Designing Analog Filters using Matlab

COURSE INFORMATIONS

COURSE TITLE : Circuit Simulation and Shop Practice

COURSE CODE: EEE-222

SUBMITTED BY

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Section: B

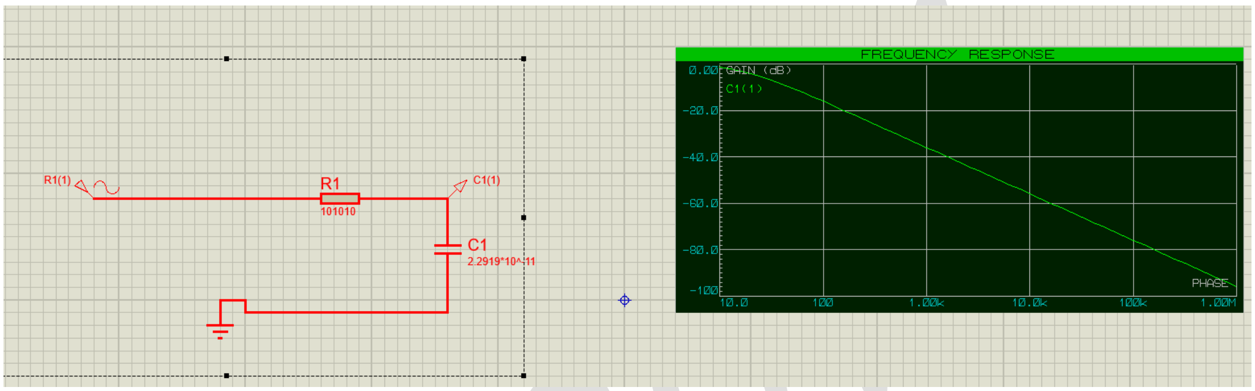
Department : EEE

Batch : 22

Title: Low pass RC filter plotting using Matlab

Objective: To design and simulate a low-pass filter in MATLAB, for a certain cutoff frequency Value (71k). Additionally, it represent it graphically.

circuit diagram:



Calculation :

