
SIMULATIONS OF PARALLEL RESONANT CIRCUIT

POWER ELECTRONICS

COLORADO STATE UNIVERSITY

PURPOSE: The purpose of this lab is to simulate the LCC circuit using MATLAB® and ORCAD Capture CIS® to better familiarize the student with some of its operating characteristics. This lab will explore some of the following aspects of the Parallel Resonant circuit:

- ❑ Input impedance
- ❑ Magnitude and phase margin
- ❑ Zero frequency
- ❑ Output power
- ❑ Output current
- ❑ Plot the natural response for the output voltage
- ❑ Zero poles
- ❑ Phase of transfer function
- ❑ Input impedance for varying loads resistance (R)

Parallel Resonant circuit Using PSPICE

NOTE: The simulations that follow are intended to be completed with ORCAD Capture CIS®. It is assumed that the student has a fundamental understanding of the operation of ORCAD Capture CIS®. ORCAD Capture CIS® provides tutorials for users that are not experienced with its functions.

PROCEDURE:

Part 1: Build the schematic shown in Figure 1.

Im is an AC current source (IAC) from the source library. It needs to be set for 0.001 Amp.

L1 is an ideal inductor from the Analog Library. Set for 0.1H.

R is an ideal resistor from the Analog Library. Set for 20k.

C5 is an ideal capacitor from the Analog library. Change the value to 100nF.

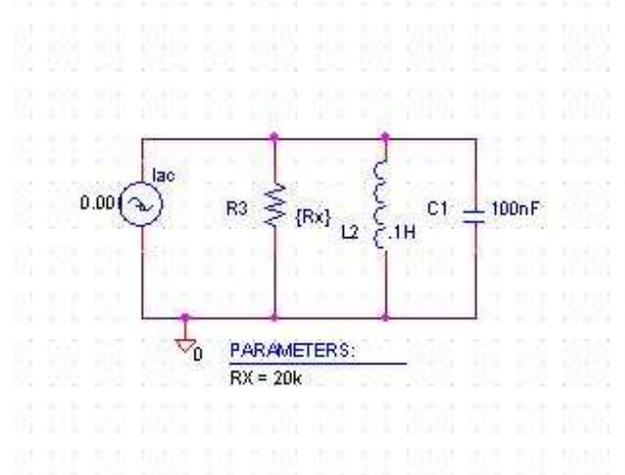
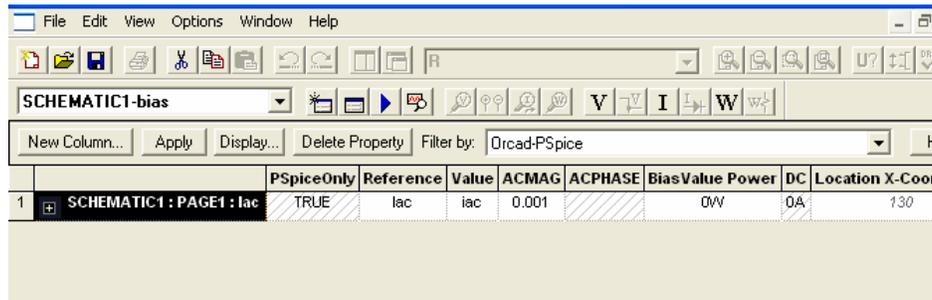


Figure 1

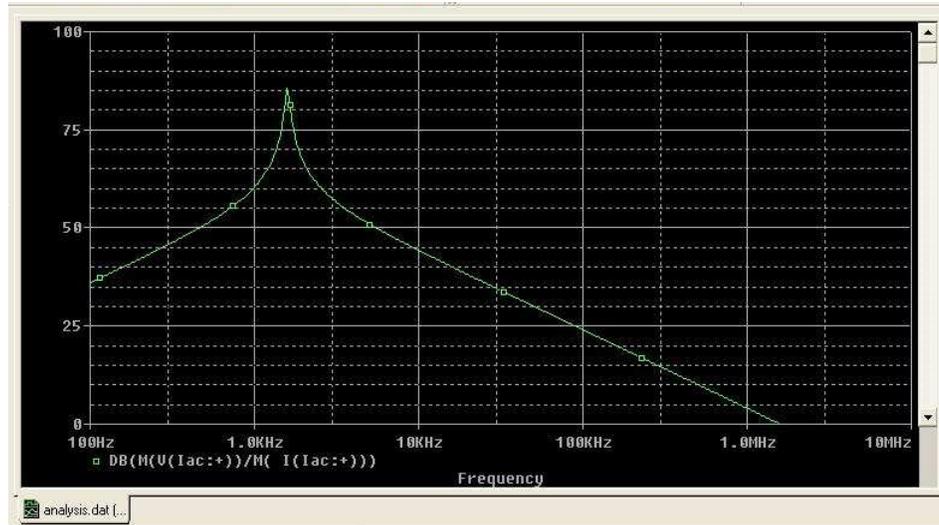
Use the student version of ORCAD Capture CIS[®] that is installed on CSU computer lab to simulate the given circuit above. Here are the steps:

1. Draw the circuit given above
2. Apply the IAC, because we want to plot the frequency response
3. Set ACMAG =0.001 in IAC

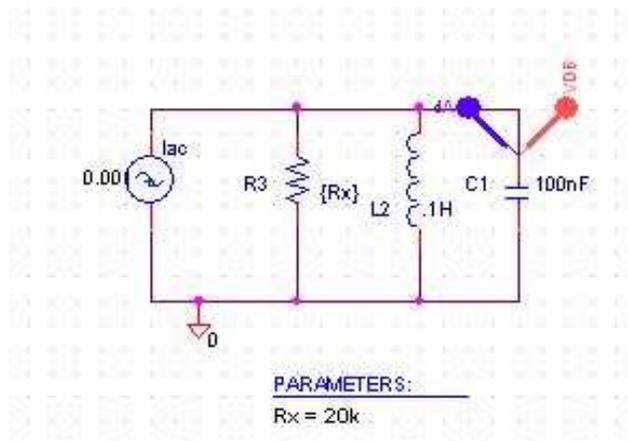


4. Do analysis setup
 - a. On the ORCAD Capture CIS[®] menu select new simulation profile
 - b. Choose AC Sweep/Noise in the Analysis type menu
 - c. Set the Start Frequency at 100, the End Frequency at 10Meg and the Points/Decade at 101
 - d. Make sure Logarithmic is selected and set to Decade
 - e. Click OK

