beta
b_degrees=b*(180/%pi);
disp('degrees',b_degrees,'Beta=')

//(ii): Computing alpha:
f1=5*(10^3);
alpha=2*(acosh(fc/f1));
disp(alpha,'alpha=')

R01=sqrt(L/C);
disp('ohms',R01,'Calculated value of R0 = ')
if R01==R0 then
    disp('Since the calculated value of the nominal
        characteristic impedence')
    disp('is the same as the considered value of the
        nominal characteristic impedence,')
    disp('our design is perfect')
else
    disp('Design is not correct')
end
```

Experiment: 2

To design prototype Band Pass filter.

Scilab code Solution 2.0 Experiment number 2

```
//Aim:To design prototype Band Pass filter.
//Software version Scilab 5.5.2
//OS Windows 7

clear;
clc;
R0=600;//Nominal characteristic impedance in ohms.
disp('ohms',R0,'Considered value of nominal
    characteristic impedence : R0 = ')
fc=10^4;//Cutoff frequency in Hz.
f2=5000;//Upper cutoff frequency in Hz.
f1=2000;//Lower cutoff frequency in Hz.
L1=R0/(%pi*(f2-f1));
disp('H',L1,'L1=')
L=L1/2;
disp('H',L,'L1/2=')
C1=(f2-f1)/(4*%pi*R0*f1*f2);
disp('F',C1,'C1=')
C=2*C1;
```

```
disp('F',C,'2*C1=')
L2=(R0*(f2-f1))/(4*%pi*f1*f2);
disp('H',L2,'L2=')
C2=1/(%pi*R0*(f2-f1));
disp('F',C2,'C2=')

//We will now check whether our design is correct or not
//For bandpass filter ,we have the relation :
// R0=sqrt(L2/C1)=sqrt(L1/C2)
//Let
R01=sqrt(L2/C1);
R02=sqrt(L1/C2);
disp('ohms',R01,'R01=')
disp('ohms',R02,'R02=')
if R01==R02 then
    R0new=R01
    disp('So, R01=R02')
else
    disp('Design is not correct')
end
if R0new==R0 then
    disp('Since R01=R02=R0 ,it indicates that the calculated values of the nominal characteristic impedence')
    disp('are the same as the considered value of the nominal characteristic impedence,')
    disp('and so our design is perfect')
else
    disp('Design is not correct')
end
```

Experiment: 3

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

Scilab code Solution 3.0 Experiment number 3

```
//AIM: Compute skin depth and ac & dc resistance of
   a wire at given frequency.
//Software version Scilab 5.5.2
//OS Windows 7

clc;
clear;
//Now let us consder 1GHz and 10GHz be the given
   frequencies
//Let the kength of the wire be 10cm with a diameter
   of 1mm
Length=10*(10^-2);//in metres
a=0.5*(10^-3);//Since diameter is 1mm, so the radius
   'a' will be 0.5*10^-3 metres
sigmacu=64.516*10^6;//in mho/metres
sigmaAl=40*10^6;//in mho/metres
sigmaAu=48.544*10^6;//in mho/metres
```

```
//sigmacu,sigmaAl,sigmaAu are the conductivities of copper,aluminium
//and gold respectively.
//The formula for skin depth is 1/sqrt(%pi*f*mu0*sigma)
//Since we have to calculate the skin depth for 3 values of frequency
// & 3 values of sigma,we will first calculate the value of
//1/sqrt(%pi*mu0) only which will be required for initial calculations
mu0=4*%pi*(10^(-7));//Standard value of permeability of free space (in H/m)
b=inv(sqrt(%pi*mu0));
//(i)At 1GHz
f1=1*(10^9);//in Hz
skindepthcu=b/(sqrt(f1*sigmacu));
skindepthAl=b/(sqrt(f1*sigmaAl));
skindepthAu=b/sqrt((f1*sigmaAu))
Rdccu=Length/(%pi*a*a*sigmacu)
RdcAl=Length/(%pi*a*a*sigmaAl);
RdcAu=Length/(%pi*a*a*sigmaAu);
Raccu=(Rdccu*a)/(2*skindepthcu);
RacAl=(RdcAl*a)/(2*skindepthAl);
RacAu=(RdcAu*a)/(2*skindepthAu);
disp("At 1GHz")
printf("Skindepth for Cu,Al,Au is as shown respectively=\n%g m\n%g m\n%g m\n",skindepthcu,skindepthAl,skindepthAu)
printf("DC resistance for Cu,Al,Au is as shown respectively=\n%g ohms\n%g ohms\n%g ohms\n",Rdccu,RdcAl,RdcAu)
printf("AC resistance for Cu,Al,Au is as shown respectively=\n%g ohms\n%g ohms\n%g ohms\n",Raccu,RacAl,RacAu)
//(ii)At 10GHz
f2=10*10^9;//in Hz
skindepthcu2=b/(sqrt(f2*sigmacu));
```

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