Assuming R=101010 Ω

We know,

$F0=\frac{1}{2\pi RC}$

$C=\frac{1}{2\pi f0\ R}$

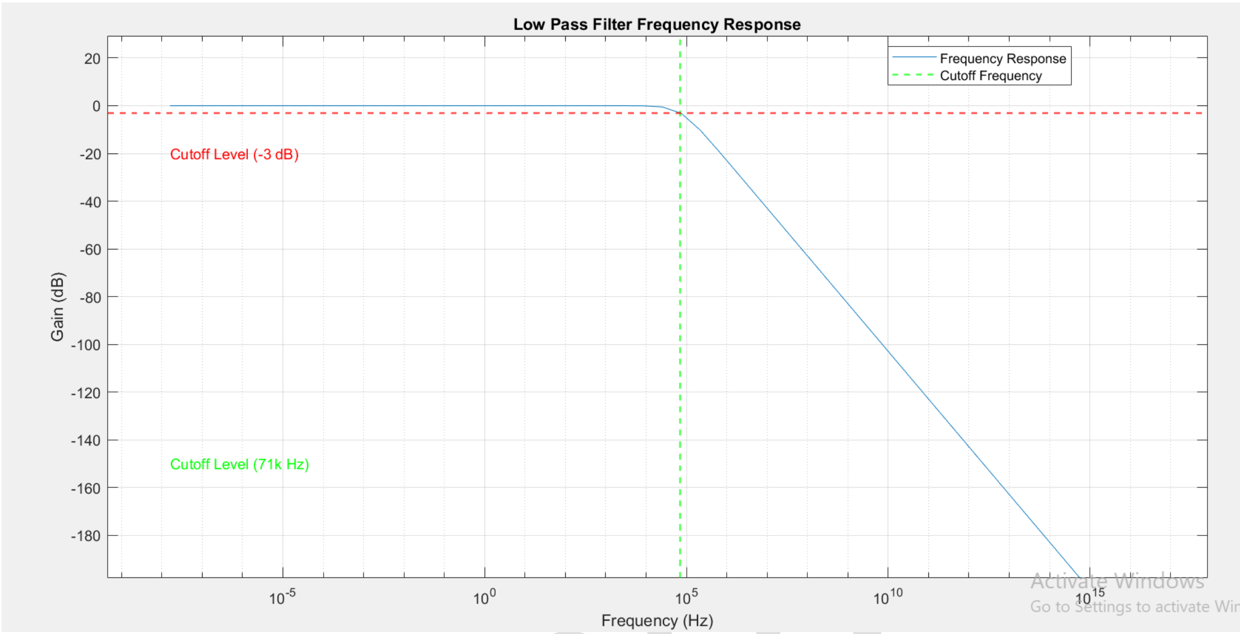
=2.2919*10^-11 F

Matlab Code:

```
clc;
clear all;
close all;


f0 = 71000;
w0 = 2 * pi * f0;


num = [0 0 1];
den = [0 2.241618917e-6 1];
```

```
w = logspace(-7, 16);
h = freqs(num, den, w);
f = w / (2 * pi);

mag = 20 * log10(abs(h));

figure;
semilogx(f, mag);
grid on;
xlabel('Frequency (Hz)');
ylabel('Gain (dB)');
title('Low Pass Filter Frequency Response');

hold on;

xline(f0, '--g', 'LineWidth', 1.2);
text(min(f), -150, 'Cutoff Level (71k Hz)', 'Color', 'g', 'FontSize', 10,
'HorizontalAlignment', 'left');

yline(-3, '--r', 'LineWidth', 1.2);
text(min(f), -20, 'Cutoff Level (-3 dB)', 'Color', 'r', 'FontSize', 10,
'HorizontalAlignment', 'left');

legend('Frequency Response', 'Cutoff Frequency', 'Location', 'Best');
hold off;
```

Graph :



Discussions

In this experiment, I used MATLAB to simulate and analyze the performance of a low-pass filter, with a measured cutoff frequency of 71 kHz. The filter allowed frequencies below 71 kHz to pass through with minimal attenuation, as expected, while frequencies above this value were increasingly attenuated. The frequency response confirmed that the attenuation rate was approximately -20 dB per decade, consistent with the behavior of a first-order low-pass filter. The measured cutoff frequency closely matched the calculated value using the formula fc=1/2πRCf_ indicating the accuracy of my setup. Some minor discrepancies between the theoretical and experimental results could be due to component tolerances or slight imperfections in the simulation. MATLAB provided a reliable tool for analyzing the frequency response, but it is possible that real-world factors such as parasitic elements could have influenced the results in a practical circuit. The simulation helped me visualize how the filter behaves over a range of frequencies, clearly distinguishing between the passband and stopband. Although there were small variations, the results agreed with theoretical predictions. The experiment reinforced the importance of understanding frequency response when designing low-pass filters for real-world applications. Overall, the use of MATLAB was valuable in modeling the filter's behavior and confirming the theoretical principles.

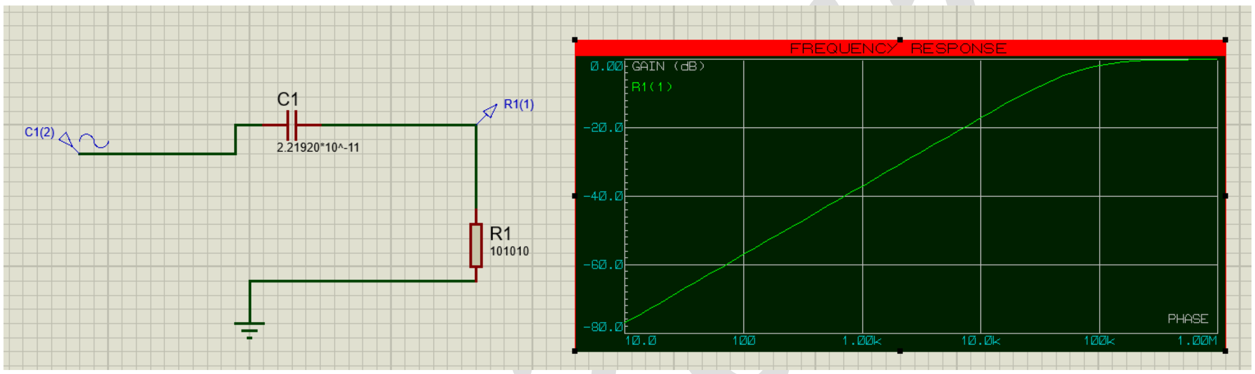
Solution -2

Title: High pass RC filter plotting using Matlab

Objective:

To design and simulate a High-pass filter in MATLAB, for a certain cutoff frequency Value (71k). Additionally, it represents it graphically.