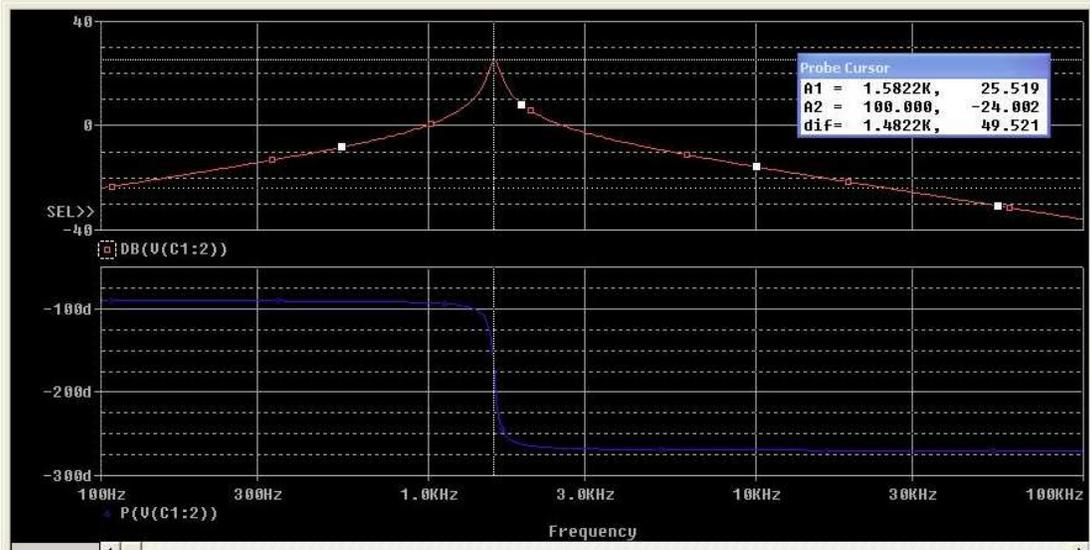
The figure below is the result of input impedance of Parallel circuit. What is the input impedance value of parallel circuit?



Next, we want to run the simulation of the output voltage of the parallel circuit. Use the same circuit as above and place the “**db magnitude of voltage marker**” and the “**phase of voltage marker**” in series next to output capacitor. (Note: Markers are in the PSpice menu)

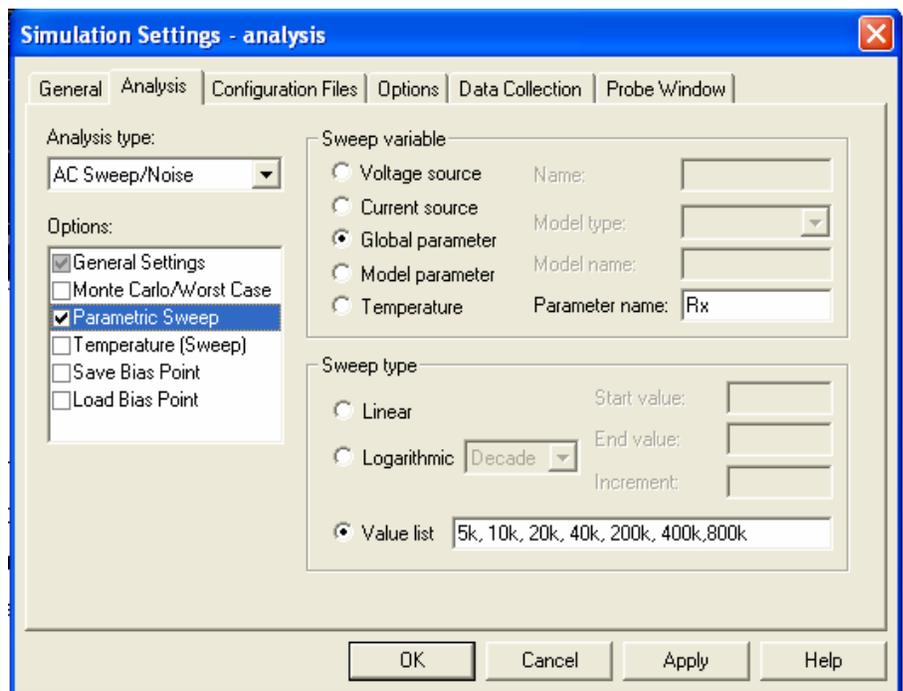


The figure below is the result of output voltage of parallel circuit. What is the value of output voltage of the parallel circuit? What is the phase value of output voltage of parallel circuit?

