BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Course No.: EEE 212 Section: C

Course Title: Numerical Technique Laboratory

Project No.: 4

Name of the Project: **PASSIVE FILTER DESIGN AND ANALYSIS.**

Name: Sajib Biswas Shuvo

ID: 1806131

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Documentation

Objective

- To view the Bode Plot for the specified type of Passive Filter and cut-off frequency.
- To view the value of Resistor, Inductor and Capacitor of the specified filter.
- To view the value of Quality Factor, Bandwidth and Error (%) of that filter.
- To view the Schematic Circuit diagram of the Filter.

Installation Procedure:

Install with the **“Passive Filter Design and Analysis.mlappinstall”** file and locate the app in the MY APPS section of the app browser. Besides, the **“Passive Filter Design and Analysis.mlapp”** file is also provided to inspect the codes. It can be opened from the inside of MATLAB from **OPEN** menu.

[N.B.: This app was designed in MATLAB 2020b. Problems may arise if the user’s MATLAB version is older than 2020b. Moreover, if the user wants to run the **.mlapp** file, then the folder named **“image_folder_new”** should be in the same directory of the **.mlapp** file.]

User Interface

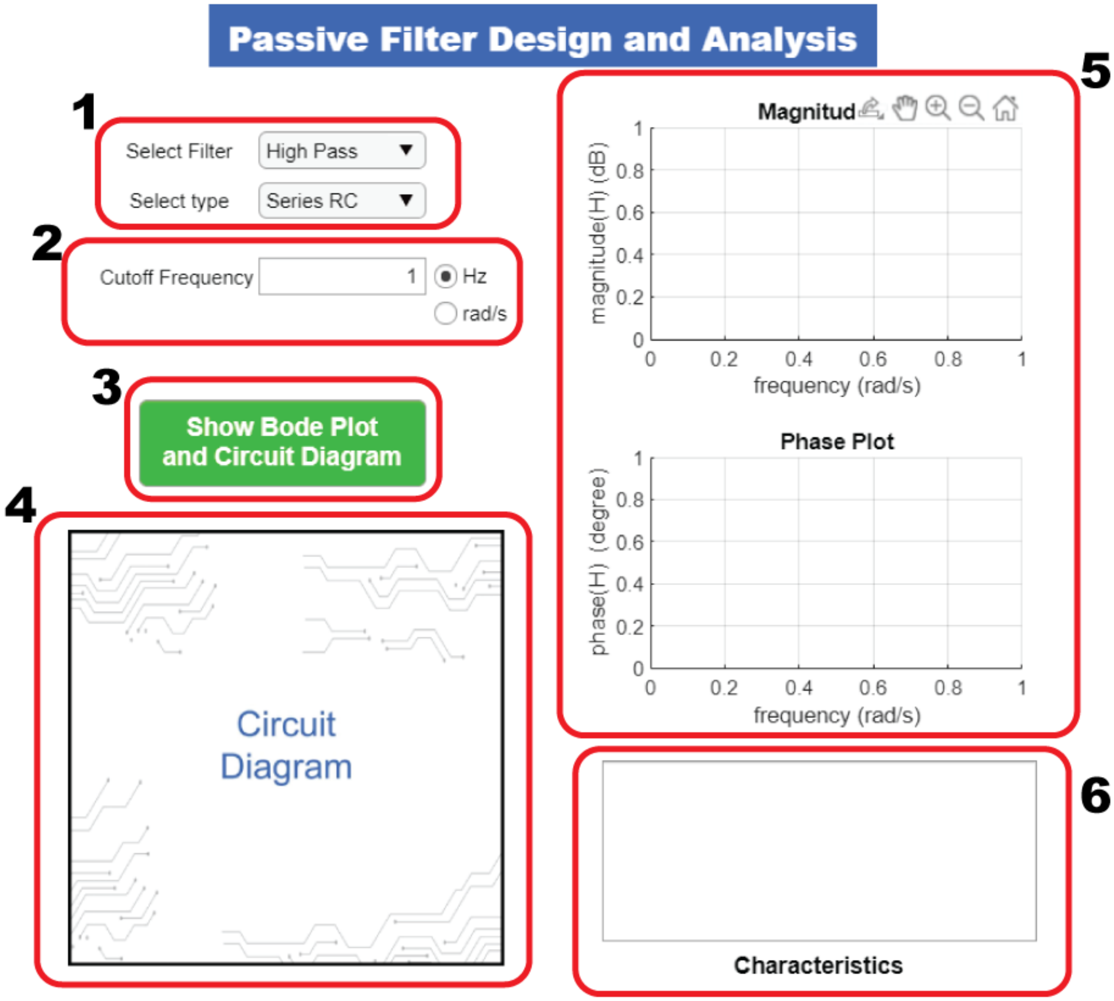

Figure 1: App layout at startup

1. Select the type of the filter
2. Input cutoff frequency and specify unit
3. Click the button to show bode plot, circuit diagram and characteristics
4. The circuit diagram will appear here
5. The bode plot will appear here
6. The value of R, L, C and Bandwidth, Quality factor and Error (%) will appear here.