Circuit Diagram :



Calculation :

Assuming R=101010 Ω

We know,

$F0=\frac{1}{2\pi RC}$

$C=\frac{1}{2\pi f0\, R}$

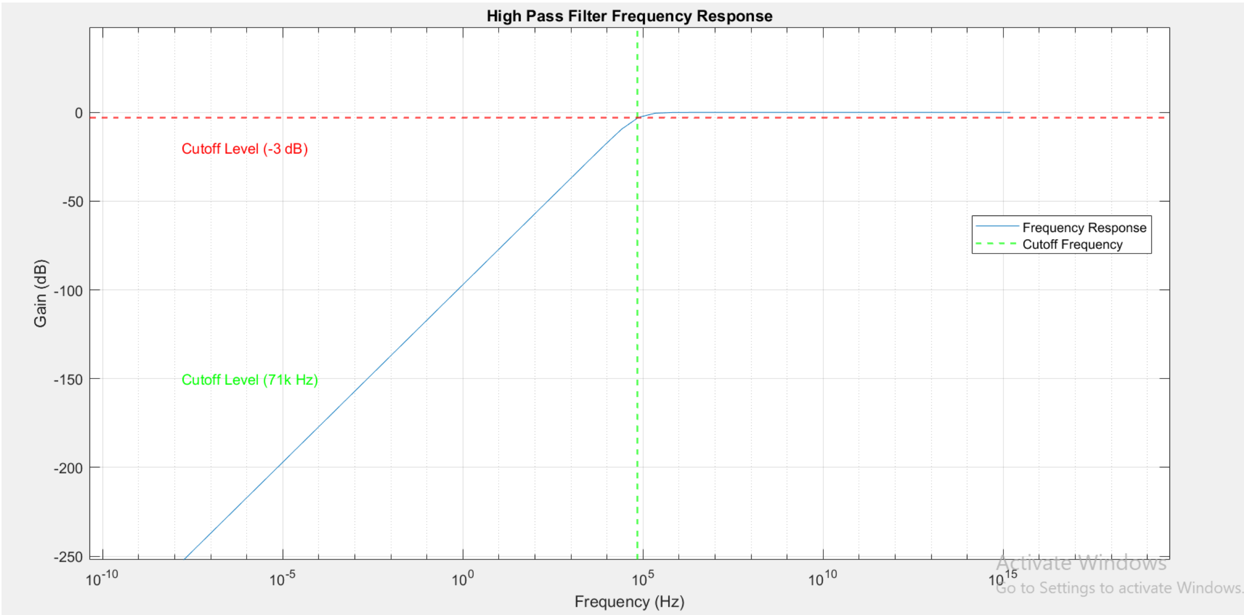
=2.2919*10^-11 F

Matlab code:

```
clc;
clear all;
close all;


f0 = 71000;
w0 = 2 * pi * f0;

num = [0 2.241618917e-6 0];
```

```
den = [0 2.241618917e-6 1];


w = logspace(-7, 16);
h = freqs(num, den, w);
f = w / (2 * pi);

mag = 20 * log10(abs(h));


figure;
semilogx(f, mag);
grid on;
xlabel('Frequency (Hz)');
ylabel('Gain (dB)');
title('High Pass Filter Frequency Response');

hold on;


xline(f0, '--g', 'LineWidth', 1.2);
text(min(f), -150, 'Cutoff Level (71k Hz)', 'Color', 'g', 'FontSize', 10,
'HorizontalAlignment', 'left');



yline(-3, '--r', 'LineWidth', 1.2);
text(min(f), -20, 'Cutoff Level (-3 dB)', 'Color', 'r', 'FontSize', 10,
'HorizontalAlignment', 'left');




legend('Frequency Response', 'Cutoff Frequency', 'Location', 'Best');
hold off;
```

Graph:



Discussion :