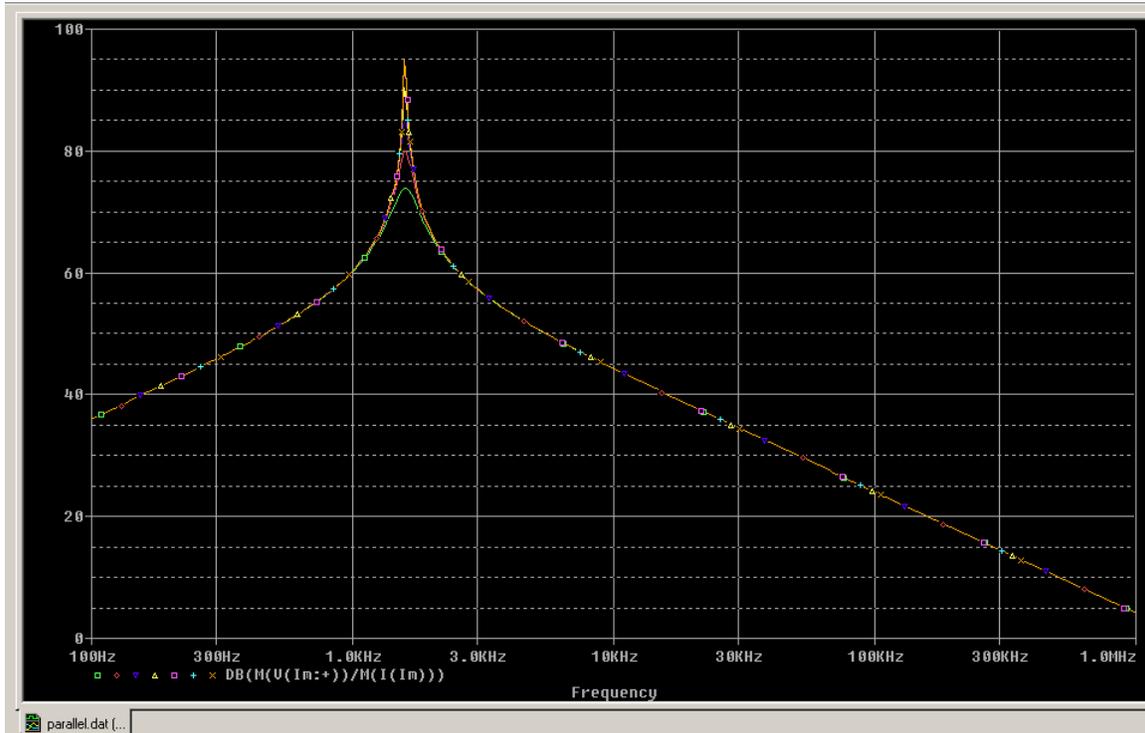


Next, we want to run the simulation of the input impedance of the series parallel resonant circuit with varying resistors value. Use the same circuit as above, and change the resistor values. Resistor values are: 5k, 10k, 20k, 40k, 200k, 400k, and 800k Ohms. To

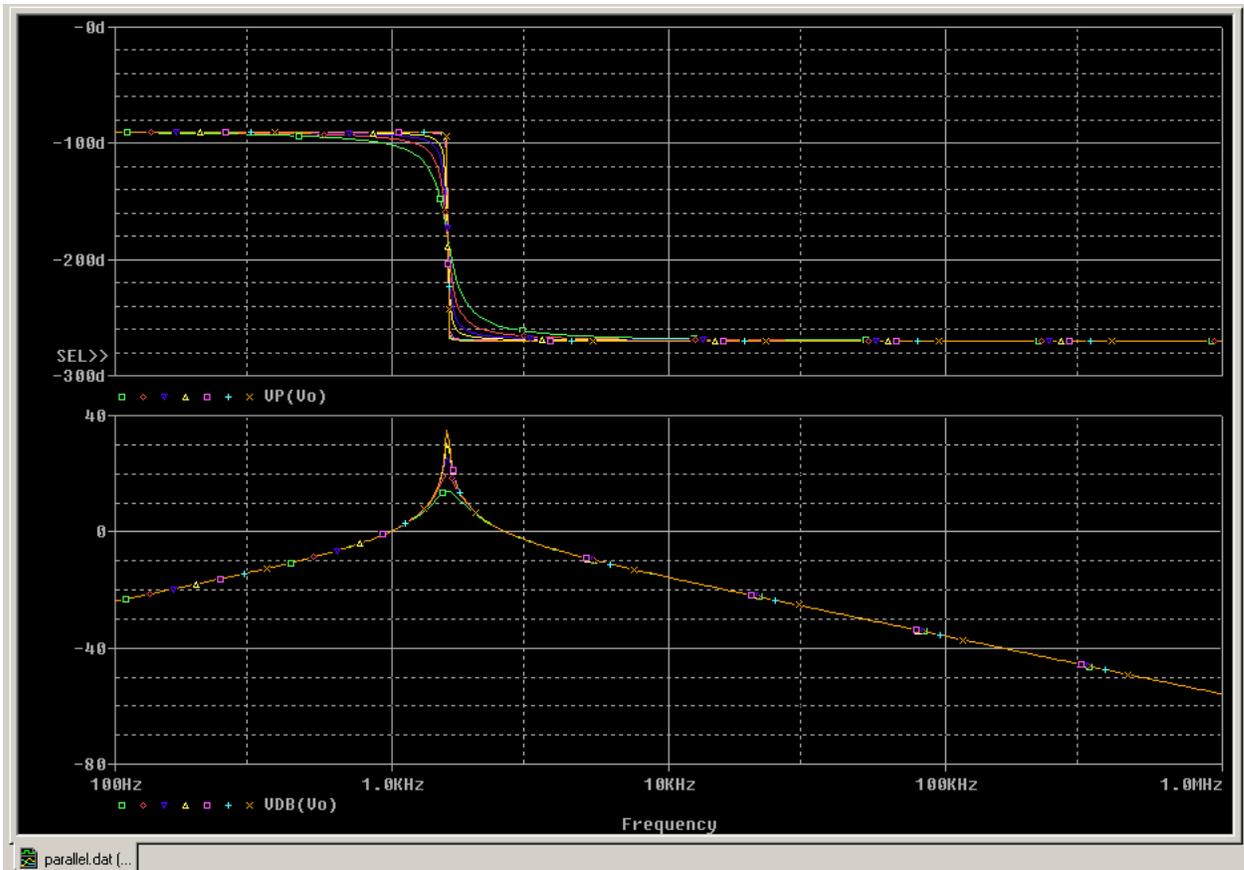
enter in these values go to Edit Simulation Setting under the Pspice menu. Under Analysis, select parametric sweep, select global parameter, and value list. Place your values in the slot for value list.



The figure below is the result of input impedance of series Parallel tank circuit.
 What are the input impedance values of parallel circuit?



Next, we want to measure the output voltage of the series parallel resonant circuit with varying resistors value. Use the same circuit as above, place the “**db magnitude of voltage marker**” and the “**phase of voltage marker**” in series next to output capacitor, and change the resistor values. These markers are located on the Pspice menu. Resistor values are: 5k, 10k, 20k, 40k, 200k, 400k, and 800k Ohms. The figure below is the result of output voltage of Parallel circuit. What are the output voltage values of parallel circuit with varying the resistor values? What are the values of the phase output voltage of parallel circuit with varying the resistor values?



