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Project: Band-Pass filter

Introduction

Band-Pass Filter (BPF)?

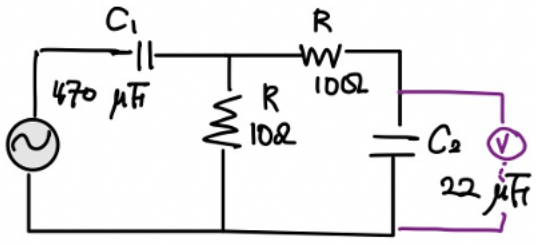
BPF is a circuit that allows signals within a specific frequency and range while attenuating others. BPF is used in applications such as communication systems, audio processing, and noise reduction. It is especially useful to filter out and focus on relevant signals or range of signals in various fields. The valid range or bandwidth for BPF, the range where Gain (V_{output}/V_{input}) remains 70.7% of the Maximum Gain. While the experiment uses Decibel-logarithmic scale for Gain, frequency range where gain is at $Gain_{max}$-3db to $Gain_{max}$ will be the bandwidth BW.

Equipment

C1=470uF, C2=22uF, R1=10Ω, R2=10Ω, Oscillator, Wires, Propscope equipment

Method

1. Set a circuit [-Generator-C1-(R1-(R2||C2)-] with Propscope connected at C2.



2. Set generator voltage Vin=1.00V.

3. Collect the Peak-to-Peak Voltage at C2 and find frequency where V at C2 is maximum (Vmax).
4. Adjust frequency to the lower side and find frequencies where peak-to-peak Voltages are 0.9Vmax 0.8Vmax 0.707Vmax 0.6Vmax 0.5Vmax.
5. Then, return to frequency where V at C2 is maximum (Vmax), and adjust to the higher side and find frequencies where peak-to-peak Voltages are 0.9Vmax 0.8Vmax 0.707Vmax 0.6Vmax 0.5Vmax.

Data

*Vmax? 0.85V

*Vmax remained almost constant for a certain range of frequency.