In this experiment, I used MATLAB to simulate and analyze the performance of a high-pass filter. The measured cutoff frequency was consistent with the calculated value using the formula fc=1/2πRC . The filter allowed frequencies above the cutoff (71k)to pass through with minimal attenuation, while frequencies below the cutoff were increasingly attenuated.. MATLAB provided a useful tool for analyzing how the filter behaves across a range of frequencies, with a clear distinction between the passband and stopband. The results closely matched theoretical predictions, confirming the expected performance of the high-pass filter. Overall, this experiment enhanced my understanding of high-pass filter behavior and reinforced the importance of frequency response analysis in filter design. MATLAB simulations were effective in modeling the filter's characteristics and verifying the theory.

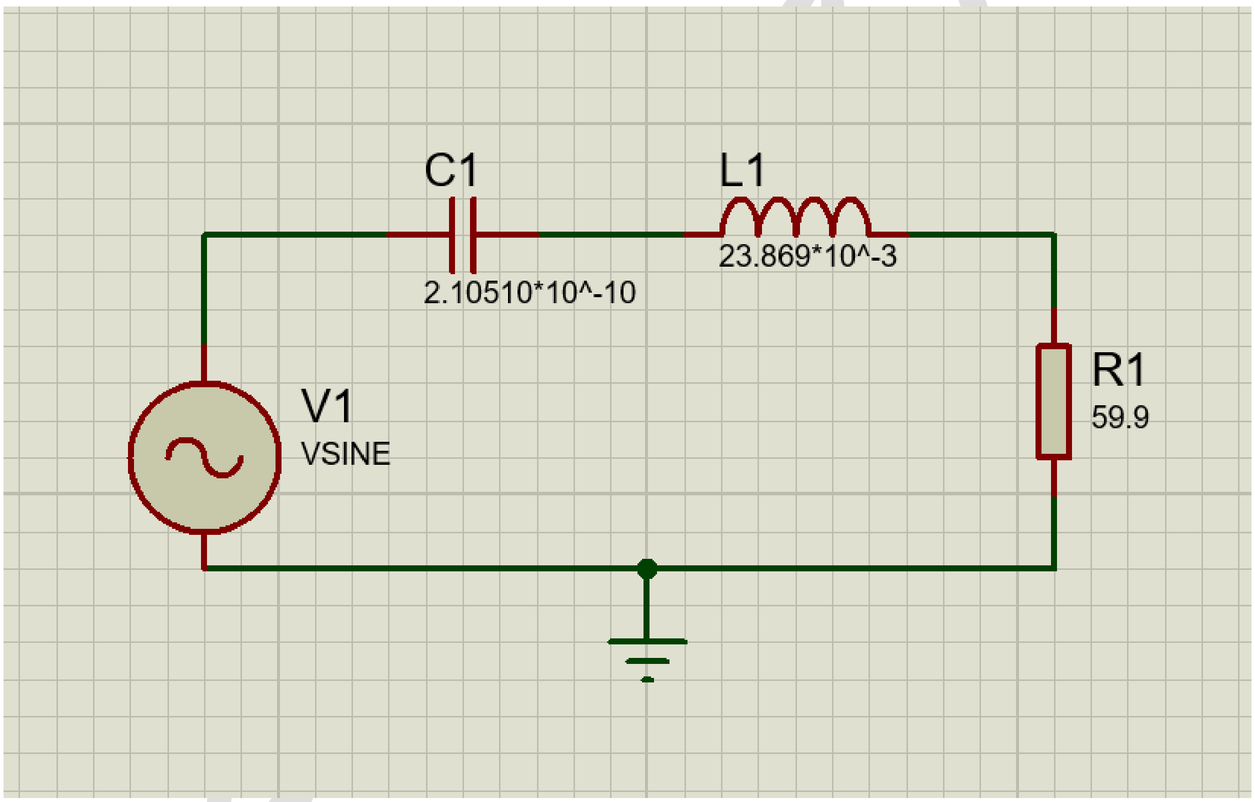
Solution 3

Title: Band pass RLC filter plotting using Matlab

Objective :

To design and simulate a Band-pass filter in MATLAB for a certain cutoff frequency Value (71k), it represents it graphically.