For Homework:

You need to re-solve the parallel resonant circuit with inductor ESR and see its effects on the magnitude and phase plots in some detail. For example choose the ratio of the L ESR to the load resistance to be in the ratio range from 0.01 to 1.

Parallel Resonant circuit using MATLAB

NOTE: The simulations that follow are intended to be completed with MATLAB[®]. It is assumed that the student has a fundamental understanding of the operation of MATLAB[®]. MATLAB[®] provides tutorials for users that are not experienced with its functions.

In this lab you will learn how to write a function to varying, calculating and plotting the input impedance, current and output voltage of the series RLC resonant tank circuit. Also plot the natural response of the parallel RLC tank circuit. You can define your own function in MATLAB. A function must start with a line.

Function return-value = function-name (arguments)

So that MATLAB will recognize it as a function. Each function must have its own file and the file must have the same as the function.

PROCEDURE:

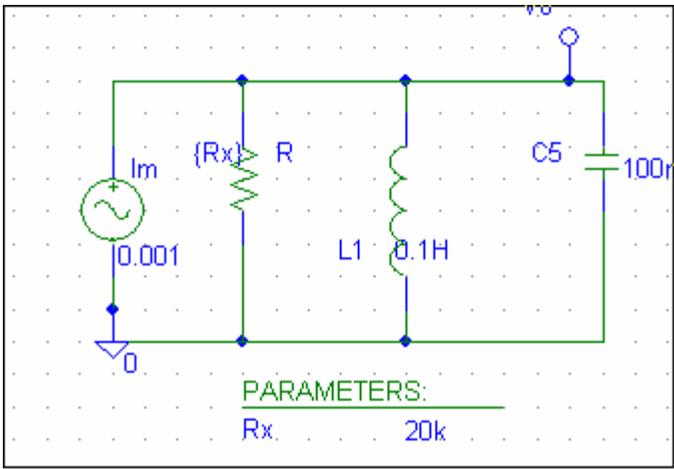
Part 1: Write a function to calculate the total input impedance of parallel RLC resonant circuit as shown in Figure 1.

I_m is a variable current. Set to 0.001 amps

L is a variable inductor. Set to 0.1H.

R is a variable ideal resistor. Set to 20000Ω.

C is a variable ideal capacitor. Set to 100nF.



```

%*****
% Parallel Resonant RLC tank circuit
% Minh Anh Thi nguyen
% Colorado State University
% Electrical and Computer Engineering student
% *****

function [Zinput]=Zinput_parallelRLC1() %is the function declaration. Note:

%The word "function" must be the first (non-comment) word of the program.
%"Zinput " is the value that this function returns, or calculates, a.k.a. the output.
%"radius" is the name of the variable taken as input.
%"Zinput_parallelRLC1" should be both the name of the function and the name
%that you use to save the file.

disp('Starting the function of Zinput_seriesRLC1');
%define all the component values and units for Tank
                                %unit
Im=0.001;                        %Amps
R=20000;                          %ohms
C=100e-9;                         %Farads
L=0.1;                             %henrys

% define the input impedance
Zinductor=tf([L 0], [0, 1]);
Zcapacitor=tf([0 1], [C 0]);
Zinput=1/(1/R+1/Zcapacitor+1/Zinductor)
figure(1)
bode(Zinput)
title('Input impedance of parallel RLC tank circuit')

% calculating important parameters of the tank

[z,p,k]=zpkdata(Zinput,'v');

wo=sqrt(1/L/C)
Beta=1/R/C
Q=wo/Beta

disp('finishedthe function of Zinput_seriesRLC1');

```

Figure 1: The input impedance of parallel RLC tank circuit.

Once the above function file is captured, the simulations can be run. First, go to your directory. Find your function file and then run your file. If there is a red

message on your MATLAB window, then you need to correct your error. Otherwise, you will see the solution as show in figure 2.

```
Starting the function of Zinput_seriesRLC1
```

```
Transfer function:
```

```
0.1 s
```

```
-----  
1e-008 s^2 + 5e-006 s + 1
```

```
wo =
```

```
10000
```

```
Beta =
```

```
500.0000
```

```
Q = |
```

```
20.0000
```

```
finishedthe function of Zinput_seriesRLC1
```

```
Transfer function:
```

```
0.1 s
```

```
-----  
1e-008 s^2 + 5e-006 s + 1
```

```
>>
```

