UNIVERSITATEA TEHNICĂ
DIN CLUJ-NAPOCA

Author: **Pleș Andrei-Valentin**
Group: **2022**
Year: **2023**
Guidance: **Mihaela Cîrlugea, Paul Farago**

RLC series circuit

Alternating current is most widely used due to the fact that it can be easily produced and it can be efficiently transported over long distances. This is because it is easy to step up or step down the voltage for any aplication using transformers and has thus become paramount in our society.

- **Resistors in AC**

There is no change in phase associated with a resistor. Applying a sinusoidal signal to the terminals of a resistor, it will generate a sinusoidal alternating current, in phase with the applied voltage.

- **Coils in AC**

Upon applying a sinusoidal voltage to the circuit terminals, the current will not instantly reach the maximum possible value, but will lag behind the voltage. The intensity of the electric current through the coil will be out of phase by $\pi/2$, following the voltage. This phenomenon is called self-induction.

- **Capacitors in AC**

Between the plates of a capacitor there is an insulating layer, called dielectric, which does not allow electric current to pass throug. In alternating current, the capacitor charges and discharges periodically, determining the presence of an electric current through its external circuit. Therefore, the voltage at the terminals of a capacitor lags behind the current by $\pi/2$.

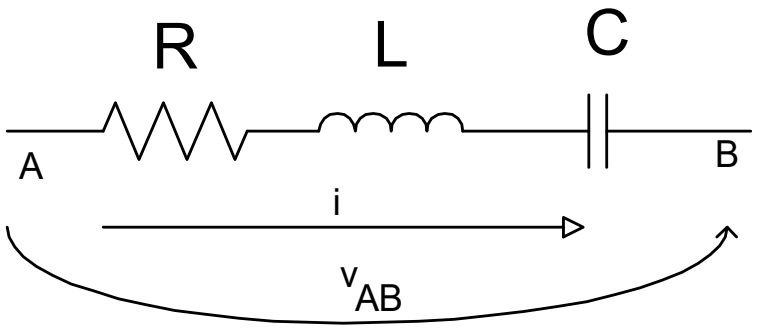
INFERENCE:

Coils and capacitors introduce phase shifts between voltage and current by +π/2 and -π/2 respectively.

$$Phase = \phi = \tan^{-1}\left[\frac{X_L - X_C}{R}\right]$$

RLC series circuit

The same current passes through all of the components in the R, L, C series circuit.



The equivalent impadance of the circuit between points A and B is as follows:

$$Z_{AB} = Z_{Sech} = R + j\omega L + \frac{1}{j\omega C} = R + j\left(\omega L - \frac{1}{\omega C}\right)$$

The modulus of this impedance is:

$$\left|Z_{Sech}\right| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} = \frac{\sqrt{\omega^2 R^2 C^2 + \left(1 - \omega^2 LC\right)^2}}{\omega C}$$

We observe that, when the frequency tends to zero or to infinity, the impedance modulus also tends to infinity. This is because in DC regime a

capacitor represents an open circuit and an inductance represents an open circuit at very high frequencies, respectively.

The imaginary part of the impedance is equal to zero at the frequency:

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

This is called the resonant frequency. At resonance, the total impedance of the circuit is minimal, and it is purely resistive:

$$Z_{Sech}(\omega_0) = R$$

Because of this, the RLC series circuit is called a “Band pass filter”. The "band-pass" filter lets signals with frequencies within a certain frequency range, called the passband, pass unattenuated, or very slightly attenuated, and drastically attenuates signals with frequencies outside the passband. This “bandwith” is measured using the Q factor:

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

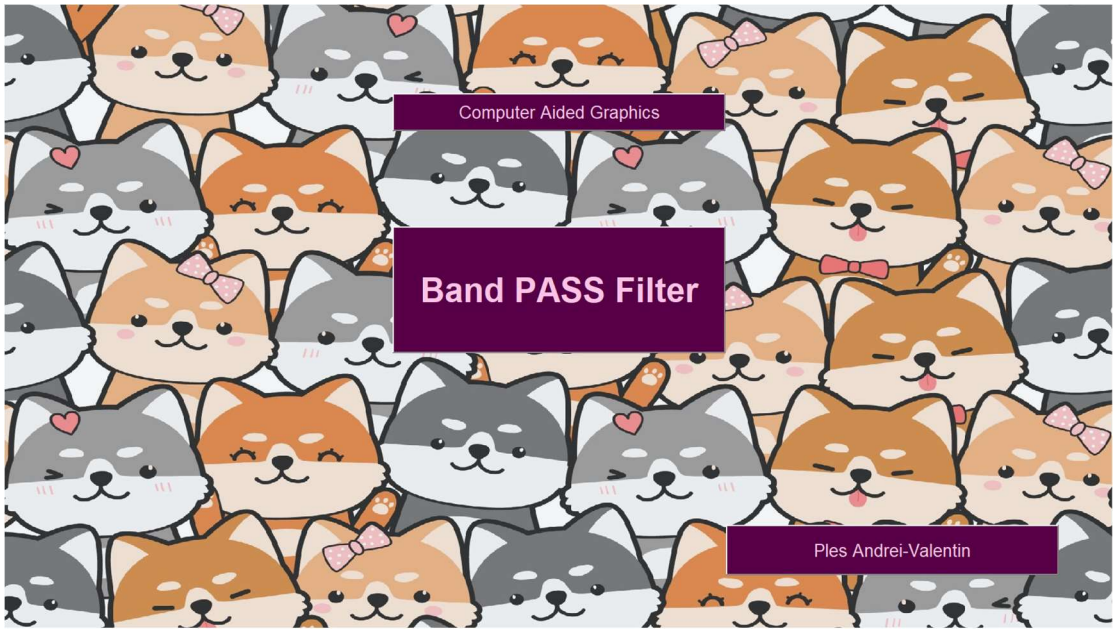
A high Q resonant circuit has a narrow bandwidth compared to a low Q, which is desirable in many applications. The cutoff frequencies for the circuit are at the point where the gain is equal to -3 dB. The gain can be calculated as follows:

$$\text{gain}=20\lg(h)=20\lg\left(\left|\frac{R}{R+j\omega L+\frac{1}{j\omega C}}\right|\right)$$

In summary, the RLC series circuit is useful for many applications, like filters, oscillators and signal processing, for studying and understanding the interaction between resistance, inductance, and capacitance in an electrical circuit.