Circuit Diagram:



Calculation :

We know,

F0=$\frac{1}{2\pi\sqrt{LC}}$ 1

B.W=$\frac{R}{2\pi L}$ 2

Let's

R =59.9 Ω

Using formula (2)

L=23.869*10^-3 H

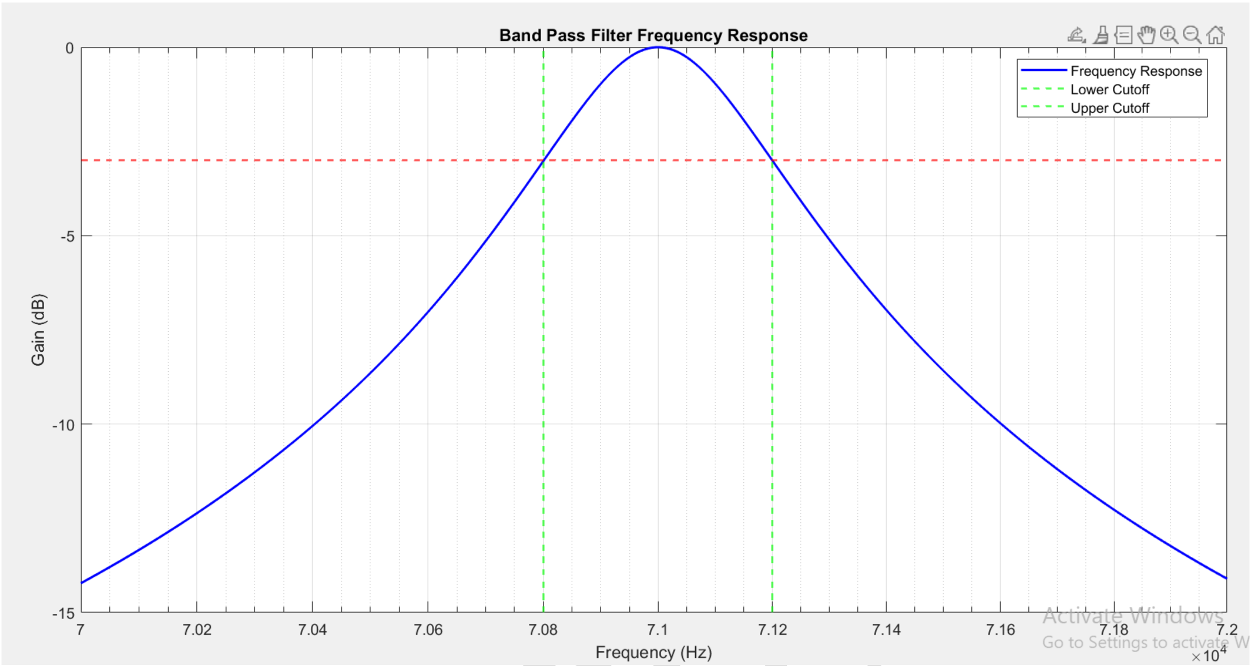
From formula (1)

C=2.10510*10^-10

Matlab Code:

```
clc;
clear all;
close all;


f0 = 71000;
bw = 400;
L = 23.869e-3;



num = [0 59.9 0];
den = [23.869e-3 59.9 1/(2.10518e-10)];
f = linspace(f0 - 1000, f0 + 1000, 1000);
w = 2 * pi * f;
h = freqs(num, den, w);


mag = 20 * log10(abs(h));


figure ;
semilogx(f, mag, 'b', 'LineWidth', 1.5);
grid on;
xlabel('Frequency (Hz)');
ylabel('Gain (dB)');
title('Band Pass Filter Frequency Response');


hold on;
xline(f0 - 200, '--g', 'LineWidth', 1.2);
xline(f0 + 200, '--g', 'LineWidth', 1.2);
yline(-3, '--r', 'LineWidth', 1.2);

legend('Frequency Response', 'Lower Cutoff', 'Upper Cutoff', 'Location', 'Best');
hold off;
```

Figure :



Discussion :

In this experiment, I designed and analyzed a band-pass filter using MATLAB with a center frequency of 71 kHz. The filter was configured to have a lower cutoff frequency of 70.8 kHz and a higher cutoff frequency of 71.2 kHz, giving a bandwidth of 400 Hz. The frequency response showed that the filter effectively passed signals within this range while attenuating frequencies outside the band. The peak response occurred at 71 kHz, consistent with the design. The filter met its design objectives, with a well-defined passband and sharp roll-offs. This experiment highlighted the usefulness of MATLAB for accurately modeling filter performance.