Flowchart

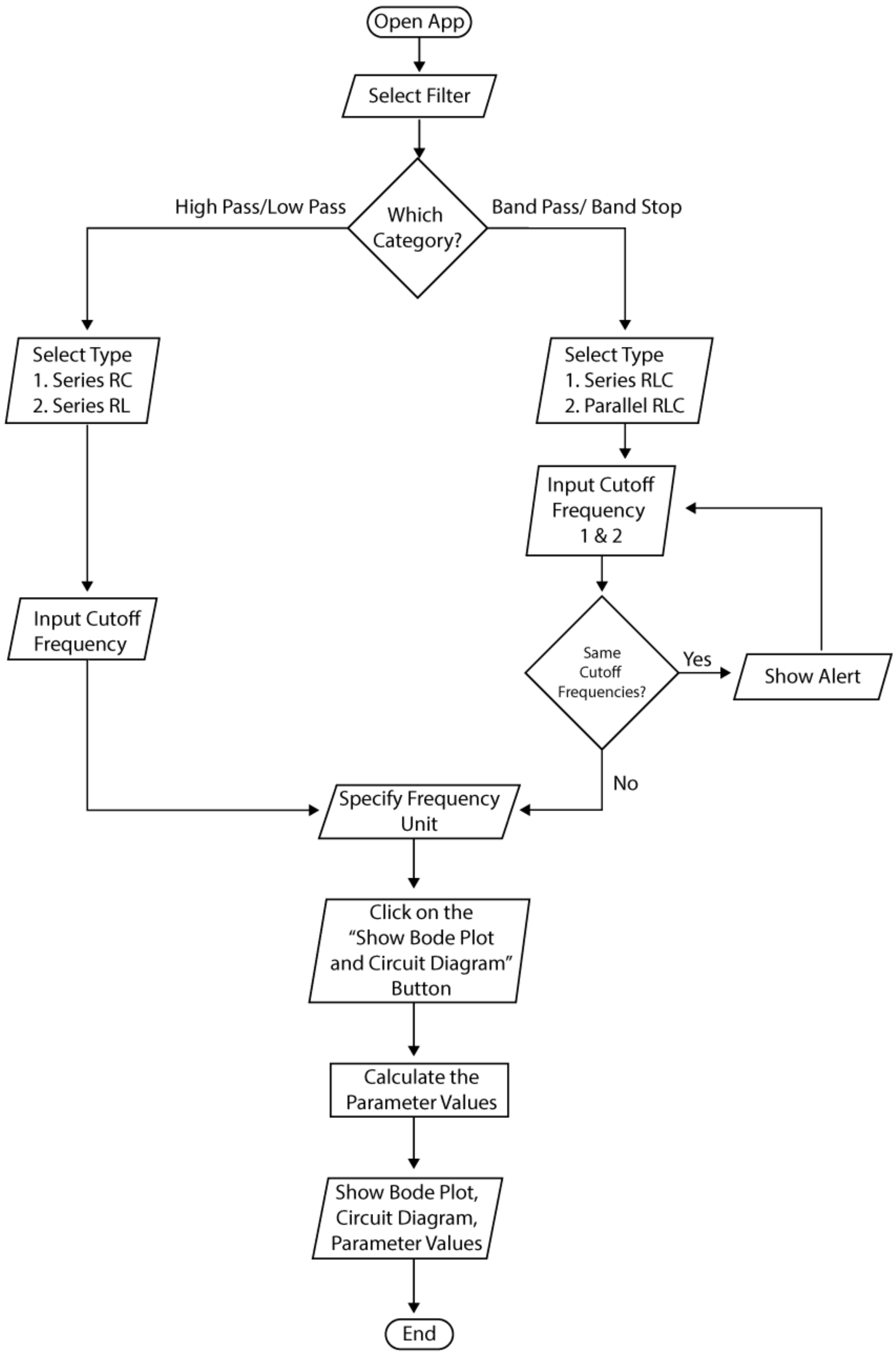

Figure 2: Flowchart of the process

Sample Results

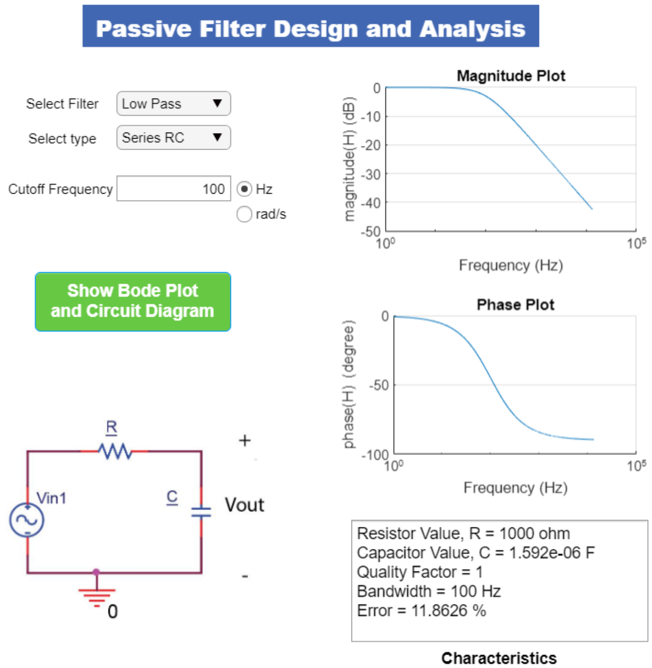

Figure 3: Low Pass, Series RC Filter with 100 Hz Cut off Frequency

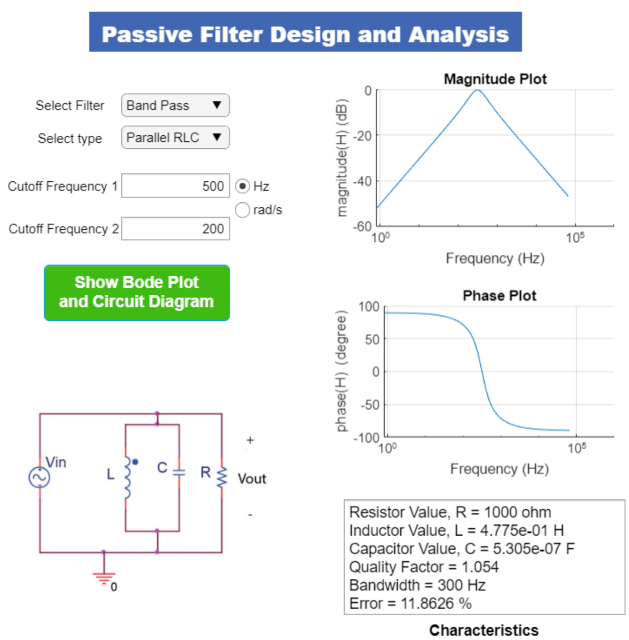

Figure 4: Band Pass Parallel RLC Filter with 200 Hz and 500 Hz Cut off frequency

Explanation

Used functions and Formulas

For cutoff frequency = $\begin{cases} \omega_c \text{ (for low pass and high pass),} \\ \quad \omega_{c1} \text{ and } \omega_{c2} \text{ (for band pass)} \end{cases}$