A quick GUIde

✸ Starting page

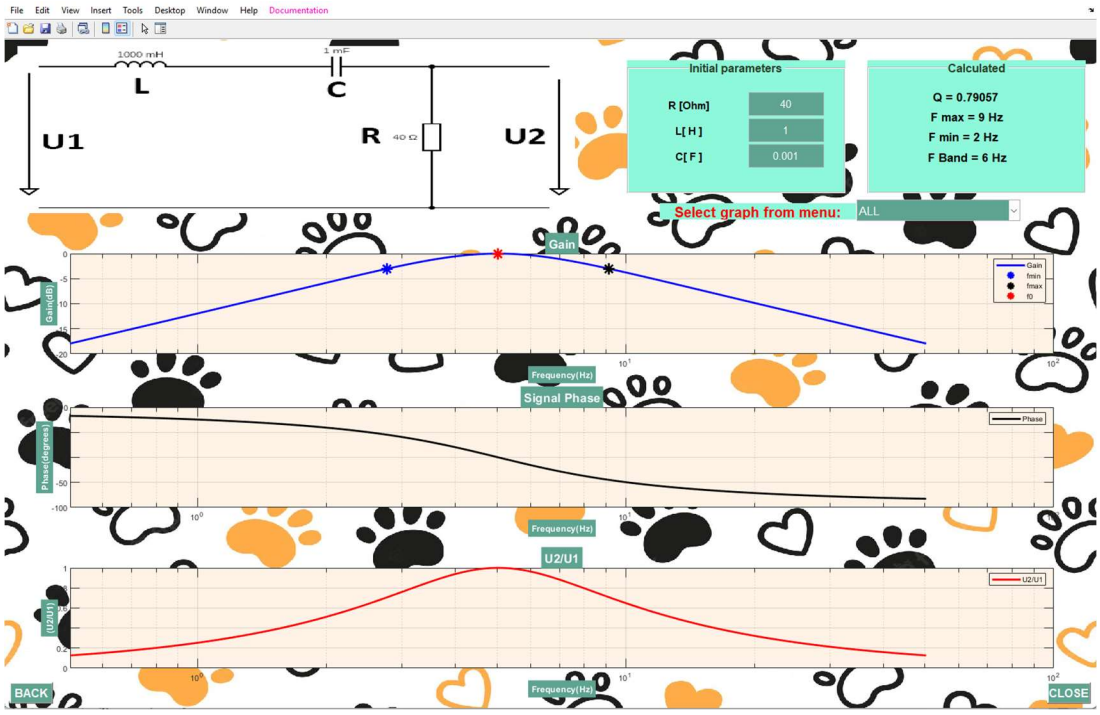


The starting page presents the user with 3 buttons atop a tastefully chosen background image. The middle « Band PASS filter » button, will lead the user to the next window inside MATLAB where all the plots and results are present. The other two buttons have callbacks to URLs outside the MATLAB browser, but are paramount to this application.

```
Fig=figure('Name',':D',...                    //open the figure and set the backround
'Units','normalized',...
'Position',[0.05 0.03 0.9 0.9],...
'NumberTitle','off',...
'color',[0.05 0.2 0.3]);
l=axes('units','normalized',...
    'position',[0 0 1 1]);
uistack(l,'bottom');
I=imread('poze/img2.jpg');
q=imagesc(I);
set(gca,'Position',[0 0 1 1]);
set(q,'alphadata',.95);
colormap gray
set(l,'handlevisibility','off',...
    'visible','off');
```

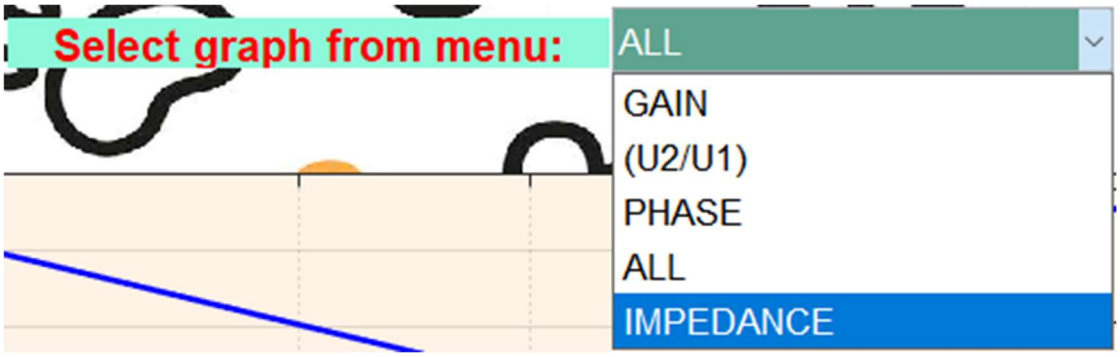
```
Bp=uicontrol('Style','pushbutton',...        //this button closes the current figure and
'Units','normalized',...                     //calls the function that handles the rest
'Position',[0.35 0.45 0.3 0.2],...           //of the GUI
'Fontsize',40,...
'Fontweight', 'b',...
'String','Band PASS Filter',...
'Callback','close;proiect(R,L,C,selectare_grafic)',...
'backgroundcolor','#580047',...
'foregroundcolor','#fec4e7',...
'Visible','on');

Bt=uicontrol('Style','pushbutton',...        //one of the buttons that open a web URL
'Units','normalized',...
'Position',[0.65 0.1 0.3 0.08],...
'Fontsize',20,...
'backgroundcolor','#580047',...
'foregroundcolor','#fec4e7',...
'Callback', 'web(url2)',...
'String', 'Ples Andrei-Valentin');
```