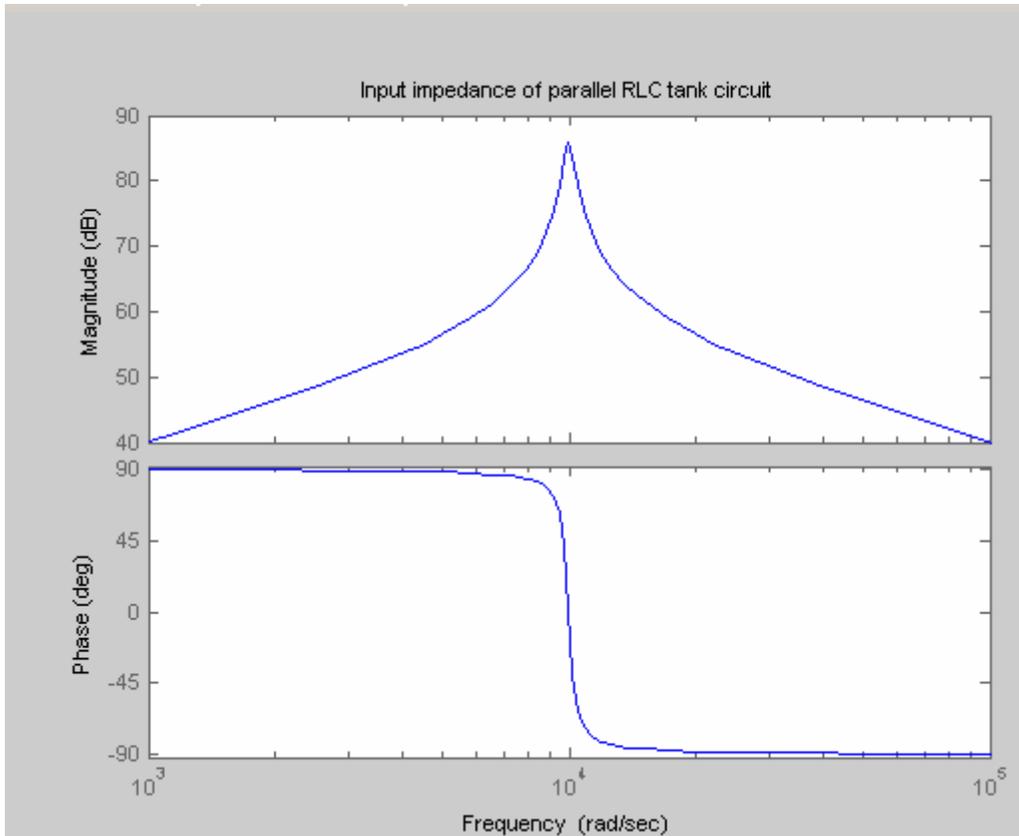


Figure2: The output of input impedance of parallel RLC tank circuit.

Next, plot the output voltage of the parallel resonant RLC tank circuit. Write another function to calculate the output voltage and plot of parallel RLC tank circuit as shown in Figure 3. All the initial variables and values are remain the same.

Im is a variable current. Set to 0.001 amps

L is a variable inductor. Set to 0.1H.

R is a variable ideal resistor. Set to 20000 Ω .

C is a variable ideal capacitor. Set to 100nF.

```

%*****
% Parallel Resonant RLC circuit
% Minh Anh Thi nguyen
% Colorado State University
% Electrical and Computer Engineering student
% *****

function []=Zinput_parallelRLC2(Zin)
%"Zin" is the name of the variable taken as input.
%define all the component values and units for Tank

disp('Starting the function of Zinput_seriesRLC2');

                                %unit
Im=0.001;                       %Amps
R=20000;                        %ohms
C=100e-9;                       %Farads
L=0.01;                          %henrys

Zin=Zinput_parallelRLC1;
Vout=Im*Zin
figure(2)
bode(Vout)
title('Output voltage in parallel RLC tank circuit')

```

Figure 3: the function to calculate the total input current of series RLC tank circuit

Once the above function file is captured, the simulations can be run. First, go to your directory. Find your function file and then run your file. If there is a red message on your MATLAB window, then you need to correct your error. Otherwise, you will see the solution as show in figure 4.

Starting the function of Zinput_seriesRLC2
Starting the function of Zinput_seriesRLC1

Transfer function:

0.1 s

1e-008 s^2 + 5e-006 s + 1

wo =

10000

Beta =

500.0000

Q =

20.0000

|
finishedthe function of Zinput_seriesRLC1

Transfer function:

0.0001 s

1e-008 s^2 + 5e-006 s + 1

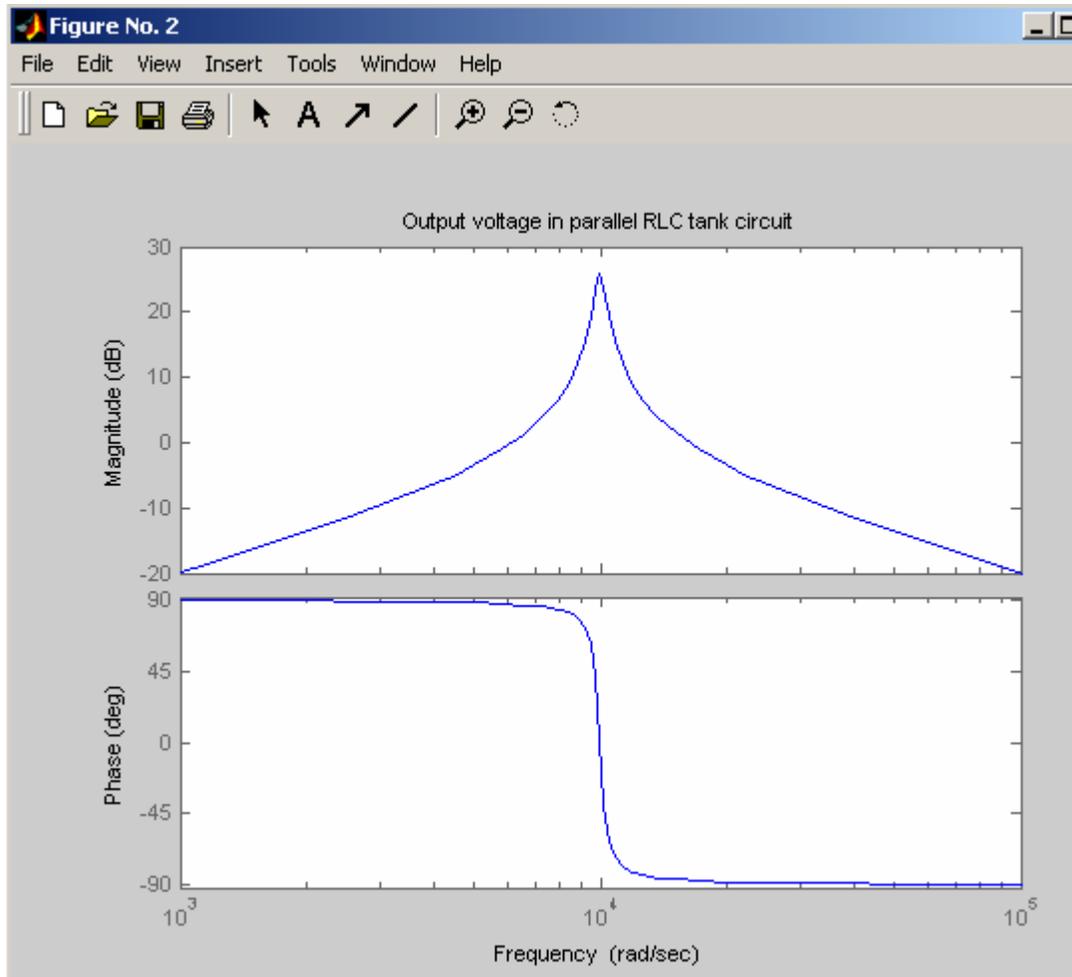


Figure 4: the output and plot of the output voltage of parallel RLC tank circuit

Now write a function to varying R of the output voltage in parallel RLC resonant circuit by adding an array of Resistors (R) value. Again all the initial variables and values are remain the same.