```
//Aim:To design m-derived T and pi section low-pass
   filter.
//Software version Scilab 5.5.2
//OS Windows 7

clear;
clc;
fc=1800;//fc is the cutoff frequency
f_infinity=2000;//f_infinity is the infinite
   attenuation frequency
R0=600;//R0 is the nominal characteristic impedence

//Computing the value of m:
m=sqrt(1-((fc/f_infinity)^2));
disp(m,'m=')
L=R0/(%pi*fc);//L is the series arm inductance
disp('H',L,'L=')
C=1/(%pi*R0*fc);//C is the shunt arm capacitance
disp('F',C,'C=')
```

```
//Computation of values of the elements for the T
    section
//of the m-derived filter:
a=(m*L/2);
disp('H',a,'mL/2=')
b=m*C;
disp('F',b,'mC=')
c=((1-(m^2))/(4*m))*L;
disp('H',c,'((1-(m^2))/(4*m))*L=')

//Computation of the values of the elements for the
    pi-section
//of the m-derived filter :
d=(m*C)/2;
disp('F',d,'mC/2=')
e=m*L;
disp('H',e,'mL=')
f=((1-(m^2))/(4*m))*C;
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

```
//Aim:To design m-derived T and pi section high-pass
    filter.
//Software version Scilab 5.5.2
//OS Windows 7

clear;
clc;
f_infinity=3.6*(10^3);//Frequency at infinite
   attenuation.
fc=4*(10^3);//Cut-off frequency.
R0=600;//Nominal characteristic impedance.

//Computing the values of m:
m=sqrt(1-((f_infinity/fc)^2));
disp(m,'m=')
C=1/(4*%pi*fc*R0);//C is the series arm capacitance.
disp('Farads',C,'C=')
L=R0/(4*%pi*fc);//L is the shunt arm inductance.
disp('Henry',L,'L=')
```

```
//Computation of the values of the circuit elements
    for T-section
//of m-derived filter :
a=(2*C)/m;
disp('Farads',a,'2C/m=')
b=L/m;
disp('Henry',b,'L/m=')
c=((4*m)/(1-(m^2)))*C;
disp('Farads',c,'((4*m)/(1-(m^2)))*C=')
//Computation of the values of the circuit elements
    for pi-section
//of m-derived filter :
d=(2*L)/m;
disp('Henry',d,'2L/m=')
e=C/m;
disp('Farads',e,'C/m=')
f=((4*m)/(1-(m^2)))*L;
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

```
//AIM:Compute width of trace,phase velocity and
    wavelength of microstripline.
//Software version Scilab 5.5.2
//OS Windows 7

clc;
clear;
Zo=50;//Considered characteristic impedence Zo=50
    ohms
printf("Considered characteristic impedence=%g ohms\
    n\n",Zo)
//We know that,for characteristic impedence of 50
    ohms,the value of w/h is 1.9
mu0=4*%pi*(10^(-7));
epsilon0=8.85*(10^(-12));
Zf=sqrt(mu0/epsilon0);//in ohms
printf('Value of Zf=%g ohms\n\n',Zf)
```