✸ Main page



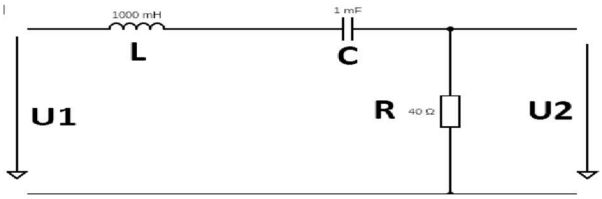
Upon opening the main page the user is presented with a picture of the circuit next to the initial parameters that can be edited. Using these parameters the Q factor, bandwith, maximum and minimum frequency are calculated and plots of the gain, phase and transfer function are shown. Using the dropdown menu, the

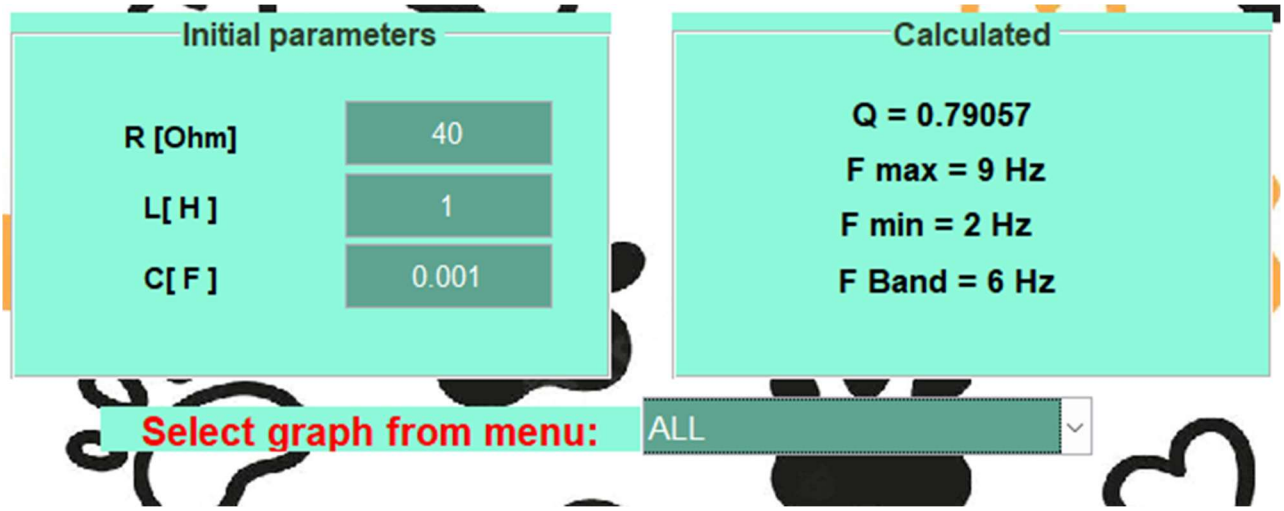
user can select to view a single plot at one time, choosing from one of the options :



A switch instruction with 5 branches is used to display what the user chooses. Let's analyze the main page further.

```
figure('Name','WOOF',...                          //this is where we open the
figure
        'Numbertitle','off',...                   //and set the position, color
        'Units','normalized',...                  //and the background image
        'Position',[0.1 0.05 0.8 0.87],...
        'Color','w',...
        'DefaultAxesColor',[1.0 0.95 0.9]);
 l=axes('units','normalized',...
    'position',[0 0 1 1]);
uistack(l,'bottom');
I=imread('poze/paw2.png');
q=imagesc(I);
set(gca,'Position',[0 0 1 1]);
set(q,'alphadata',.95);
colormap gray
set(l,'handlevisibility','off',...
    'visible','off');

im=imread('poze/ftb.png');          //placing
the
image(im);                        //circuit diagram
in
axis off;                         //the top left
set(gca,'Position',[0.012 0.74 0.51 0.25]);
```





The default parameters can be easily edited with any value by clicking on the highlighted box and typing a number.

```
param=uibuttongroup('Visible','on',...                    //this created the turqoise
                    'BackgroundColor','#8ef9da',...       //rectangle in which the buttons
                    'ForegroundColor','#2b3e28',...       //and text elements get grouped
                    'FontSize',12,...
                    'FontWeight','b',...
                    'TitlePosition','centertop',...
                    'Title','Initial parameters',...
                    'Position',[0.57 0.77 0.20 0.20]);
% resistance
                    uicontrol('Style','Text',...                          //text
                              'Units','Normalized',...
                              'Position',[0.1 0.65 0.35 0.15],...
                              'BackgroundColor','#8ef9da',...
                              'ForegroundColor','#000000',...
                              'FontSize',11,...
                              'FontWeight','b',...
                              'String',' R [Ohm]',...
                              'Parent',param);
                    uicontrol('Style','Edit',...                    //edit button
                              'Units','Normalized',...
                              'Position',[0.56 0.65 0.35 0.2],...
                              'BackgroundColor','#5ea490',...
                              'ForegroundColor','w',...
                              'FontSize',11,...
                              'String',R,...

'Callback','R=str2num(get(gco,''String''));close;proiect(R,L,C,selectare_grafic)',...
                              'Parent',param);
```

