ASSIGNMENT - 03

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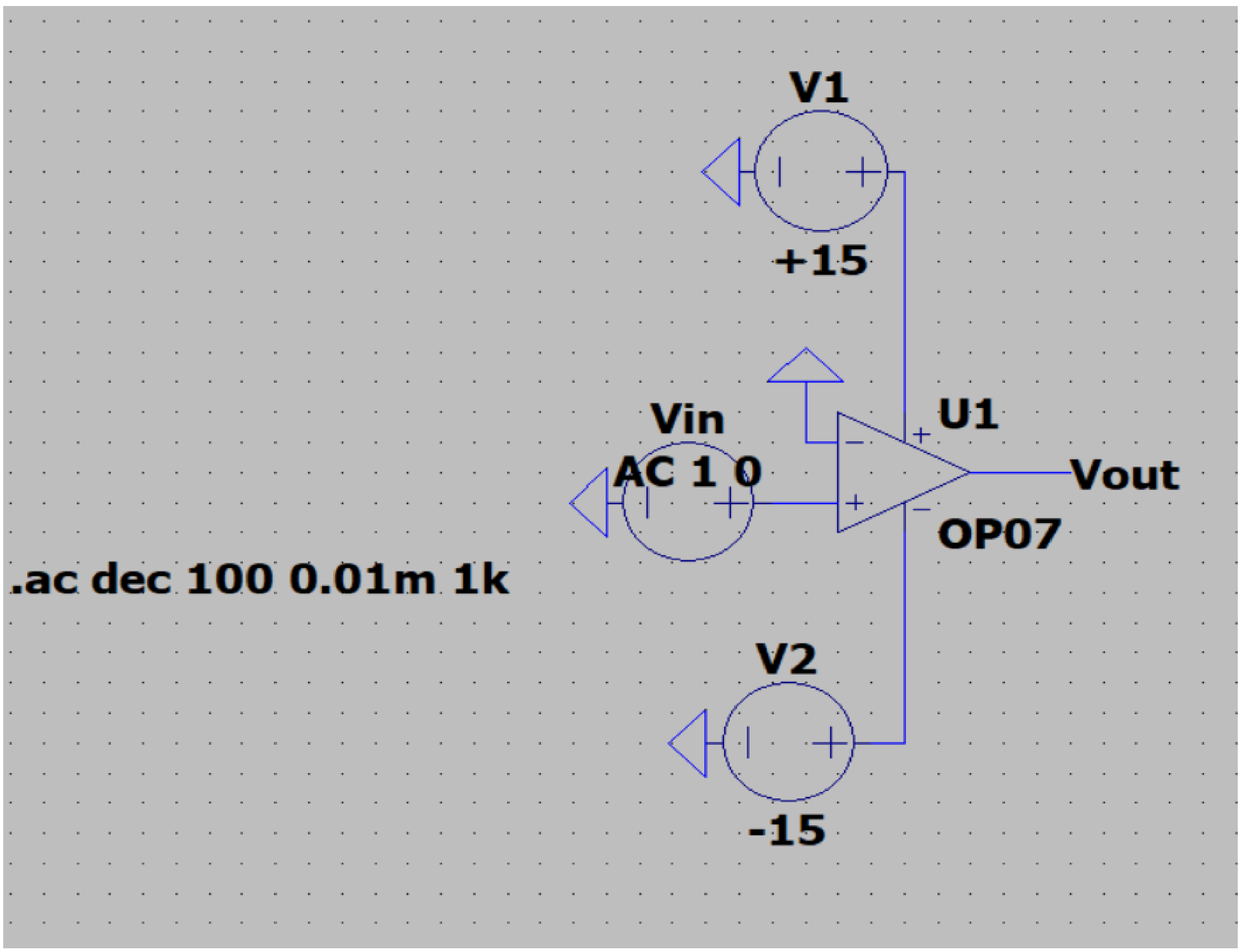
EE22BTECH11025

Question (1a)

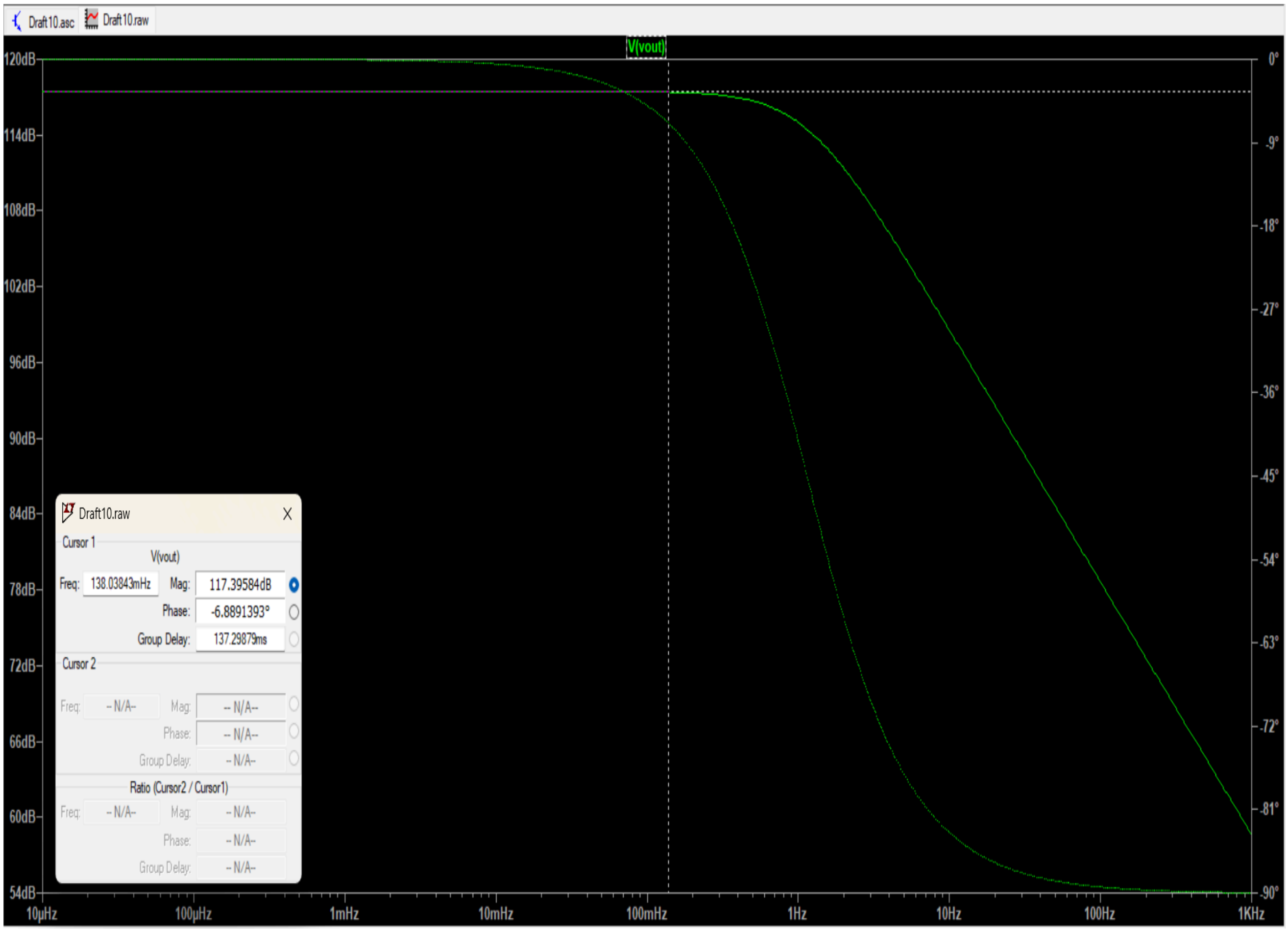
Find the open-loop gain of the amplifier and -3dB bandwidth by plotting its frequency response.