```
h=40;//in mil
f=2*10^9;//in Hz
//Er=epsilonr
Er=4.6;
//taking A=2*pi*(Zo/Zf)*(sqrt(Er+1/2))+((Er-1)/(Er+1))*(0.23+0.11/Er)
A=2*%pi*(Zo/Zf)*(sqrt((Er+1)/2))+((Er-1)/(Er+1))*(0.23+0.11/Er);
printf("Value of A=%g \n\n",A)
a=(8*exp(A))/(exp(2*A)-2);//a means the calculation of w/h
//Eeff=effective dielectric constant.
if a>1 then
Eeff=((Er+1)/2)+((Er-1)/2)*((1+12*(a^-1))^-0.5);
printf("Effective permittivity=%g\n\n",Eeff)
Zo1=Zf/(sqrt(Eeff)*(1.393+a+(2/3)*log(a+1.444)));
else
Eeff=((Er+1)/2)+((Er-1)/2)*(((1+12*(a^-1))^-0.5)+(0.04(1-a)^2));
printf("Effective permittivity=%g\n\n",Eeff)
Zo1=(Zf/(2*%pi*sqrt(Eeff)))*log((8*(a^-1))+(0.25*a));
end
Zo1=int(Zo1);
printf("Computed characteristic impedence,Zo1=%g ohms\n\n",Zo1)
if Zo1==Zo then
    printf("The computed value of Zo1 is same as the considered value of Zo\n")
    printf("Hence our design is correct.\n\n")
else
    printf("Design is incorrect.\n\n")
end
w=a*h;
printf("Width of the trace=%g mils\n\n",w)
c=3*10^8;
vp=c/(sqrt(Eeff));
printf("Phase velocity=%g m/s\n\n",vp)
```

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

Experiment: 7

To design composite low-pass filter.

Scilab code Solution 7.0 Experiment number 7

```
//Aim:To design composite low-pass filter.
//Software version Scilab 5.5.2
//OS Windows 7

clear;
clc;
R0=75;//R0 is the nominal impedence(in ohms).
fc=2*(10^6);//fc is the cut-off frequency in Hz.
f_infinity=2.05*(10^6);//f_infinity represents that the infinite attenuation.
//pole is placed at 2.05 MHz.

//Constant k section :
L=R0/(%pi*fc);
disp('H',L,'L=')
C=1/(%pi*R0*fc);
disp('F',C,'C=')

//m-derived section :
```

```
m=sqrt(1-((fc/f_infinity)^2));
disp(m,'m=')
a=(m*L)/2;
disp('H',a,'For m-derived section , mL/2=')
b=m*C;
disp('F',b,'For m-derived section , mC=')
c=((1-(m^2))/(4*m))*L;
disp('H',c,'For m-derived section , ((1-(m^2))/(4*m))*L=')

//Matching sections: with m=0.6
//Let us call this new 'm' as 'm1'.
m1=0.6;
d=(m1*L)/2;
disp('H',d,'For matching section , m1L/2=')
e=(m1*C)/2;
disp('F',e,'For matching section , m1C/2=')
f=((1-(m1^2))/(2*m1))*L;
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

```
//Aim:To design composite high-pass filter.
//Software version Scilab 5.5.2
//OS Windows 7

clear;
clc;
R0=75;//R0 is the nominal impedence (in ohms)
fc=50*(10^3);//fc is the cut-off frequency (in Hz)
f_infinity=48*(10^3);

//Constant k section :
L=R0/(4*%pi*fc);
disp('H',L,'L=')
C=1/(4*%pi*R0*fc);
disp('F',C,'C=')
twoC=2*C;
disp('F',twoC,'2C=')

//m-derived section :
```

```
//Computing m
m=sqrt(1-((f_infinity/fc)^2));
disp(m,'m=')
a=(2*C)/m;
disp('F',a,'2C/m=')
b=L/m;
disp('H',b,'L/m=')
c=(4*m*C)/(1-(m^2));
disp('F',c,'(4*m*C)/(1-(m^2))=')

//Matching sections: with m=0.6
//Let us call this new 'm' as m1
m1=0.6;
d=(2*C)/m1;
disp('F',d,'2C/m1=')
e=(2*L)/m1;
disp('H',e,'2L/m1=')
f=(2*m1*C)/(1-(m1^2));
disp('F',f,'(2*m1*C)/(1-(m1^2))=')
//Some of the capacitors will be in series
C1=(d*twoC)/(d+twoC);
disp('F',C1,'C1=')
C2=(twoC*a)/(twoC+a);
disp('F',C2,'C2=')
C3=(a*d)/(a+d);
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