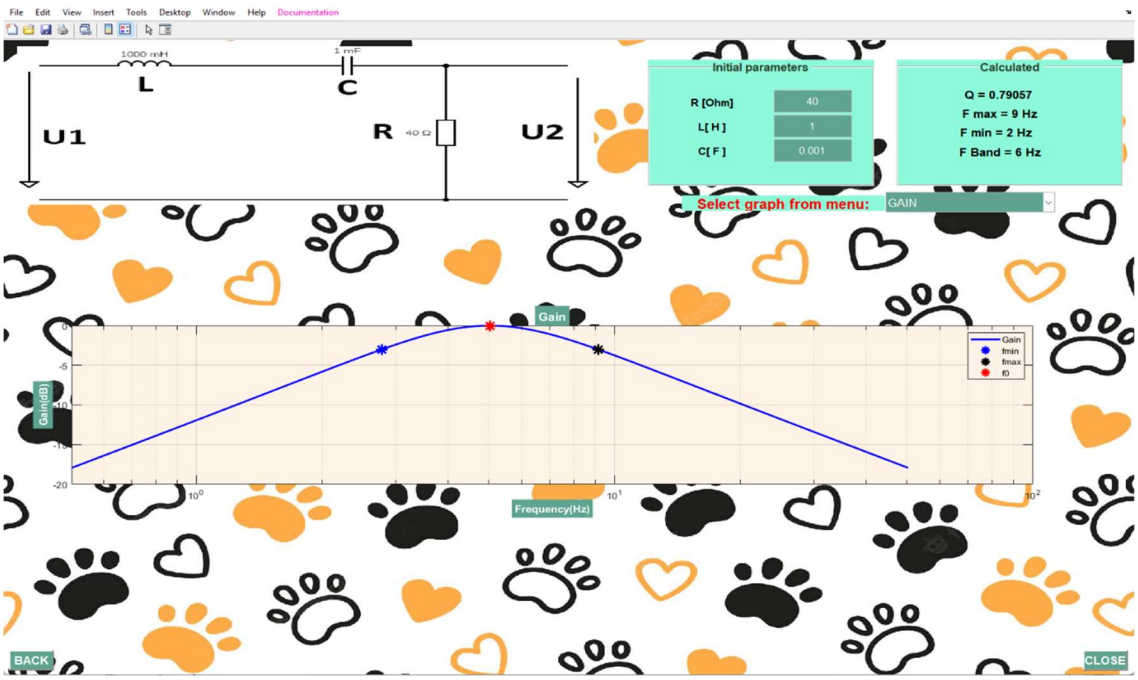
After pressing enter, the button executes the callback, calling upon the main function again using the new value that the user chose. Everything will get recalculated using the new values according to the formulas :

```
Q=sqrt(L/C)./R;                         % quality factor
f0=1/(2*pi*sqrt(L*C));                  % cutoff frequency
x=logspace(-1,1,300);
f=x.*f0;
w=2.*pi.*f;
fmin=f0*(sqrt(1+4*Q.^2)-1)/(2*Q); %minimum frequency
fmax=f0*(sqrt(1+4*Q.^2)+1)/(2*Q); %maximum frequency
BandaFrecv=fmax-fmin;          %bandwith
```

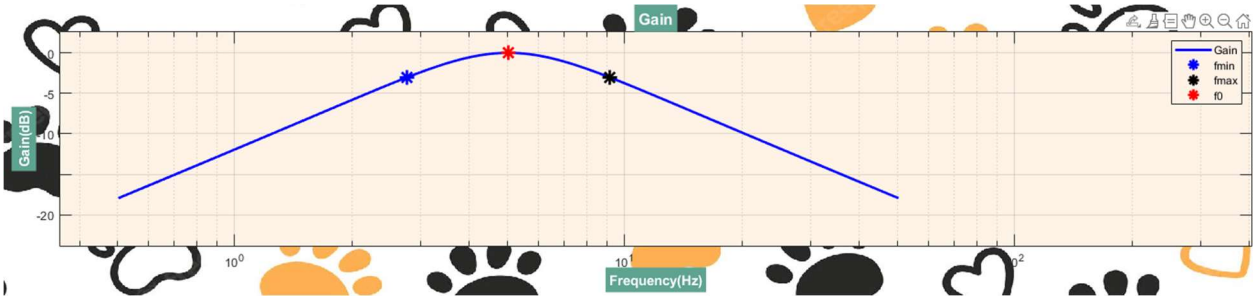
Next up, let's look into the dropdown menu and how it works.

```
uicontrol('Style','Text',...                                    //text next to menu
                'Units','Normalized',...
                'Position',[0.6 0.73 0.18 0.025],...
                'FontSize',15,...
                'BackgroundColor','#8ef9da',...
                'ForegroundColor','r',...
                'FontWeight','b',...
                'String','Select graph from menu:');
    uicontrol('Style','PopupMenu',...                                  //creating the popup menu
              'BackgroundColor','#5ea490',...
              'ForegroundColor','w',...
              'Units','normalized',...
              'Position',[0.78 0.73 0.15 0.03],...
              'value',selectare_grafic,...
              'String','GAIN|(U2/U1)|PHASE|ALL|IMPEDANCE',... //options for the menu
              'FontSize',13,...

'Callback','selectare_grafic=get(gco,''value'');close;proiect(R,L,C,selectare_grafic)');
```