Solution (1a) ;

I have used OP07 for the open-loop gain and -3dB frequency response.



Circuit configuration



Open-loop gain response

The open-loop gain is given as,

$$20log(A) = 117.395$$

$$A = 7.4 * 10^5$$

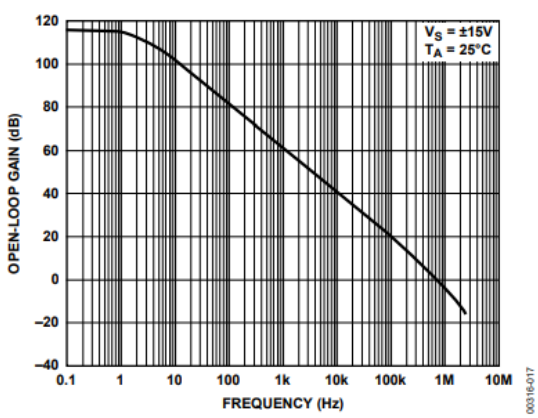
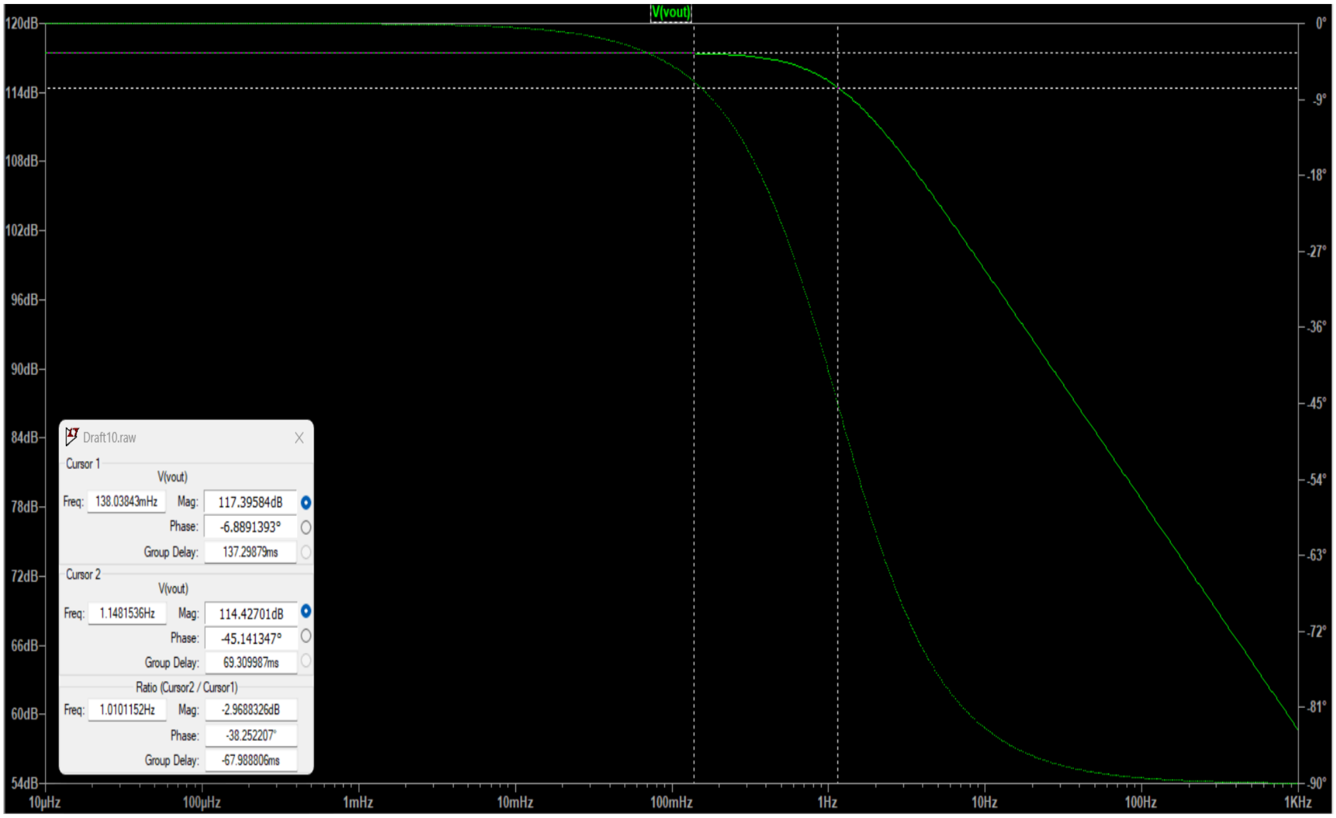