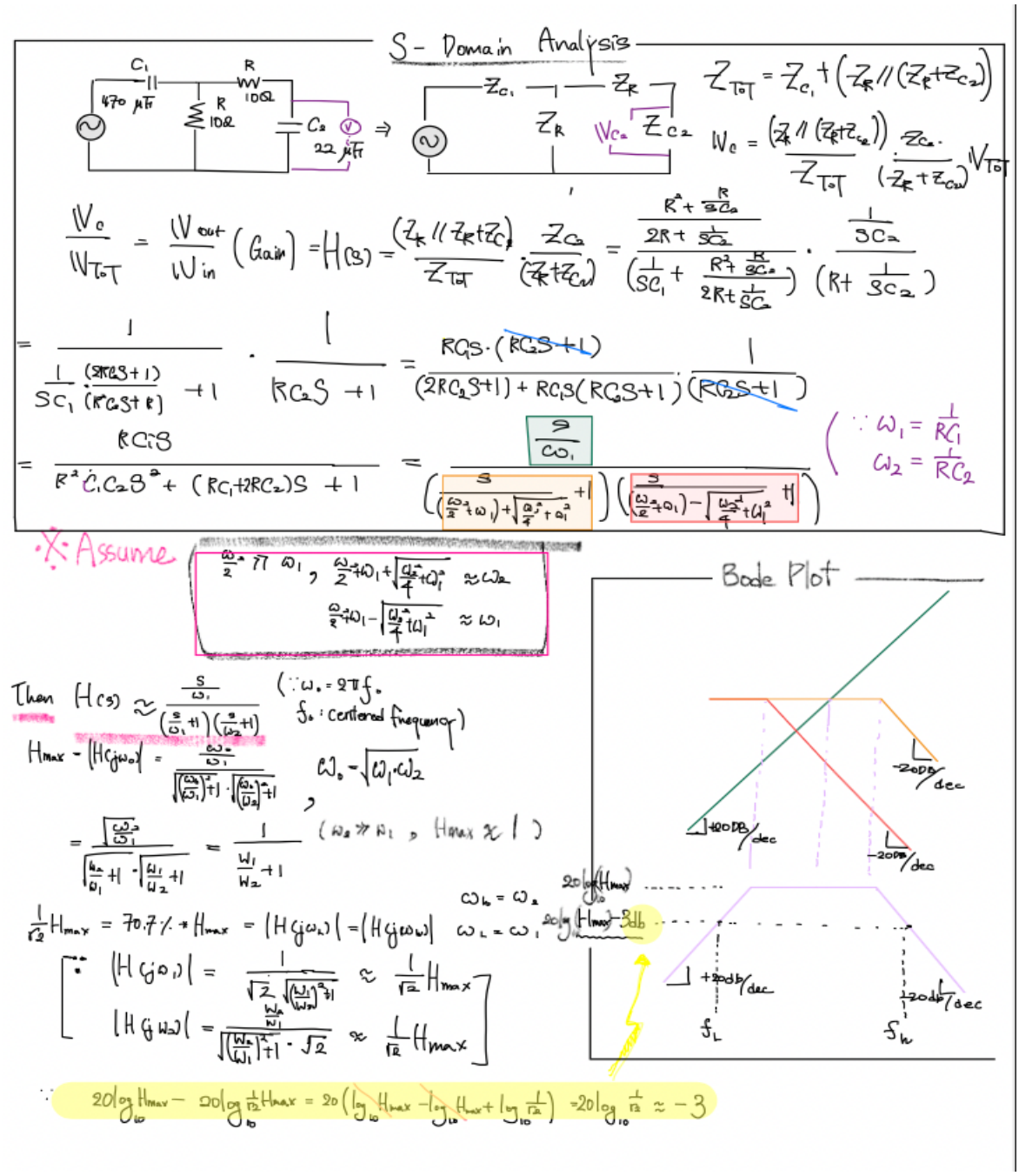
Peak Voltage (V)		Peak-to-Peak V (V) (Peak**x2**)	Voltage Gain (dB) $20\log_{10}(V_{peak}/V_{in})$	Frequency (Hz) Left-Hand-Side from Vmax frequency	Frequency (Hz) Right-Hand-Side from Vmax frequency
Vmax	0.850	1.70	-1.41		
0.9Vmax	0.765	1.53	-2.33	49.9	345.6
0.8Vmax	0.680	1.36	-3.35	34.1	535.8
0.707Vmax	0.605	1.21	-4.42	26.0	714.4
0.6Vmax	0.51	1.02	-5.85	19.7	955.0
0.5Vmax	0.425	0.850	-7.43	15.3	1223

*Experimental Bandwidth BW:688.4Hz

*Experimental Left cut-off frequency:26.0Hz

*Experimental Right cut-off frequency:714.4Hz

Theoretical Calculation



***Generally given Cut-Off frequency(at RC BPF)**

-ω1= 2πf_l=1/(R1C1)

-ω2=2πf_h=1/(R2C2)

% Error

Theoretical $f_L = \frac{\omega_1}{2\pi} = \frac{1}{2\pi R_1 C_1} = \frac{1}{2\pi(10)*(470\times10^{-6})}$

$= 33.86\ Hz$

Theoretical $f_h = \frac{\omega_2}{2\pi} = \frac{1}{2\pi R_2 C_2} = \frac{1}{2\pi*(10)*(22\times10^{-6})}$

$= 723.4\ Hz$

Theoretical $f_{center} = \frac{\omega_0}{2\pi} = \frac{\sqrt{\omega_1\omega_2}}{2\pi} = \sqrt{f_1 * f_2}$

$= 156.5\ Hz$

Experimental $f_{center} = \sqrt{f_L * f_S} = \sqrt{(26.0)*(7144)}$

$= 136.9\ Hz$

$BW_{Th} = f_h^{Th} - f_L^{Th} = 689.6\ Hz$

BW NTB ADDed

BW % Error : $\frac{|BW_{Th} - BW_{ex}|}{BW_{Th}} \times 100 = 0.174\ \%$

f_{center} % Error : $\frac{|f_{center}^{Th} - f_{center}^{ex}|}{f_{center}^{Th}} \times 100 = 13.0\ \%$

BW %Error=0.74%, f_{center} %Error=13.0%

Results

Did it work? Yes, they worked well.