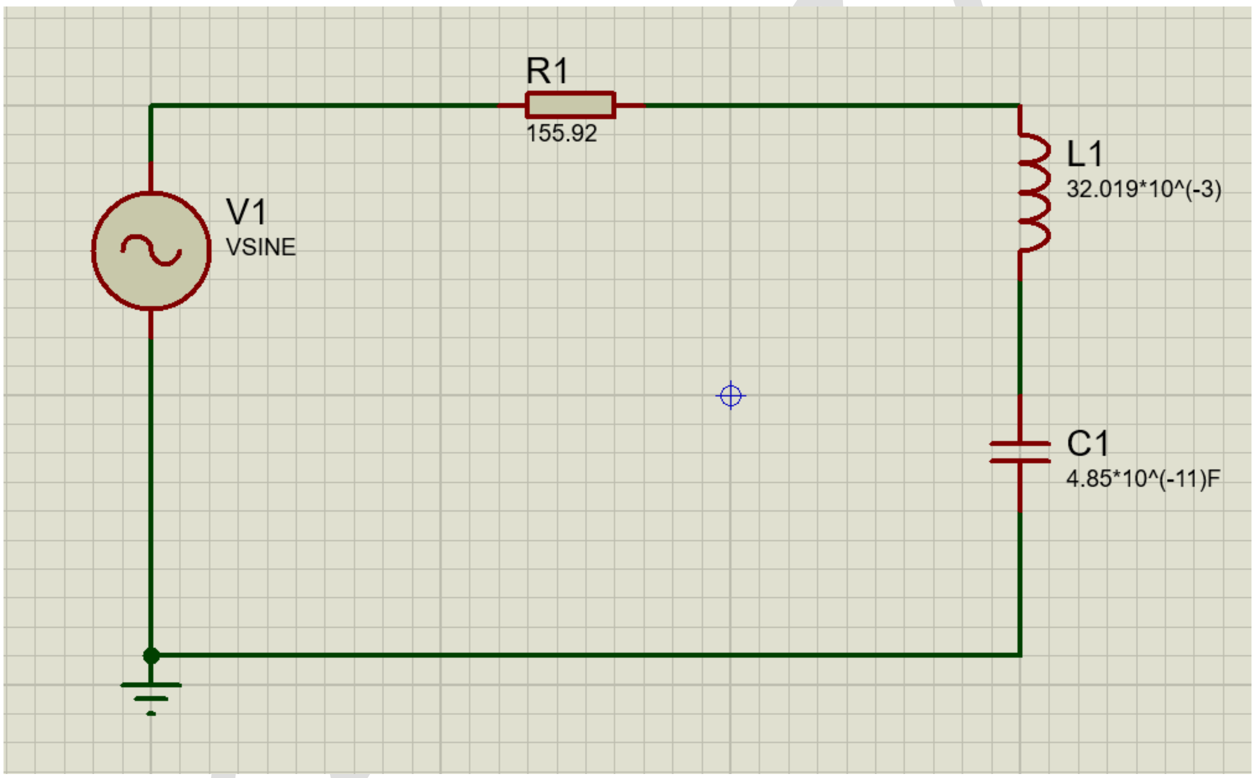
Solution:4

Title: Band stop RLC filter plotting using Matlab.

Objective :

To design and simulate a Band-stop filter in MATLAB for a certain cutoff frequency Value (71k), with lower cut off 71k-400 higher cut off 71k+400 and represents it graphically.