Figure 17. Open-Loop Frequency Response

This is same as the one given in the datasheet



-3dB bandwidth response

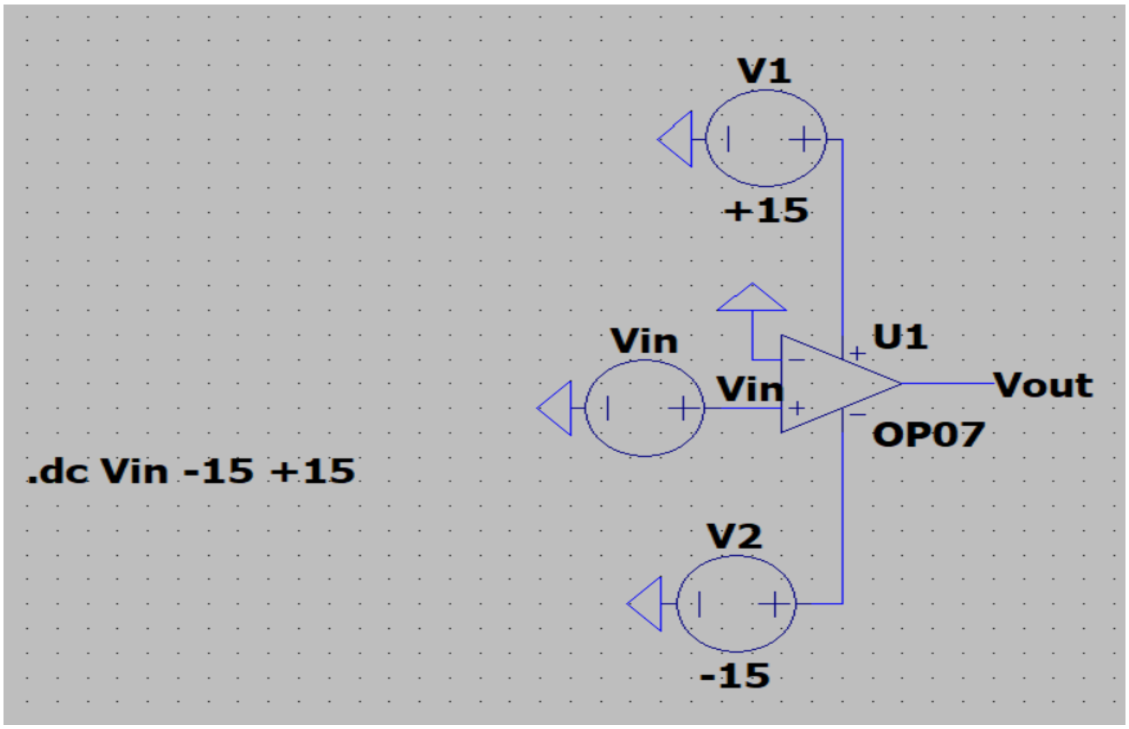
The -3db bandwidth is at 138.038mHZ

Question (1b)

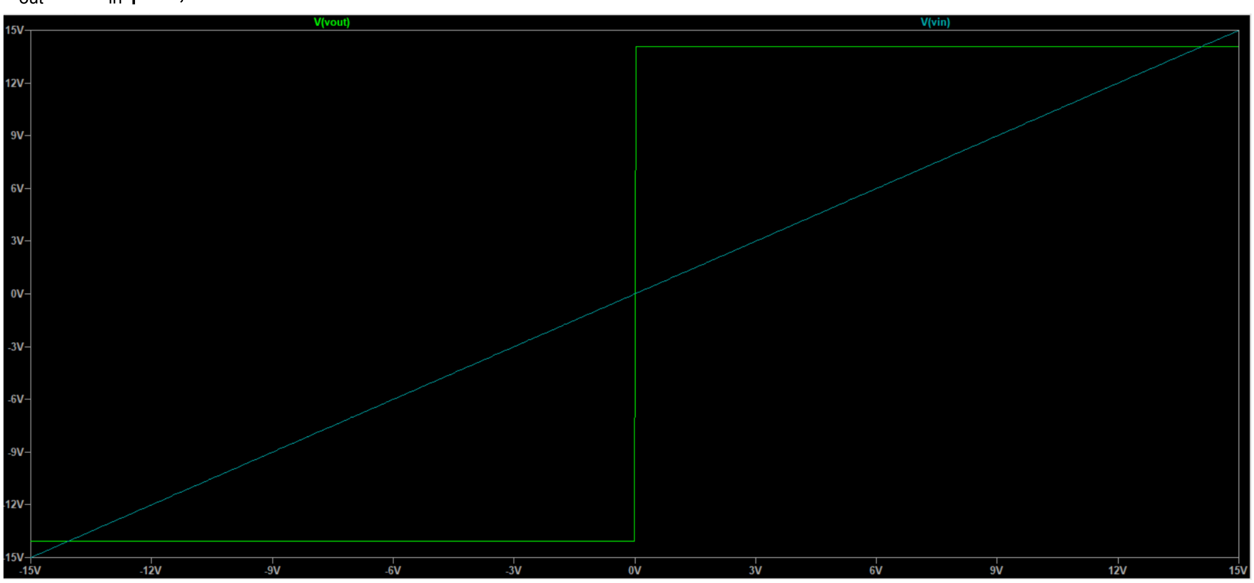
Find the input and output range of the omp in which it could be used as an amplifier without distrotion.

Solution (1b) ;

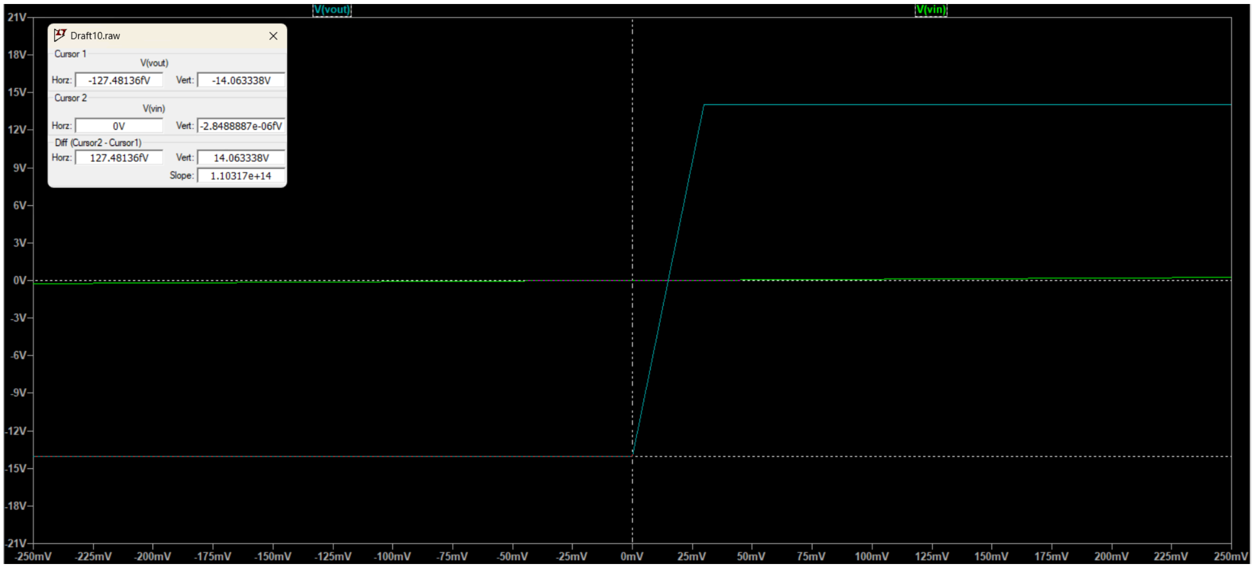
The circuit configuration



V_{out} vs V_{in} plot,



The lower range of V_{in} and V_{out} ;