Im is a variable current. Set to 0.001 amps

L is a variable inductor. Set to 0.1H.

R is a variable ideal resistor. Set to 20000Ω.

C is a variable ideal capacitor. Set to 100nF.

Write a loop function to do the varying resistors value, calculate and plot the output voltage of parallel RLC resonant circuit. When the function to varying R of the output voltage of parallel RLC resonant circuit function file is captured, the simulations can be run. If there is any error message on your MATLAB windows, then correct your error and then rerun the simulation. Otherwise, you will see the result as show below

```

%*****
% parallel RLC Resonant circuit
% Minh Anh Thi nguyen
% Colorado State University
% Electrical and Computer Engineering student
% *****

function [Zinput]=Zinput_parallelRLC3()

disp('Starting the function of Zinput_seriesRLC3');
%define all the component values and units for Tank
%unit
Im=0.001;           %amps
R=20000;            %ohms
C=100e-9;           %Farads
L=0.1;              %henrys

% define the varying loads value
R=[R/4 R/2 R R*2 R*10 R*20 R*40]

% define the input impedance for varing Rs

for i=1:7
    Zinductor=tf([L 0], [0,1]);
    Zcapacitor=tf([0 1], [C 0]);
    Zinput=1/(1/R(i)+1/Zcapacitor+1/Zinductor);
    Vm=Im*Zinput;
    figure(3)
    bode(Vm)
    if i==1,
        hold,
    end
end
end
title('Output voltage parallel RLC tank circuit for varing R')
disp('finishedthe function of Zinput_seriesRLC3');

```

Figure 5: A function to calculate and plot of the output voltage in parallel RLC resonant circuit with varying Resistor

```
Starting the function of Zinput_seriesRLC3  
  
R =  
      5000      10000      20000      40000      200000      400000      800000  
  
Current plot held  
finishedthe function of Zinput_seriesRLC3  
  
Transfer function:  
      0.1 s  
-----  
1e-008 s^2 + 1.25e-007 s + 1
```

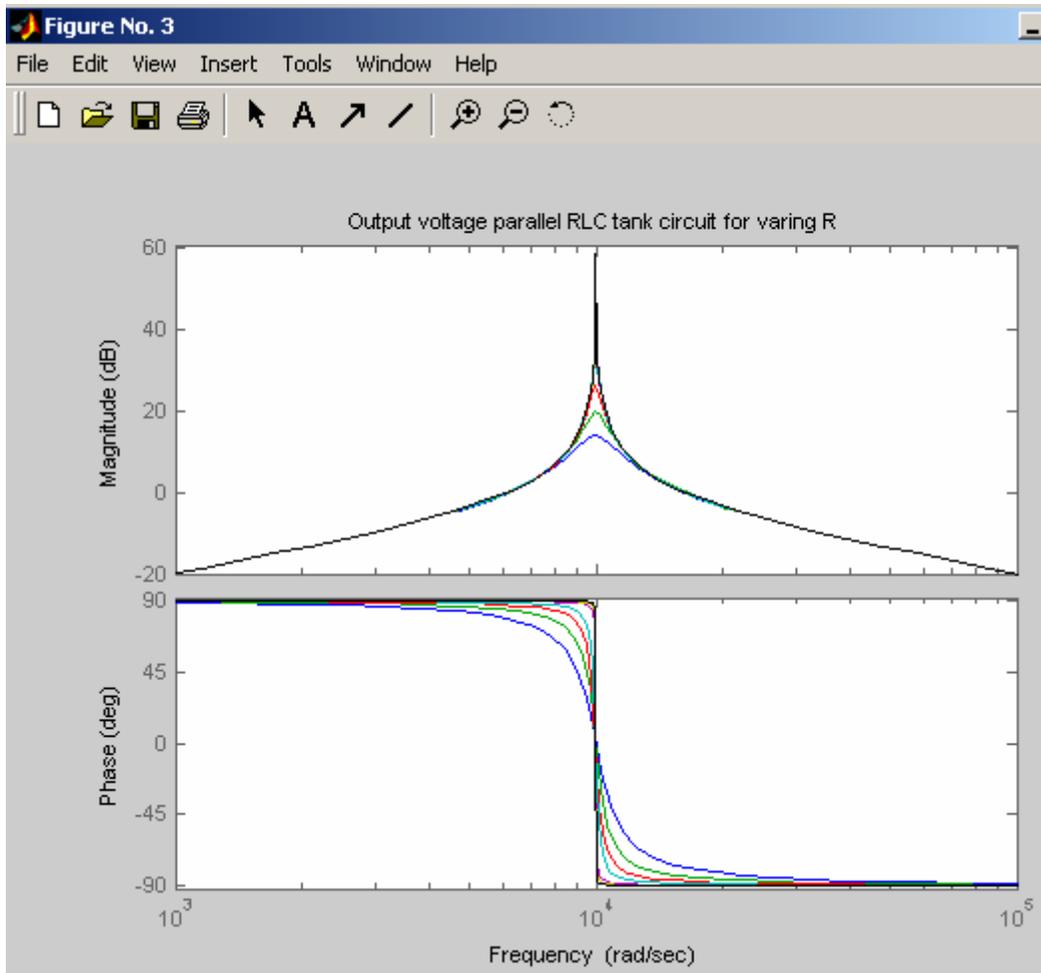


Figure 6: Output voltage of parallel RLC resonant circuit with varying Resistor

For Homework:

You need to re-solve the parallel resonant circuit with inductor ESR and see its effects on the magnitude and phase plots in some detail. For example choose the ratio of the L ESR to the load resistance to be in the ratio range from 0.01 to 1.

Next write m file to varying R of the natural response of current in parallel RLC resonant circuit by adding an array of Resistors (R) value. Again all the initial variables are remain the same but change their values.