Consider the user selected the GAIN option. He will see the following simplified window, containing just one plot instead of three, which is easier to analyze closer. Let's also see how this graph is created.



```
switch(selectare_grafic)
       case 1
                        Q=sqrt(L/C)./R;          %quality factor
                        f0=1/(2*pi*sqrt(L*C));   %cutoff frequency
                        x=logspace(-1,1,300);
                        f=x.*f0;
                        w=2.*pi.*f;
                        subplot('Position',[0.01 0.08 0.28 0.26]);
                               Title='BAND PASS FILTER';
                                            fmin=f0*(sqrt(1+4*Q.^2)-1)/(2*Q);
                                            fmax=f0*(sqrt(1+4*Q.^2)+1)/(2*Q);
                                            BandaFrecv=fmax-fmin;
                                            faza1=45;
                                            faza2=-45;
             % formulas
                              % Uout/Uin
                         numarator=R;
                         numitor=R+1i.*w.*L+1./(1i.*w.*C);
                         h=abs(numarator./numitor);
                            %gain
                         gain=20*log10(h);
                            %frequency
                         f=w/(2*pi);
                            %phase
                          Faza=angle(numarator./numitor)*180./pi;

            % gain plot
            subplot('Position', [0.06 0.30 0.85 0.25]);
                  semilogx(f,gain,'b',fmin,-3,'b*',fmax,-
3,'k*',f0,0,'r*','MarkerSize',12,'MarkerFaceColor',[0.5,0.5,0.5],'LineWidth',2);
                        grid on;
                        xlabel('Frequency(Hz)','Color','w',
'BackgroundColor','#5ea490','FontWeight','b');
                        ylabel('Gain(dB)','Color','w',
'BackgroundColor','#5ea490','FontWeight','b');
                        title('Gain','Fontweight','b','FontSize',13,'Color','w',
'BackgroundColor','#5ea490');
                        legend('Gain','fmin','fmax','f0');
```



The gain plot is the first option in the dropdown menu, so it is handled in the switch case 1. Things like the quality factor and resonance frequency are calculated and then used in formulas specific to each graph to plot the relevant data with a blue line of thickness 2 and 3 markers at points of interest.

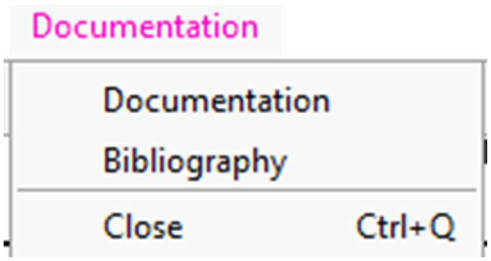
The impedance is calculated using the following formula and then plotted:

```
zz = R + 1./(j.*w.*C) + (j.*w.*L);
z = abs(zz);
```

In the bottom corners of the windows there are two buttons. One is for going back to the start page and the other closes the application. Their functions are easy to implment in MATLAB using the pushbutton style, with « start() » and « close » callback function respectively. The code looks like this :

```
//the back button
uicontrol('Style','pushbutton',...
          'Units','normalized',...
          'BackgroundColor','#5ea490',...
          'ForegroundColor','w',...
          'FontWeight','bold',...
          'Position',[0.005 0.005 0.04 0.032],...
          'String','BACK',...
          'FontSize',12,...
          'Callback','start()');
//the close button
uicontrol('Style','pushbutton',...
          'Units','normalized',...
          'BackgroundColor','#5ea490',...
          'ForegroundColor','w',...
          'FontWeight','bold',...
          'Position',[0.955 0.005 0.04 0.032],...
          'String','CLOSE',...
          'FontSize',12,...
          'Callback','close');
```

Lastly, there is also a UI menu that leads to the documentation of the GUI, bibliography and a close command than can easily be accessed at any time using the shortcut Ctrl+Q.



```
f=uimenu('Label','Documentation',...                    //implementation of UI menu
         'foregroundcolor','#Ff00c5');                  //pink color for contrast
uimenu(f,'Label', 'Documentation',...
    'Callback','open(''Documentatie.docx'')');          //callback to respective files
uimenu(f,'Label','Bibliography',...
    'Callback','open(''Bibliografie.docx'')');
uimenu(f,'Label','Close',...
    'Callback','close',...                              //close
    'Separator','on','Accelerator','Q');                //shortcut
```

Conclusion

In conclusion, RLC series circuits are useful because they can exhibit a wide range of behaviors based on the values of resistance, inductance, and capacitance. They have many real-world applications, such as filtering unwanted frequencies from a signal, generating signals, signal processing and smoothing out ripples in a power supply. The behavior of RLC circuits can be studied using circuit analysis techniques, such as Kirchhoff's laws and the impedance method. These circuits are a fundamental building block of many electronic devices and they have many practical applications in a wide range of industries. This GUI is only a small window into the vast variety of things to analyze in regards to the RLC series circuit and the broad range of possibilities within the MATLAB programming enviroment.