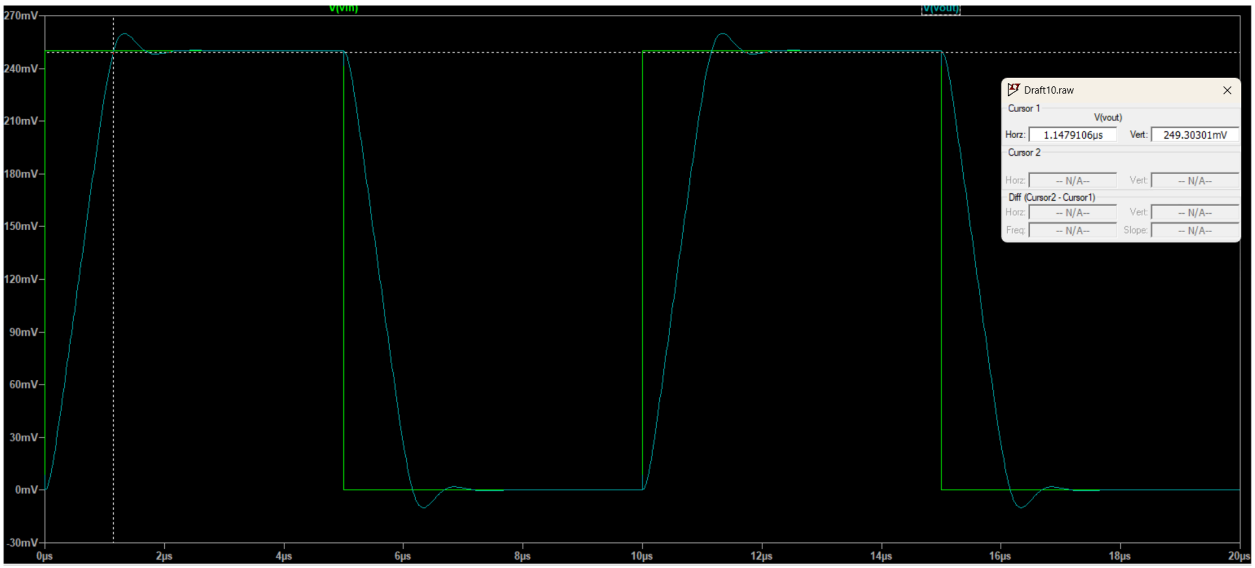
The Upper range of V_{in} and V_{out}

Thus, the range of V_{in} and V_{out} for which amplification has no distortion is [-2.84fV,29.99mV] and [-14.06V,14.06V], respectively.

Question (1c)

Calculate the slew rate of the opamp.

Solution (1c) ;



The slew rate is given as

$$Sr = (\text{change in } V_{out}) / (\text{Time interval}) ;$$
$$Sr = 249.4mV / 1.14us = 0.23$$

OP07 Data Sheet

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
DYNAMIC PERFORMANCE						
$T_A = 25°C$						
Slew Rate	SR	$R_L \geq 2\ k\Omega^3$	0.1	0.3		V/µs
Closed-Loop Bandwidth	BW	$A_{VOL} = 1^5$	0.4	0.6		MHz
Open-Loop Output Resistance	R_O	$V_O = 0, I_O = 0$		60		Ω
Power Consumption	P_d	$V_S = \pm 15$ V, No load		75	120	mW
		$V_S = \pm 3$ V, No load		4	6	mW
Offset Adjustment Range		$R_P = 20\ k\Omega$		±4		mV

We again see that our simulated value for slew rate matches with the one given in the datasheet.

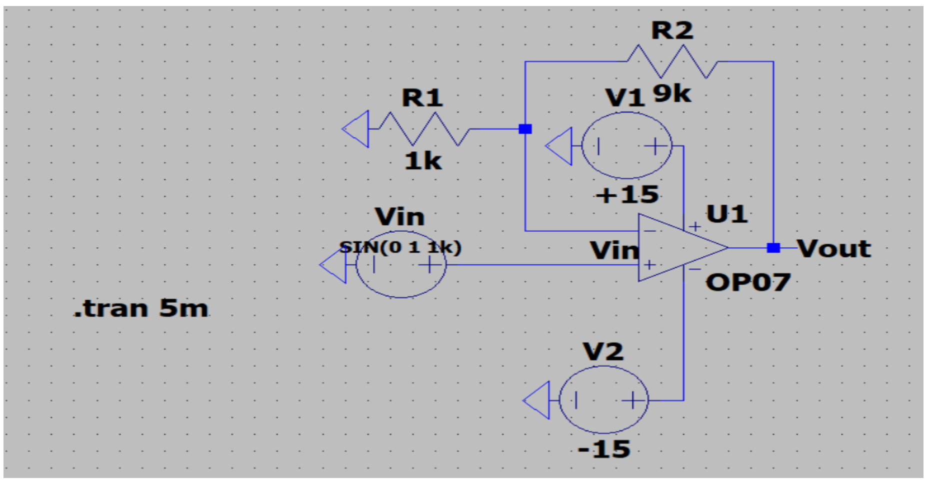
Question (1d,1e) ;

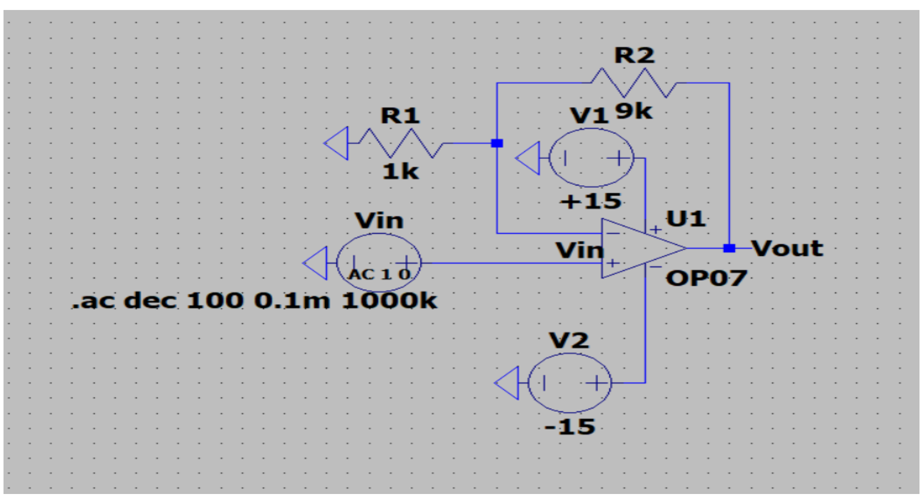
Configure the opamp in negative feedback with to achieve the voltage gain of 10 and -10.

Plot the frequency response of the systems designed in previous part and find the new -3dB BW.