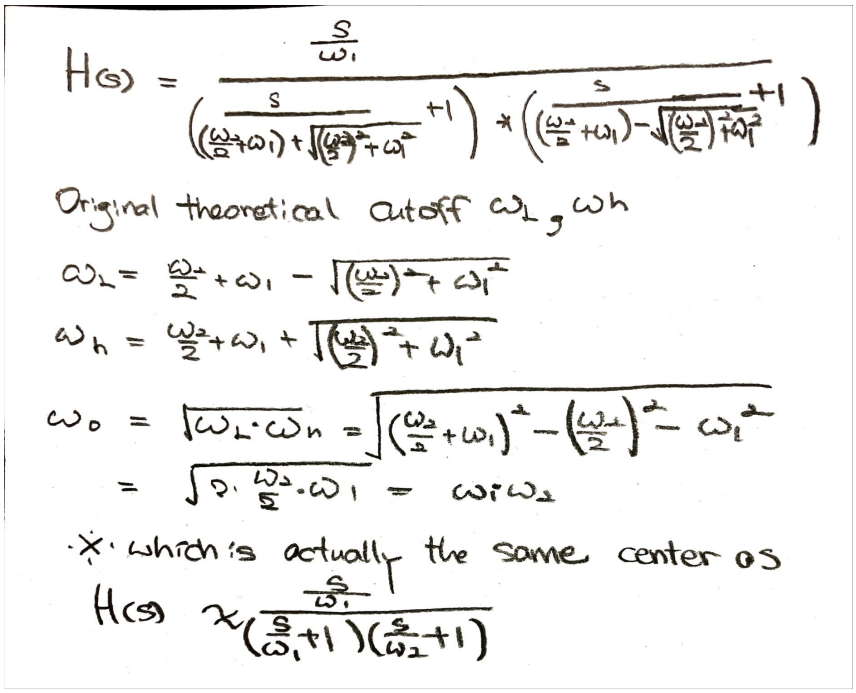
Good way to do whatever your thing does? Yes, it works to sort out certain range of frequencies. However, to get precise range, we need less tolerance circuit components.

The BW % error 0.74% shows that the experiment value 688.4Hz matches closely with the theoretical value 689.4Hz. However, this cannot represent the range, so our group calculated %Error for center frequency, which includes two cut-off frequency properties.