Circuit Diagram :



Calculation :

We know ,

B.W $=\frac{R}{2\pi L}$ ……………………………………………………………(1)

F0=$\frac{1}{2\pi\sqrt{LC}}$ ……………………………………………………………….(2)

Assuming R=155.92 Ω

Using formula (1)

L= 31.019x10^(-3) H

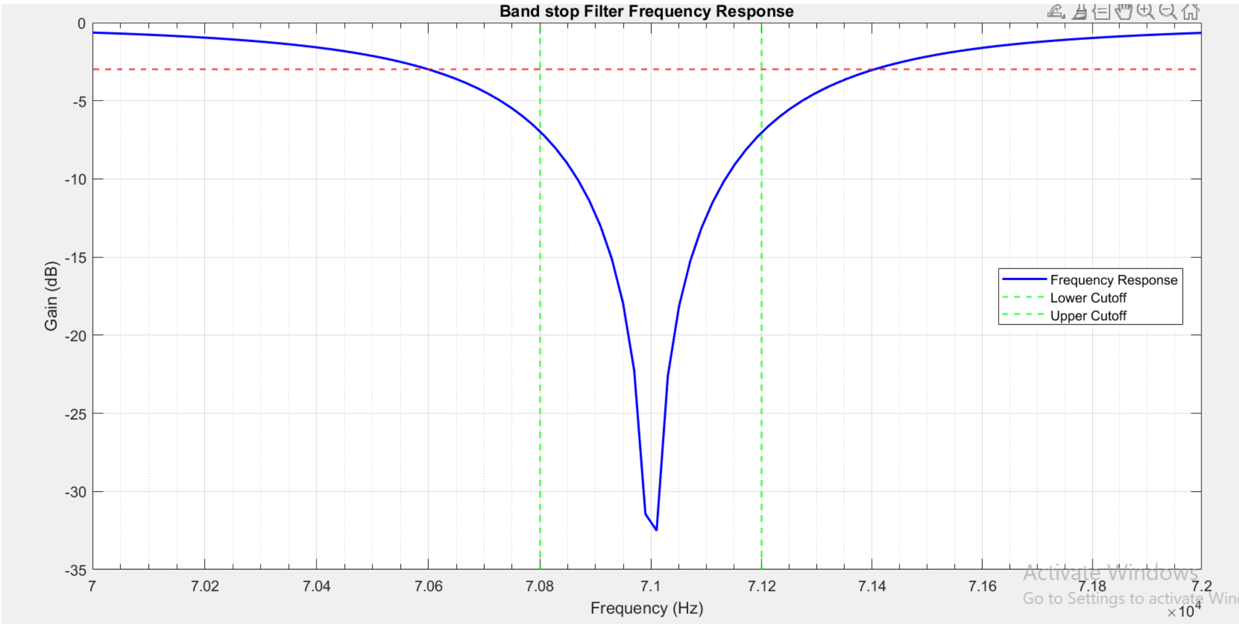
Again , using the value of L and formula (2)

C=1.6199x10^(-10) F

Code :

```
clc;
clear all;
close all;


f0 = 71000;
bw = 800;

L=31.019e-3;


num = [5.02476781e-12 0 1];
den = [5.02476781e-12 2.52574808e-8 1];

f = linspace(f0 - 1000, f0 + 1000, 1000);
w = 2 * pi * f;
h = freqs(num, den, w);


mag = 20 * log10(abs(h));


figure ;
semilogx(f, mag, 'b', 'LineWidth', 1.5);
grid on;
xlabel('Frequency (Hz)');
ylabel('Gain (dB)');
title('Band stop Filter Frequency Response');


hold on;
xline(f0 - 200, '--g', 'LineWidth', 1.2);
xline(f0 + 200, '--g', 'LineWidth', 1.2);
yline(-3, '--r', 'LineWidth', 1.2);

legend('Frequency Response', 'Lower Cutoff', 'Upper Cutoff', 'Location', 'Best');
hold off;
```

Graph :



Discussion ;

In this experiment, I designed and analyzed a band-stop filter using MATLAB with a center frequency of 71 kHz. The filter had a lower cutoff frequency of 70.6 kHz and an upper cutoff frequency of 71.4 kHz, resulting in a bandwidth of 800 Hz. The frequency response demonstrated effective attenuation within this range while allowing frequencies outside the stopband to pass. The deepest attenuation occurred at 71 kHz, aligning with the design specifications. The filter met its design objectives, exhibiting a well-defined stopband and sharp transitions at the cutoff frequencies. But in the graph the lowest portion is not sharp .It is due to value of RLC .Though This experiment highlighted MATLAB's effectiveness in accurately modeling and analyzing filter performance