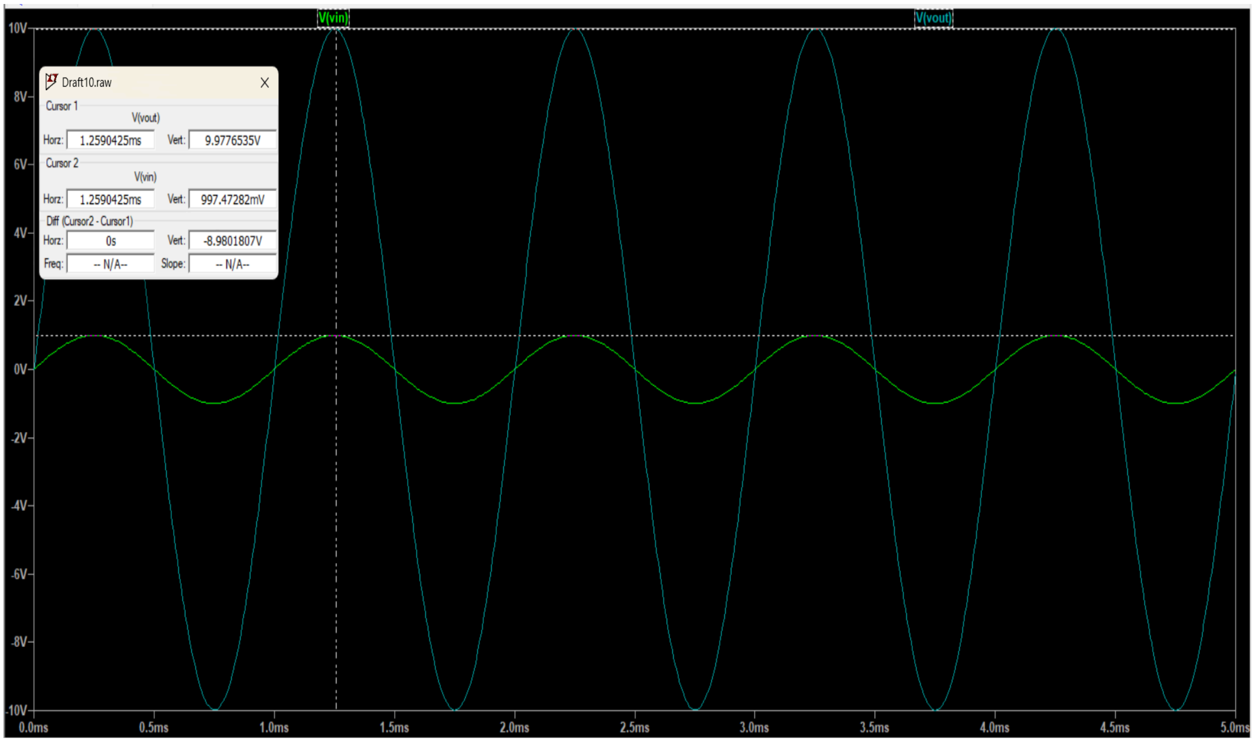
Solution (1d,1e) ;

For +10 gain,





The circuit used for simulations



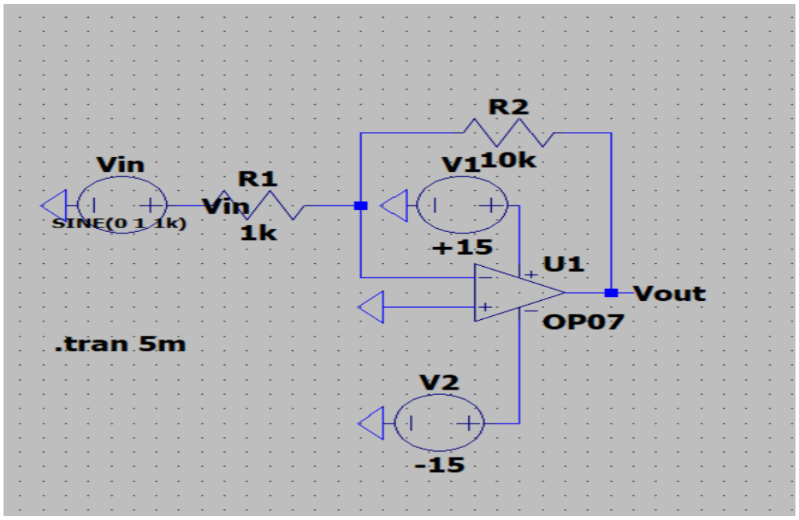
The gain is almost equal to the +10;

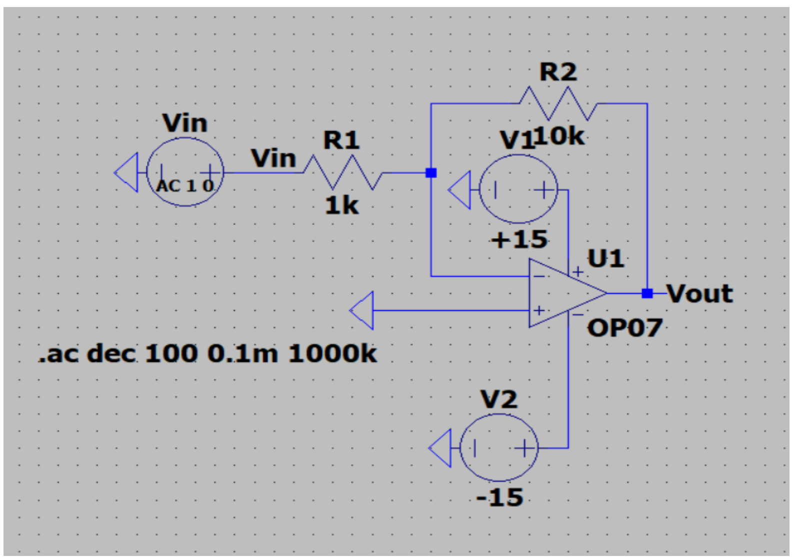
Thus, we have verified that voltage gain is equal to A = (1 + R2/R1)