```
//AIM:To design Butterworth low pass filter with 3dB
    ripple and plot response of filter.
//Software version Scilab 5.5.2
//OS Windows 7

clc;
clear;
f=2;//f=normalized frequency.
IL=20;//IL is the insertion loss (in dB).
E=10^0.3-1;
N=0.5*(log(10^(0.1*IL)-1)/log((f)+log(E)));
A=N-int(N);
if(A>0)
    N=int(N)+1;
end;
disp(N,"Order of filter=")
printf("values of filter element are\n")
```

```
for i=1:N
    g(i)=2*sin((((i*2)-1)*%pi)/(2*N));
    printf("g(%g)=%g\n",i,g)
end

//IL=10log(1+(f)^2*N)
//Now ploting IL Vs normalized frequency graph.
f=0:0.1:5;
IL=10*log10(1+f.^(2*N));
title('Response of Butterworth low pass filter in
    terms of ''Insertion-loss(IL) versus frequency''
    ');
ylabel("IL in dB");
xlabel("normalized frequency");
plot2d(f,IL);
//representing values of IL in console.
f=0:0.5:5;
IL=10*log10(1+f.^(2*N));
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

```
//AIM:To design Low pass Chebyshev filter and plot response.
//Software version Scilab 5.5.2
//OS Windows 7

clc;
clear;
//ripple
rp=6;//ripple in dB.
ohm=2;//ohm=normalized frequency.
IL=50;//IL is the insertion loss (in dB).
a=sqrt(10^(rp/10)-1)
//To optain order of filter N
// Using equation IL=10*log(1+a^2*(T^2(   )))
num=acosh(sqrt((10^(0.1*IL)-1)/(a^2)))
dem=acosh(ohm)
N=num/dem
x=N-int(N)
if(x>0);
```

```
    N=int(N)+1;
end
disp(N,"Order of filter=");
ohm=0:0.01:1;
T=cos(N*(acos(ohm)));
IL=10*log10(1+(T.^2).*a^2);
title('Response of low pass Chebychev filter');
ylabel("IL in dB");
xlabel("normalized frequency");
plot2d(ohm,IL);
ohm=0:0.1:1;
T=cos(N*(acos(ohm)));
IL=10*log10(1+(T.^2).*a^2);
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

```
//Aim:To convert  low- pass filter to high- pass ,
   band -pass and band-stop.
//Software version Scilab 5.5.2
//OS Windows 7

clc;
clear;
//we are considering order of filter as 5 hence
   there will be three
//inductors and two capacitors
L=[1.7058 2.5408 1.7058]
c=[1.2296 1.2296]
fc=60*10^6
wc=2*%pi*fc
fu=2*10^9
wu=2*%pi*fu
fl=1.9*10^9
```

```
wl=2*%pi*fl
wd=wu-wl;
wo=sqrt(wu*wl)
del=wd/wo;
//high pass filter.
disp("Converting values to High pass filter")
disp("Here inductor is converted into cpacitor &
    cpacitor is converted into inductor")
disp("For capacitor")
c1=(L*wc).^-1;
disp(c1)
disp("For inductor")
L1=(wc*c).^-1;
disp(L1)
//band pass filter
disp("Converting values to band pass filter")
disp("Here inductor is coverted into series
    inductance and cpacitance value are as follows")
disp("For inductor")
L2=L*(del*wo).^-1;
disp(L2)
disp("For capacitor")
c2=((L*wo).^-1)*del;
disp(c2)
disp("Here capacitor is coverted into serice
    inductance and cpacitance value are as follows")
disp("For inductor")
L2=del/(wo*c);
disp(L2)
disp("For capacitor")
c2=c/(wo*del);
disp(c2)
//band stop filter.
disp("Convertion values of band stop filter")
disp("Here inductor is coverted into parallel
    inductance and cpacitance value are as follows")
disp("For inductor")
L3=(L*del)/wo;
```

```
disp(L3)
disp("For capacitor")
c3=(wo*L*del).^-1;
disp(c3)
disp("Here capacitance is coverted into serice
    inductance and cpacitance value are as follows")
disp("For inductor")
L3=(wo*c*del).^-1;
disp(L3)
disp("For capacitor")
c3=(c*del)/wo;
disp(c3)
```