Appendix

Start.m

```
% Ples Andrei-Valentin
% Gr 2022
% Band pass filter
clear all
close all
clc
Fig=figure('Name',':D',...
'Units','normalized',...
'Position',[0.05 0.03 0.9 0.9],...
'NumberTitle','off',...
'color',[0.05 0.2 0.3]);

l=axes('units','normalized',...
    'position',[0 0 1 1]);
```

```
uistack(l,'bottom');
I=imread('poze/img2.jpg');
q=imagesc(I);
set(gca,'Position',[0 0 1 1]);
set(q,'alphadata',.95);
colormap gray
set(l,'handlevisibility','off',...
    'visible','off');
% initiere date %
    R=40;
    L=1;
    C=0.001;
selectare_grafic=4;

Bp=uicontrol('Style','pushbutton',...
'Units','normalized',...
'Position',[0.35 0.45 0.3 0.2],...
'Fontsize',40,...
'Fontweight', 'b',...
'String','Band PASS Filter',...
'Callback','close;proiect(R,L,C,selectare_grafic)',...
'backgroundcolor','#580047',...
'foregroundcolor','#fec4e7',...
'Visible','on');

url = 'https://www.omfgdogs.com/#';

Bt=uicontrol('Style','pushbutton',...
'Units','normalized',...
'Position',[0.35 0.8 0.3 0.06],...
'Fontsize',20,...
'backgroundcolor','#580047',...
'foregroundcolor','#fec4e7',...
'Callback', 'web(url)',...
'String','Computer Aided Graphics');

url2 = 'https://openpuppies.com/#Dp9iPV8';

Bt=uicontrol('Style','pushbutton',...
'Units','normalized',...
'Position',[0.65 0.1 0.3 0.08],...
'Fontsize',20,...
'backgroundcolor','#580047',...
'foregroundcolor','#fec4e7',...
'Callback', 'web(url2)',...
'String', 'Ples Andrei-Valentin');
```