Now for the -3dB bandwidth frequency response,

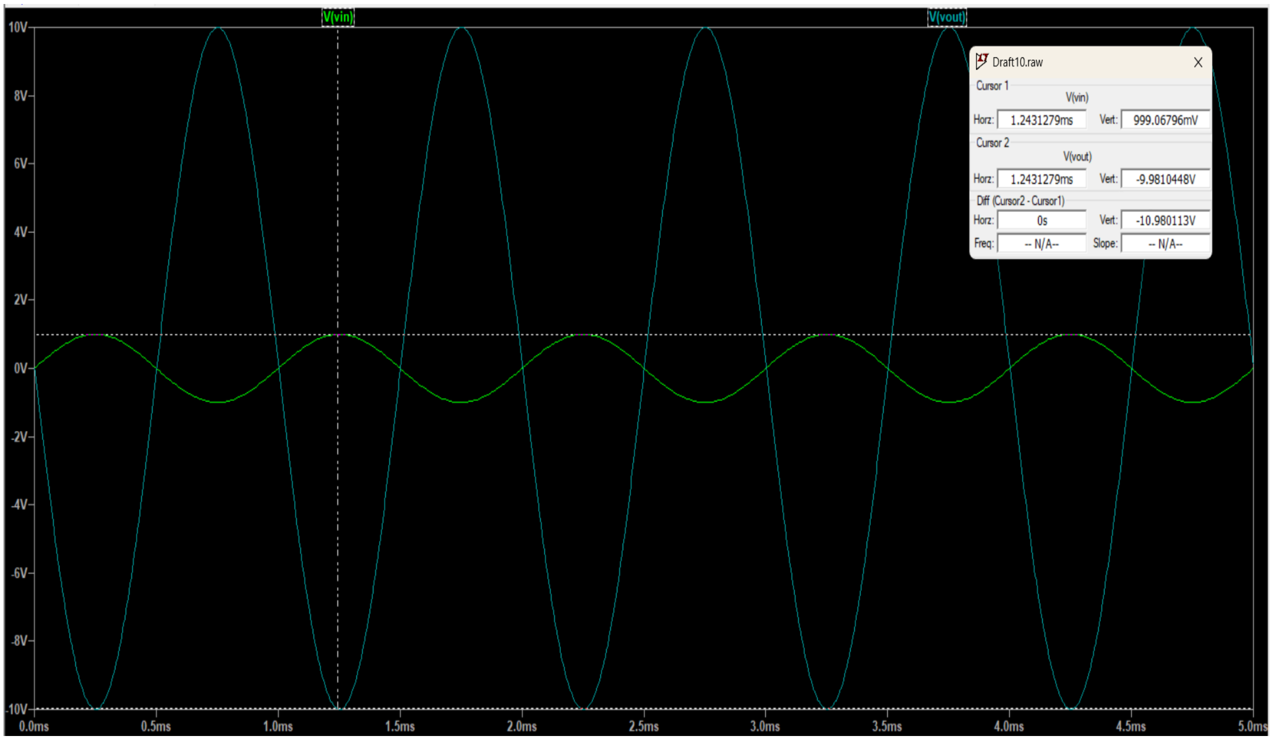
The new -3dB frequency is 88.38KHz

For -10 gain ;





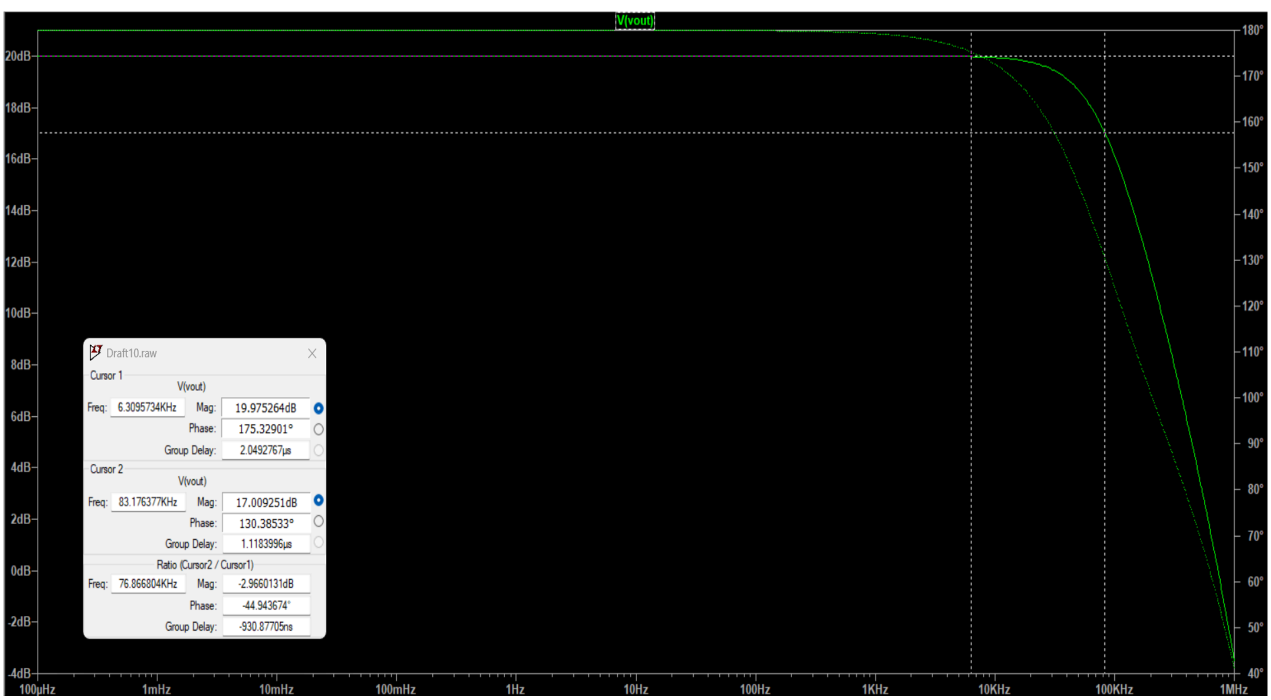
The circuit used for simulation



The gain is almost equal to the -10;

Thus, we have verified that voltage gain is equal to A = (- R2/R1)

Now for the -3dB bandwidth frequency response,



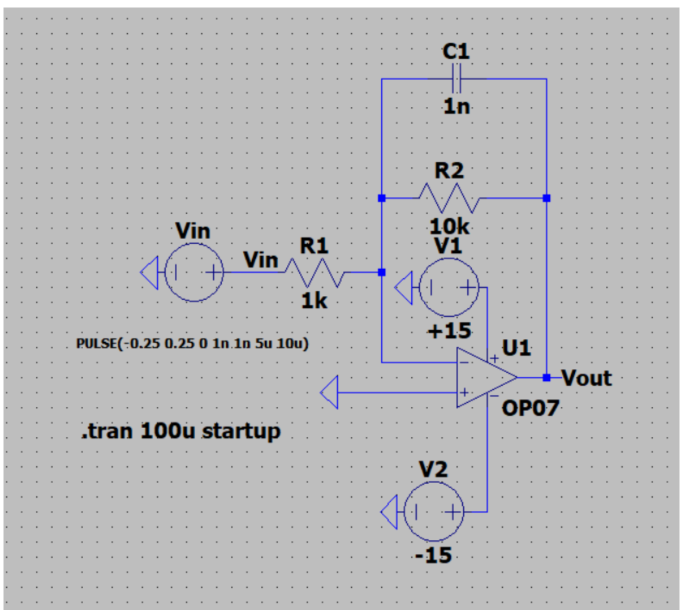
The new -3dB bandwidth frequency is 76.866 KHz