Im is a variable current. Set to 1 volts

L is a variable inductor. Set to 39.487 H.

R is a variable ideal resistor. Set to 2000 Ω .

C is a variable ideal capacitor. Set to 1 μ F

Io is a variable ideal of inductor current. Set to 0 amps.

Vo is a variable ideal of capacitor voltage. Set to 0 volts.

Write a loop function to do the varying resistors value, calculate and plot the natural response of current for parallel RLC resonant circuit. When the m file to varying R of the natural response of current in parallel RLC resonant circuit file is captured, the simulations can be run. If there is any error message on your MATLAB windows, then correct your error and then rerun the simulation. Otherwise, you will see the result as show below

```

%*****
% Parallel RLC Resonant circuit
% Minh Anh Thi nguyen
% Colorado State University
% Electrical and Computer Engineering student
% *****

% clear all the windows
clc;
disp('Starting the natural response of current')

%define all the component values and units for Tank
                                %unit
Im=1;                            %Amps
R=2000;                          %ohms
C=1e-6;                          %Farads
L=39.487;                        %henrys
Io=0;                            %amps (initial Ic on inductor)
Vo=0;                            %Volts ( initial Vc on capacitor)

% Defining impedances of the RLC circuit

% the inductor impedance
Zinductor=tf([L 0], [0 1]);
% the capacitor impedance
Zcapacitor=tf([0 1],[C 0]);

% define the varying loads
R=[R/4 R/2 R R*2 R*10]
% stepp to the inductor current for varing R
hold off

% defining the input impedance for varying Rs.
jmax=5;

for i=1:jmax
    Zinput=1/(1/Zcapacitor+1/Zinductor+1/R(i));
    Output_voltage=Im*Zinput;
    Iinductor=Output_voltage/Zinductor;
    figure(4)
    Step(Iinductor)
    title('the natural response of inductor current in a parralell RLC circuit')
    if i==1,
        hold,
    end;
end

disp('finished the function natural response of current');

```

Figure 11: The m file to calculate and plot the natural response of current in parallel RLC resonant circuit with varying Resistor

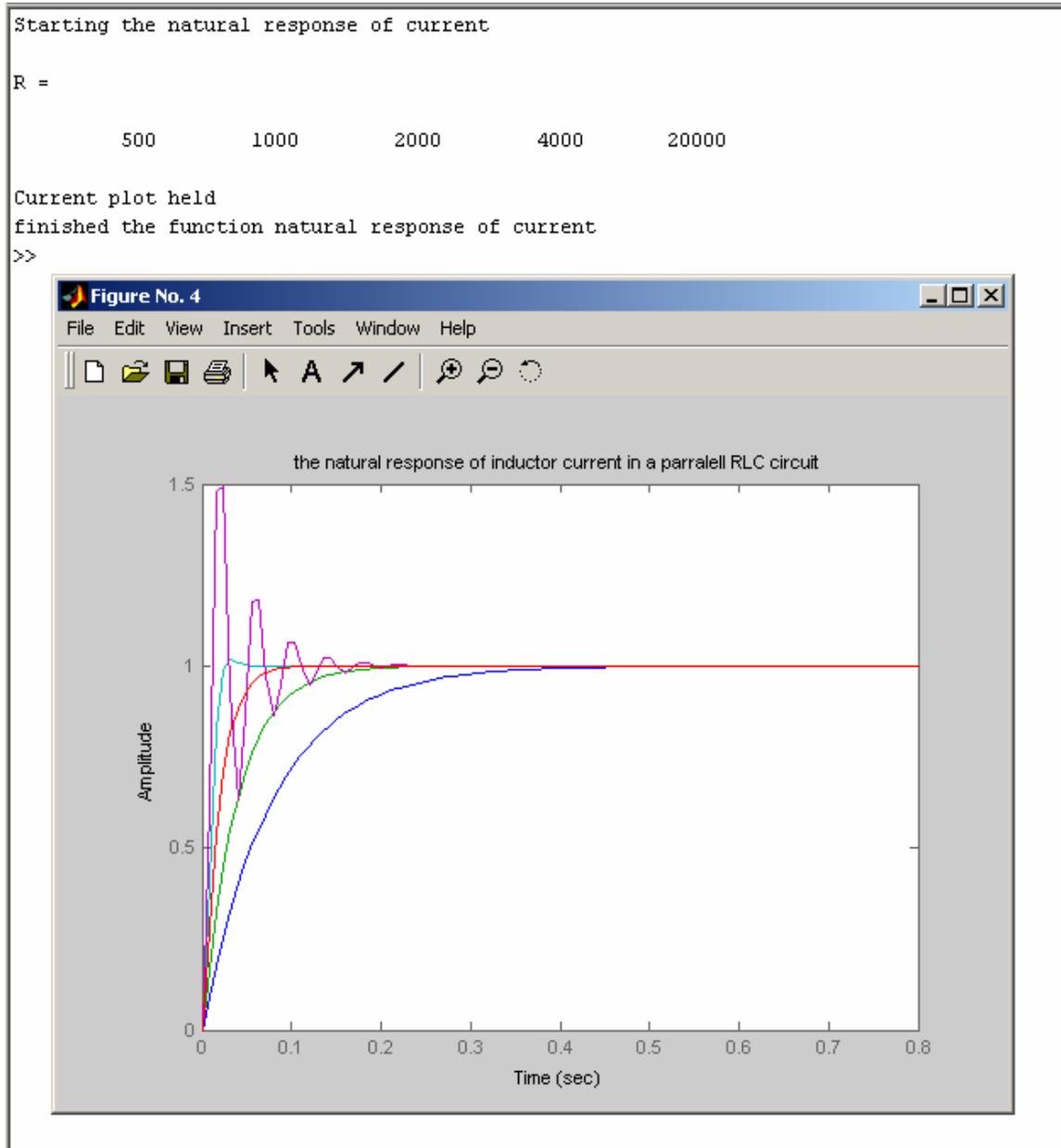


Figure 12: This figure is shown the output of the natural responses of current in parallel RLC resonant circuit with varying Resistor

Now write m file to varying R of the natural response of output voltage in a parallel RLC resonant circuit by adding an array of Resistors (R) value. Again all the initial variables are remain the same but change their values.