$$\tau = \frac{1}{\omega_c}$$

$$s = j\omega$$

Bandwidth, $B = \omega_{c1} - \omega_{c2}$ rad/s

$$\omega_0 = \sqrt{\omega_{c1}\omega_{c2}}$$

Type of the filter	Transfer Function
Low pass RL and RC	$H = \dfrac{1}{1 + s\,\tau}$
High pass RL and RC	$H = \dfrac{s\,\tau}{1 + s\,\tau}$
Band pass RLC (Series and Parallel)	$H = \dfrac{sB}{s^2 + sB + \omega_0^2}$
Band stop RLC (Series and Parallel)	$H = \dfrac{s^2 + \omega_0^2}{s^2 + sB + \omega_0^2}$

Warnings and Tooltips

For band pass and band stop filters, if both the cutoff frequencies are the same, then an error message will pop up.

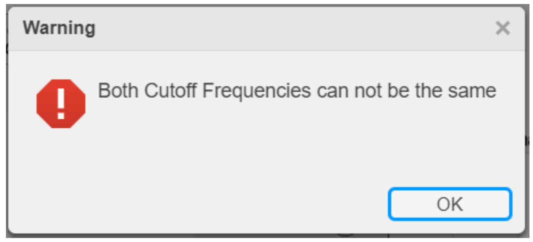

Figure 5: Warning message

Besides, hovering over the mouse cursor on some fields of the app will show relevant tooltips for better understanding of that field.

Figure 6: Tooltips

Characteristics Calculation

For all the filters, R is fixed as 1000 ohm.

The value of L and C are measured as follows:

Type of the filter	Formula
Low pass and High pass RL	$L = \frac{R}{\omega_c}$
Low pass and High pass RC	$C = \frac{1}{R\omega_c}$
Band pass and Band stop series RLC	$L = \frac{R}{B}$ $C = \frac{1}{L\omega_0^2}$

Band pass and Band stop parallel RLC	$L = \frac{BR}{\omega_0^2}$ $C = \frac{1}{L\omega_0^2}$

Here, **Quality factor**, $Q = \frac{\omega_0}{B}$

Where, $\omega_0 = \begin{cases} \omega_c & , for\ low\ pass\ and\ high\ pass\ filters \\ \sqrt{\omega_{c1}\omega_{c2}} & , for\ band\ pass\ and\ band\ stop\ filters \end{cases}$

And, **Bandwidth**, B = $\begin{cases} \omega_c & , for\ low\ pass\ filters \\ |\omega_{c1} - \omega_{c2}| & , \text{for bandpass and band stop filters} \\ \infty & , for\ high\ pass\ filters \end{cases}$

For **error calculation**, and an error function was declared for each type of filter. The error function is defined as follows:

Error function, E(f) = 1 - |transfer function|

The error is measure with the following formula:

$$\%\ of\ error = \frac{Absolute\ Error}{Area\ Enclose\ by\ the\ Ideal\ filter} = \frac{Absolute\ Error}{1 \times Bandwidth}$$

$$\text{Where, Absolute Error} = \begin{cases} \int_0^{fc} E(f)\ d(f), & \text{for lowpass filter} \\ \int_{fc1}^{fc2} E(f)\ d(f), & for\ bandpass\ and\ bandstop\ filter \end{cases}$$

Here, f_c, f_{c1} and f_{c2} are the cutoff frequencies. Transfer function is taken in the format where the magnitude varies from 0 to 1.
Error is not calculated for high pass filter.

Prospects of Improvement:

Higher order filters can be used to increase the accuracy and selectivity of the filter.