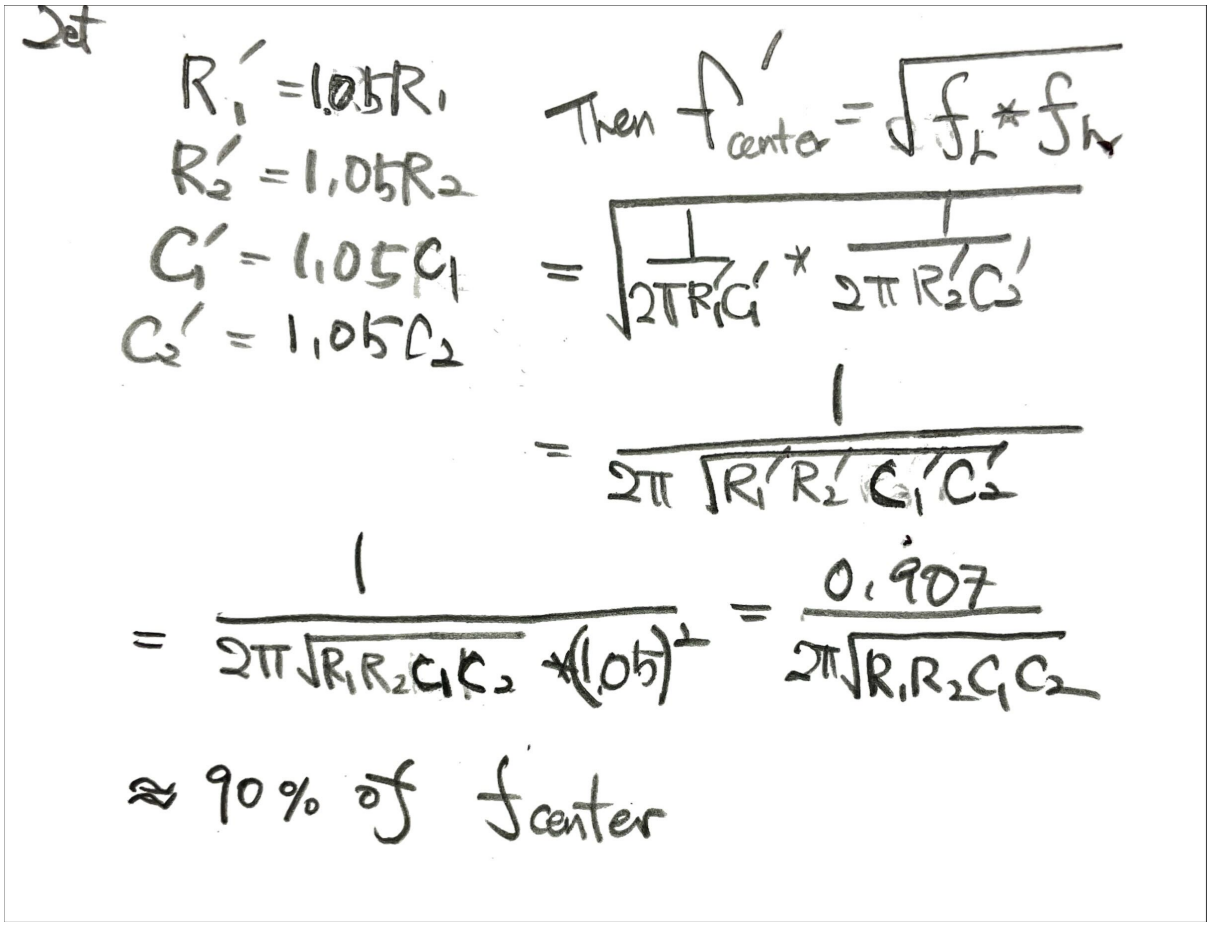
The f_{center} %Error 13.0% demonstrates that there is a significant difference between the theoretical value 156.5Hz and experimental value 136.3Hz.

Reflection

At first, we assumed the error would come from both approximation for H(s) and tolerance because the center frequency %Error was 13.0% which was substantial. However, when we calculated center angular frequency with original theoretical values($0.5w_2+w_1+\sqrt{(0.25w_2^2+w_1^2)}$, $0.5w2+w1-\sqrt{(0.25w_2^2+w_1^2)}$), it came out that the center frequencies were the same.



Then, we figured out that this factor would not influence our results. Then, we figured out that the center frequency only depends on R_1, R_2, C_1, C_2 ($f_{cente} = 1/(2\sqrt{(R_1R_2C_1C_2)}$). Therefore, the case for error would come out from the product of those four tolerances. For instance, if we have +5% off tolerance for R_1, R_2, C_1, C_2 components, then the actual frequency came out as –10% off from the theoretical frequency.



In conclusion, the observed center frequency shift results from only one factor, which is tolerance of circuit components because the frequency only depends on values of resistors and capacitors in the circuit.

Reference

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