Im is a variable current. Set to 1 volts

L is a variable inductor. Set to 39.487 H.

R is a variable ideal resistor. Set to 2000 Ω .

C is a variable ideal capacitor. Set to 1 μ F

Io is a variable ideal of inductor current. Set to 0 amps.

Vo is a variable ideal of capacitor voltage. Set to 0 volts.

Write a loop function to do the varying resistors value, calculate and plot the natural response of output voltage in a parallel RLC resonant circuit. When the m file to varying R of the natural response of parallel RLC resonant circuit file is captured, the simulations can be run. If there is any error message on your MATLAB windows, then correct your error and then rerun the simulation.

Otherwise, you will see the result as show below

```

%*****
% Parallel RLC Resonant circuit
% Minh Anh Thi nguyen
% Colorado State University
% Electrical and Computer Engineering student
% *****
% clear all window
clc;
disp('Starting the natural response of capacitor voltage')
%define all the component values and units for Tank
%unit
Im=1; %amps
R=2000; %ohms
C=1e-6; %Farads
L=39.487; %henrys
Io=0; %amps (initial Ic on inductor)|
Vo=0; %Volts ( initial Vc on capacitor)

% transfer function of tank current with initial conditions

% Defining impedances of the RLC circuit

% the inductor impedance
Zinductor=tf([L 0], [0 1]);
% the capacitor impedance
Zcapacitor=tf([0 1],[C 0]);

% define the varying loads
R=[R/4 R/2 R R*2]
% stepp to the inductor current for varing R
hold off
% defining the input impedance for varying Rs.

hold off
% defining the input impedance for varying Rs.
for i=1:4
    Zinput=1/(1/Zcapacitor+1/Zinductor+1/R(i))
    Voutput=Im*Zinput;
    Iindutor=Voutput/Zinductor;
    figure(5)
    step(Voutput)
    if i==1,
        hold,
    end;
end
end
title('natural response of capacitor voltage')
disp('finished the function natural response of capacitor voltage');

```

Figure 13: the m file to calculate and plot the natural response of current in a parallel RLC resonant circuit with varying Resistor

```
Starting the natural response of capacitor voltage
R =
      500      1000      2000      4000

Transfer function:
      39.49 s
-----
3.949e-005 s^2 + 0.07897 s + 1

Current plot held

Transfer function:
      39.49 s
-----
3.949e-005 s^2 + 0.03949 s + 1

Transfer function:
      39.49 s
-----
3.949e-005 s^2 + 0.01974 s + 1

Transfer function:
      39.49 s
-----
3.949e-005 s^2 + 0.009872 s + 1

finished the function natural response of capacitor voltage
>>
```

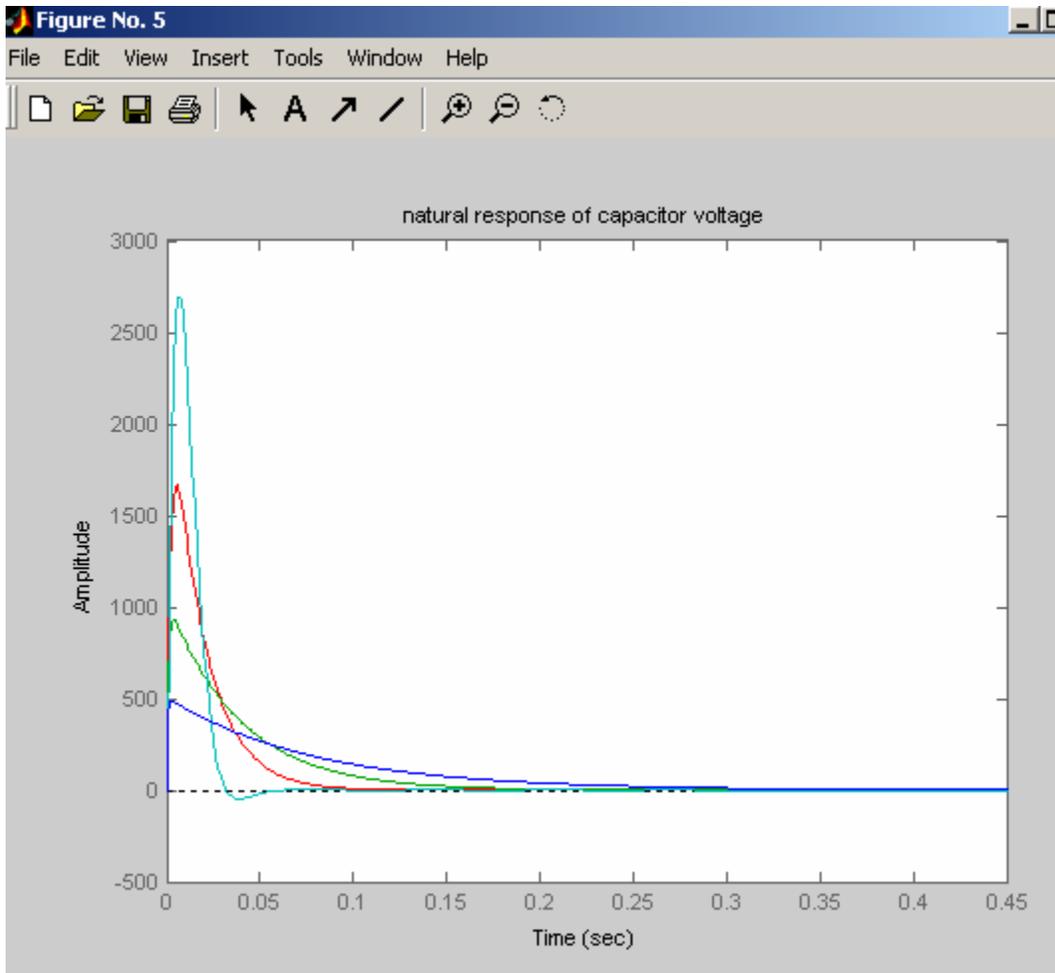


Figure 14: the output of the natural response of capacitor voltage in a parallel RLC resonant circuit with varying Resistor