proiect.m

```
function proiect(R,L,C,selectare_grafic)
% main window
figure('Name','WOOF',...
        'Numbertitle','off',...
        'Units','normalized',...
        'Position',[0.1 0.05 0.8 0.87],...
```

```
       'Color','w',...
       'DefaultAxesColor',[1.0 0.95 0.9]);
 l=axes('units','normalized',...
    'position',[0 0 1 1]);
uistack(l,'bottom');
I=imread('poze/paw2.png');
q=imagesc(I);
set(gca,'Position',[0 0 1 1]);
set(q,'alphadata',.95);
colormap gray
set(l,'handlevisibility','off',...
    'visible','off');
    % menu
          f=uimenu('Label','Documentation',...
         'foregroundcolor','#Ff00c5');
uimenu(f,'Label', 'Documentation',...
    'Callback','open(''Documentatie.pdf'')');
uimenu(f,'Label','Bibliography',...
    'Callback','open(''Bibliografie.pdf'')');
uimenu(f,'Label','Close',...
    'Callback','close',...
    'Separator','on','Accelerator','Q');
% data
        param=uibuttongroup('Visible','on',...
                      'BackgroundColor','#8ef9da',...
                      'ForegroundColor','#2b3e28',...
                      'FontSize',12,...
                      'FontWeight','b',...
                      'TitlePosition','centertop',...
                      'Title','Initial parameters',...
                      'Position',[0.57 0.77 0.20 0.20]);
         % resistance
                    uicontrol('Style','Text',...
                              'Units','Normalized',...
                              'Position',[0.1 0.65 0.35 0.15],...
                              'BackgroundColor','#8ef9da',...
                              'ForegroundColor','#000000',...
                              'FontSize',11,...
                              'FontWeight','b',...
                              'String',' R [Ohm]',...
                              'Parent',param);
                    uicontrol('Style','Edit',...
                              'Units','Normalized',...
                              'Position',[0.56 0.65 0.35 0.2],...
                              'BackgroundColor','#5ea490',...
                              'ForegroundColor','w',...
                              'FontSize',11,...
                              'String',R,...
'Callback','R=str2num(get(gco,''String''));close;proiect(R,L,C,selectare_grafic)',...
                              'Parent',param);
           % coil
                    uicontrol('Style','Text',...
                              'Units','Normalized',...
                              'Position',[0.1 0.43 0.35 0.15],...
                              'FontSize',11,...
```

```
                                'BackgroundColor','#8ef9da',...
                                'ForegroundColor','#000000',...
                                'FontWeight','b',...
                                'String',' L[ H ]',...
                                'Parent',param);
                        uicontrol('Style','Edit',...
                                'Units','Normalized',...
                                'Position',[0.56 0.43 0.35 0.2],...
                                'BackgroundColor','#5ea490',...
                                'ForegroundColor','w',...
                                'FontSize',11,...
                                'String',L,...
'Callback','L=str2num(get(gco,''String''));close;proiect(R,L,C,selectare_grafic)',...
                                'Parent',param);
            % cap
                        uicontrol('Style','Text',...
                                 'Units','Normalized',...
                                 'Position',[0.1 0.21 0.35 0.15],...
                                 'BackgroundColor','#8ef9da',...
                                 'ForegroundColor','#000000',...
                                 'FontSize',11,...
                                 'FontWeight','b',...
                                 'String',' C[ F ]',...
                                 'Parent',param);
                        uicontrol('Style','Edit',...
                                 'Units','Normalized',...
                                 'Position',[0.56 0.21 0.35 0.2],...
                                 'BackgroundColor','#5ea490',...
                                 'ForegroundColor','w',...
                                 'FontSize',11,...
                                 'String',C,...
'Callback','C=str2num(get(gco,''String''));close;proiect(R,L,C,selectare_grafic)',...
                                 'Parent',param);
% calcul
              uibuttongroup('Visible','on',...
                            'BackgroundColor','#8ef9da',...
                            'ForegroundColor','#2b3e28',...
                            'FontSize',12,...
                            'FontWeight','b',...
                            'TitlePosition','centertop',...
                            'Title','Calculated',...
                            'Position',[0.79 0.77 0.20 0.2]);
            uicontrol('Style','pushbutton',...
           'Units','normalized',...
           'BackgroundColor','#5ea490',...
           'ForegroundColor','w',...
           'FontWeight','bold',...
           'Position',[0.005 0.005 0.04 0.032],...
           'String','BACK',...
           'FontSize',12,...
           'Callback','start()');

            uicontrol('Style','pushbutton',...
           'Units','normalized',...
           'BackgroundColor','#5ea490',...
```

```
          'ForegroundColor','w',...
          'FontWeight','bold',...
          'Position',[0.955 0.005 0.04 0.032],...
          'String','CLOSE',...
          'FontSize',12,...
          'Callback','close');
% dropdown
      uicontrol('Style','Text',...
                'Units','Normalized',...
                'Position',[0.6 0.73 0.18 0.025],...
                'FontSize',15,...
                'BackgroundColor','#8ef9da',...
                'ForegroundColor','r',...
                'FontWeight','b',...
                'String','Select graph from menu:');
     uicontrol('Style','PopupMenu',...
               'BackgroundColor','#5ea490',...
               'ForegroundColor','w',...
               'Units','normalized',...
               'Position',[0.78 0.73 0.15 0.03],...
               'value',selectare_grafic,...
               'String','GAIN|(U2/U1)|PHASE|ALL|IMPEDANCE',...
               'FontSize',13,...
'Callback','selectare_grafic=get(gco,''value'');close;proiect(R,L,C,selectare_grafic)
');
                           im=imread('poze/ftb.png');
                           image(im);
                           axis off;
                  set(gca,'Position',[0.012 0.74 0.51 0.25]);
% graf
switch(selectare_grafic)
      case 1
        % calcule
                       Q=sqrt(L/C)./R;         %factorul de calitate
                       f0=1/(2*pi*sqrt(L*C));  %frecventa de taiere
                       x=logspace(-1,1,300);
                       f=x.*f0;
                       w=2.*pi.*f;
                                    numarator=R;
                                    numitor=R+1i.*w.*L+1./(1i.*w.*C);
                                    fmin=f0*(sqrt(1+4*Q.^2)-1)/(2*Q);
                                    fmax=f0*(sqrt(1+4*Q.^2)+1)/(2*Q);
                                    BandaFrecv=fmax-fmin;
                                    faza1=45;
                                    faza2=-45;
            % formule
                          %Uies/Uin
                        h=abs(numarator./numitor);
                          %calcul gain
                        gain=20*log10(h);
                          %frecventa
                        f=w/(2*pi);
                          %faza
                         Faza=angle(numarator./numitor)*180./pi;
```

```
            % gain
            subplot('Position', [0.06 0.30 0.85 0.25]);
                  semilogx(f,gain,'b',fmin,-3,'b*',fmax,-
3,'k*',f0,0,'r*','MarkerSize',12,'MarkerFaceColor',[0.5,0.5,0.5],'LineWidth',2);
                        grid on;
                        xlabel('Frequency(Hz)','Color','w',
'BackgroundColor','#5ea490','FontWeight','b');
                        ylabel('Gain(dB)','Color','w',
'BackgroundColor','#5ea490','FontWeight','b');
                        title('Gain','Fontweight','b','FontSize',13,'Color','w',
'BackgroundColor','#5ea490');
                        legend('Gain','fmin','fmax','f0');

   case 2
    % calcule
                         Q=sqrt(L/C)./R;          %factorul de calitate
                         f0=1/(2*pi*sqrt(L*C));   %frecventa de taiere
                         x=logspace(-1,1,300);
                         f=x.*f0;
                         w=2.*pi.*f;