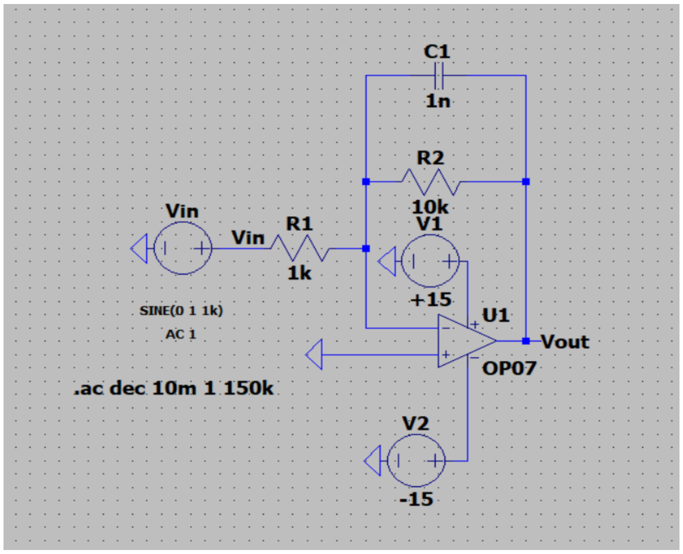
Question (1f) ;

Design a practical integrator using the same opamp, used in the part a, for input signals with frequency ranging from 10 kHz to UGB frequency of the system. Plot the frequency response of the integrator. Please mind that for a practical integrator, the minimum frequency of the input signal must be at least 10 times than the cut-off frequency of the system. Choose the passive components wisely to achieve the proper response. Apply a square waveform to this integrator with a time period of 10 us and demonstrate the working of the integrator.

Solution (1f) ;

The circuit configuration used ,



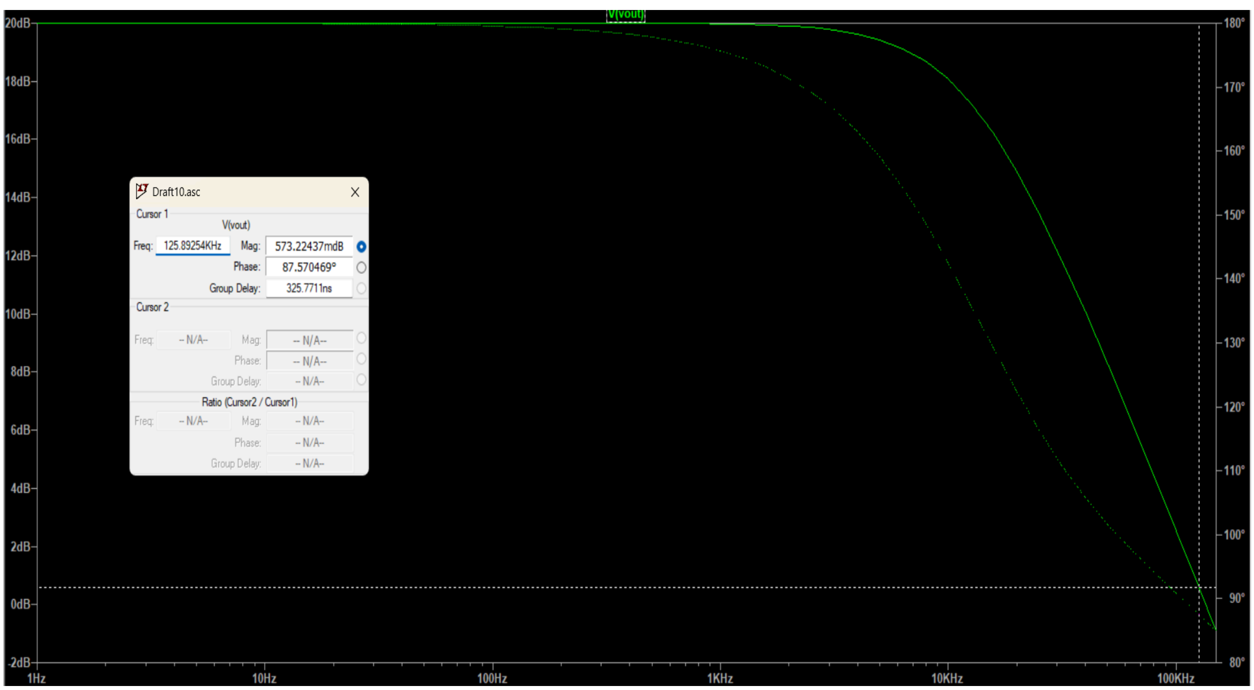


Calculations:

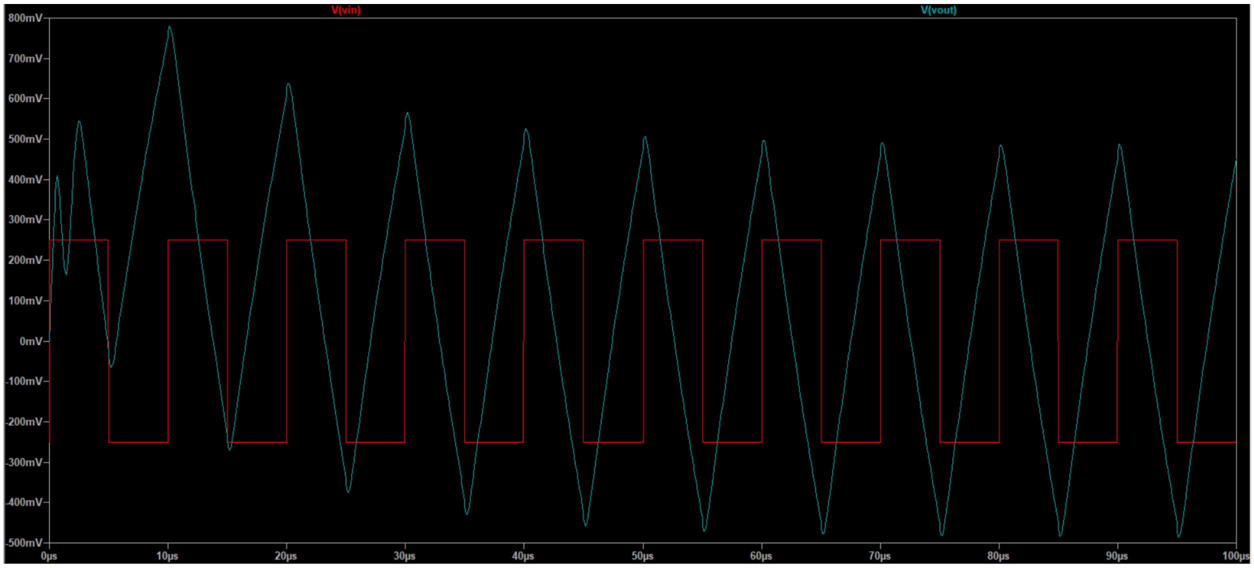
$F_a = \frac{1}{2\pi R2C1}$ and $F_b = \frac{1}{2\pi R1C1}$

R1 = 1k , R2 = 10k C1 = 1n

F_a = 12kHz and F_b = 125kHz



This is frequency response of the integrator.