                                       numarator=R;
                                       numitor=R+1i.*w.*L+1./(1i.*w.*C);
                                       fmin=f0*(sqrt(1+4*Q.^2)-1)/(2*Q);
                                       fmax=f0*(sqrt(1+4*Q.^2)+1)/(2*Q);
                                       BandaFrecv=fmax-fmin;
                                       faza1=45;
                                       faza2=-45;
             % formule
                            %Uout/Uin
                          h=abs(numarator./numitor);
                            %gain
                          gain=20*log10(h);
                            %frecventa
                          f=w/(2*pi);
                            %faza
                           Faza=angle(numarator./numitor)*180./pi;
        % U2/U1
                        subplot('Position',  [0.06 0.30 0.85 0.25]);
                         semilogx(f,h,'r','LineWidth',2);
                         grid on;
                         xlabel('Frequency(Hz)','Color','w',
'BackgroundColor','#5ea490','FontWeight','b');
                         ylabel('(U2/U1)','Color','w',
'BackgroundColor','#5ea490','FontWeight','b');
                         title('U2/U1','Fontweight','b','FontSize',13,'Color','w',
'BackgroundColor','#5ea490');
                         legend('U2/U1');

    case 3
              % calcule
                         Q=sqrt(L/C)./R;          %factorul de calitate
                         f0=1/(2*pi*sqrt(L*C));   %frecventa de taiere
                         x=logspace(-1,1,300);
                         f=x.*f0;
                         w=2.*pi.*f;
```

```
                                    numarator=R;
                                    numitor=R+1i.*w.*L+1./(1i.*w.*C);
                                    fmin=f0*(sqrt(1+4*Q.^2)-1)/(2*Q);
                                    fmax=f0*(sqrt(1+4*Q.^2)+1)/(2*Q);
                                    BandaFrecv=fmax-fmin;
                                    faza1=45;
                                    faza2=-45;
            % formule
                        %Uout/Uin
                       h=abs(numarator./numitor);
                        %gain
                       gain=20*log10(h);
                        %frecventa
                       f=w/(2*pi);
                        %faza
                        Faza=angle(numarator./numitor)*180./pi;
          % faza
                    subplot('Position',   [0.06 0.30 0.85 0.25]);
                    semilogx(f,Faza,'k','LineWidth',2);
                    grid on;
                    xlabel('Frequency(Hz)','Color','w',
'BackgroundColor','#5ea490','FontWeight','b');
                    ylabel('Phase(degrees)','Color','w',
'BackgroundColor','#5ea490','FontWeight','b');
                    title('Signal
Phase','Fontweight','b','FontSize',13,'Color','w', 'BackgroundColor','#5ea490');
                    legend('Phase');

    case 4
        % calcule
                     Q=sqrt(L/C)./R;         %factorul de calitate
                     f0=1/(2*pi*sqrt(L*C));  %frecventa de taiere
                     x=logspace(-1,1,300);
                     f=x.*f0;
                     w=2.*pi.*f;
                                    numarator=R;
                                    numitor=R+1i.*w.*L+1./(1i.*w.*C);
                                    fmin=f0*(sqrt(1+4*Q.^2)-1)/(2*Q);
                                    fmax=f0*(sqrt(1+4*Q.^2)+1)/(2*Q);
                                    BandaFrecv=fmax-fmin;
                                    faza1=45;
                                    faza2=-45;
            % formule
                        %Uout/Uin
                       h=abs(numarator./numitor);
                        %gain
                       gain=20*log10(h);
                        %cfrecventa in functie de w
                       f=w/(2*pi);
                        %faza
                        Faza=angle(numarator./numitor)*180./pi;
         % gain
                  subplot('Position', [0.06 0.53 0.9 0.15]);
                     semilogx(f,gain,'b',fmin,-3,'b*',fmax,-
3,'k*',f0,0,'r*','MarkerSize',12,'MarkerFaceColor',[0.5,0.5,0.5],'LineWidth',2);
```

```
                    grid on;
                    xlabel('Frequency(Hz)','Color','w',
'BackgroundColor','#5ea490','FontWeight','b');
                    ylabel('Gain(dB)','Color','w',
'BackgroundColor','#5ea490','FontWeight','b');
                    title('Gain','Fontweight','b','FontSize',13,'Color','w',
'BackgroundColor','#5ea490');
                    legend('Gain','fmin','fmax','f0');
          % U2/U1
                 subplot('Position',  [0.06 0.06 0.9 0.15]);
                    semilogx(f,h,'r','LineWidth',2);
                    grid on;
                    xlabel('Frequency(Hz)','Color','w',
'BackgroundColor','#5ea490','FontWeight','b');
                    ylabel('(U2/U1)','Color','w',
'BackgroundColor','#5ea490','FontWeight','b');
                    title('U2/U1','Fontweight','b','FontSize',13,'Color','w',
'BackgroundColor','#5ea490');
                    legend('U2/U1');
           % faza
                 subplot('Position',   [0.06 0.30 0.9 0.15]);
                    semilogx(f,Faza,'k','LineWidth',2);
                    grid on;
                    xlabel('Frequency(Hz)','Color','w','FontWeight','b',
'BackgroundColor','#5ea490');
                    ylabel('Phase(degrees)','Color','w','FontWeight','b',
'BackgroundColor','#5ea490');
                    title('Signal
Phase','Fontweight','b','FontSize',13,'Color','w', 'BackgroundColor','#5ea490');
                    legend('Phase');
    case 5
                     % calcule
                     Q=sqrt(L/C)./R;         %factorul de calitate
                     f0=1/(2*pi*sqrt(L*C));  %frecventa de taiere
                     x=logspace(-1,1,300);
                     f=x.*f0;
                     w=2.*pi.*f;
                                  numarator=R;
                                  numitor=R+1i.*w.*L+1./(1i.*w.*C);
                                  fmin=f0*(sqrt(1+4*Q.^2)-1)/(2*Q);
                                  fmax=f0*(sqrt(1+4*Q.^2)+1)/(2*Q);
                                  BandaFrecv=fmax-fmin;
                                  faza1=45;
                                  faza2=-45;
            % formule
                      zz = R + 1./(j.*w.*C) + (j.*w.*L);
                      z = abs(zz);
                      f=w/(2*pi);
           % impedance
                    subplot('Position',   [0.06 0.30 0.85 0.25]);
                    semilogx(f,z,'g','LineWidth',2);
                    grid on;
                    xlabel('Frequency(Hz)','Color','w',
'BackgroundColor','#5ea490','FontWeight','b');
```

```
                        ylabel('Impedance(Ohm)','Color','w',
'BackgroundColor','#5ea490','FontWeight','b');
                        title('IMPEDANCE','Fontweight','b','FontSize',13,'Color','w',
'BackgroundColor','#5ea490');
                        legend('Impedance');

end
   % properties
            uicontrol('Style','Text',...
                      'Units','Normalized',...
                      'Position',[0.82,0.9,0.12,0.025],...
                      'BackgroundColor','#8ef9da',...
                      'ForegroundColor','k',...
                      'FontSize',13,...
                      'FontWeight','b',...
                      'String',['Q = ',num2str(Q)]);
            uicontrol('Style','Text',...
                      'Units','Normalized',...
                      'Position',[0.823,0.87,0.12,0.025],...
                      'BackgroundColor','#8ef9da',...
                      'ForegroundColor','k',...
                      'FontSize',13,...
                      'FontWeight','b',...
                      'String',['F max = ',num2str(fix(fmax)),' Hz ']);
            uicontrol('Style','Text',...
                      'Units','Normalized',...
                      'Position',[0.82,0.84,0.12,0.025],...
                      'BackgroundColor','#8ef9da',...
                      'ForegroundColor','k',...
                      'FontSize',13,...
                      'FontWeight','b',...
                      'String',['F min = ',num2str(fix(fmin)),' Hz ']);
            uicontrol('Style','Text',...
                      'Units','Normalized',...
                      'Position',[0.823,0.81,0.12,0.025],...
                      'BackgroundColor','#8ef9da',...
                      'ForegroundColor','k',...
                      'FontSize',13,...
                      'FontWeight','b',...
                      'String',['F Band = ',num2str(fix(BandaFrecv)),' Hz ']);

end
```