The time response of the integrator.

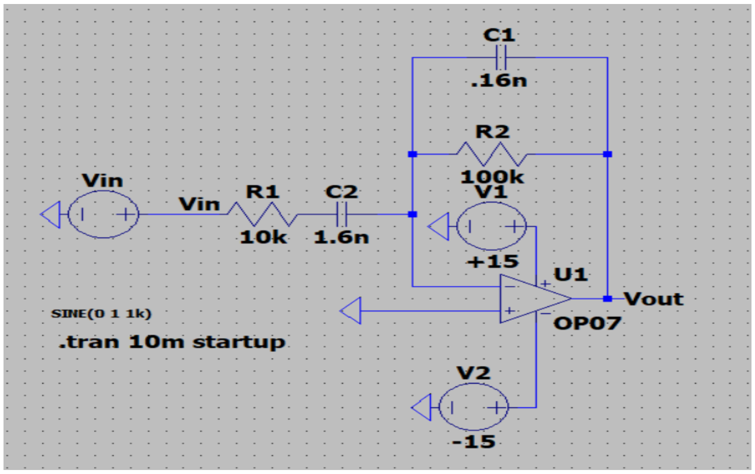
Due to transient effect, there is some instability in the system initially,
We see that for a square wave, a triangular wave is obtained for steady state

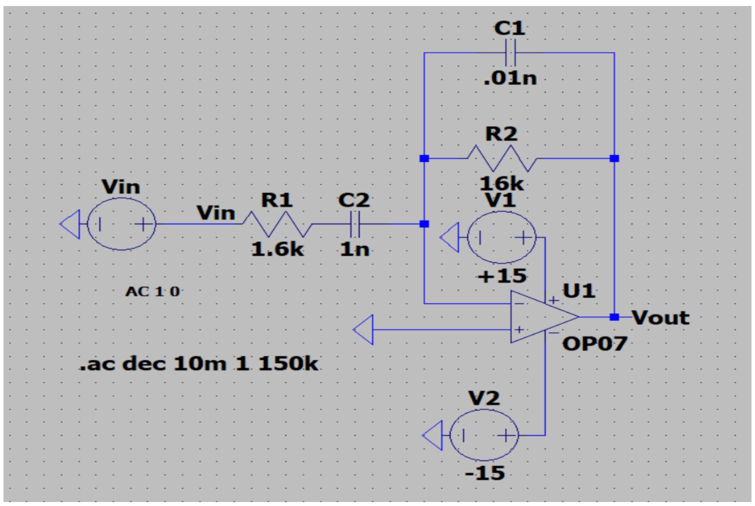
Question (1g)

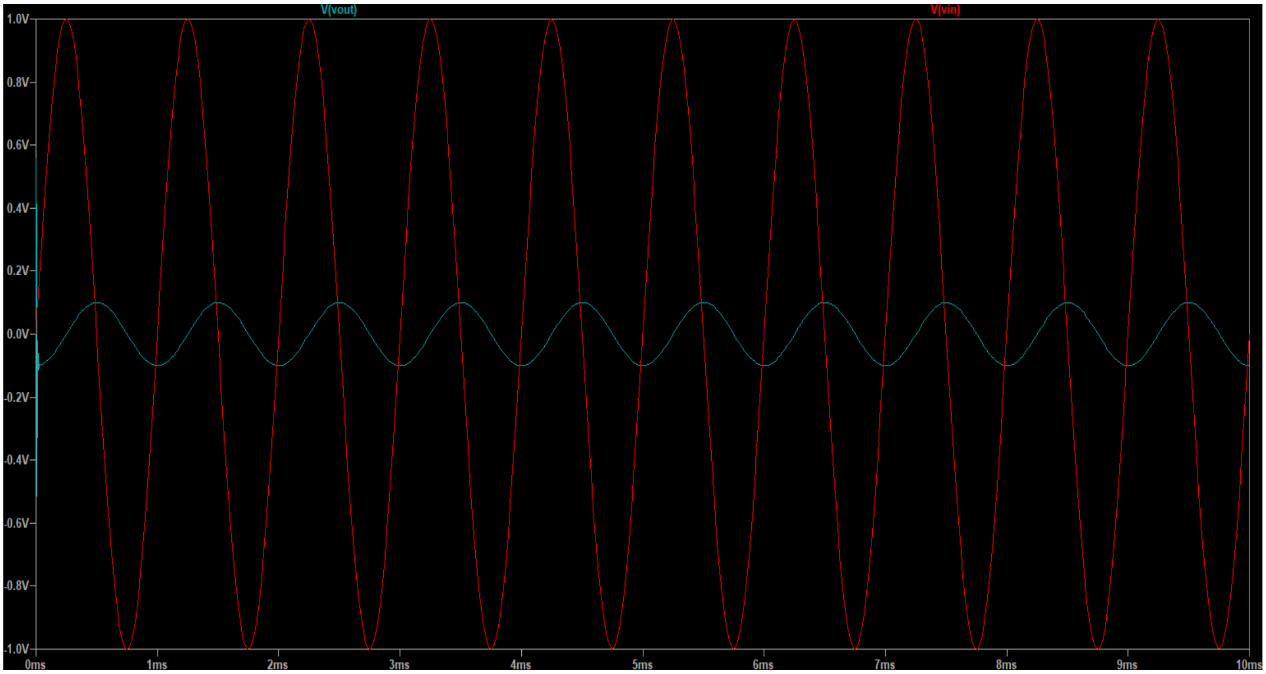
Design a practical differentiator using the same opamp, used in the part a, for input signals with frequency ranging from DC to 10 kHz. To realized the system, keep a series resistor with the forward capacitor and keep a capacitor in parallel with feedback resistor. Please mind that for a practical differentiator, the maximum frequency of the input signal must be at least 10 times lesser than the cut-off frequency of the system. Choose the passive components wisely to achieve the proper response. Plot the frequency response of the differentiator. Apply a sinusoidal waveform of 1 kHz to this system and demonstrate the working of the differentiator.

Solution (1g) ;

The circuit used


C1
.16n
R2
100k
Vin
Vin
R1
C2
V1
10k
1.6n
+15
U1
Vout
SINE(0 1 1k)
OP07
.tran 10m startup
V2
-15

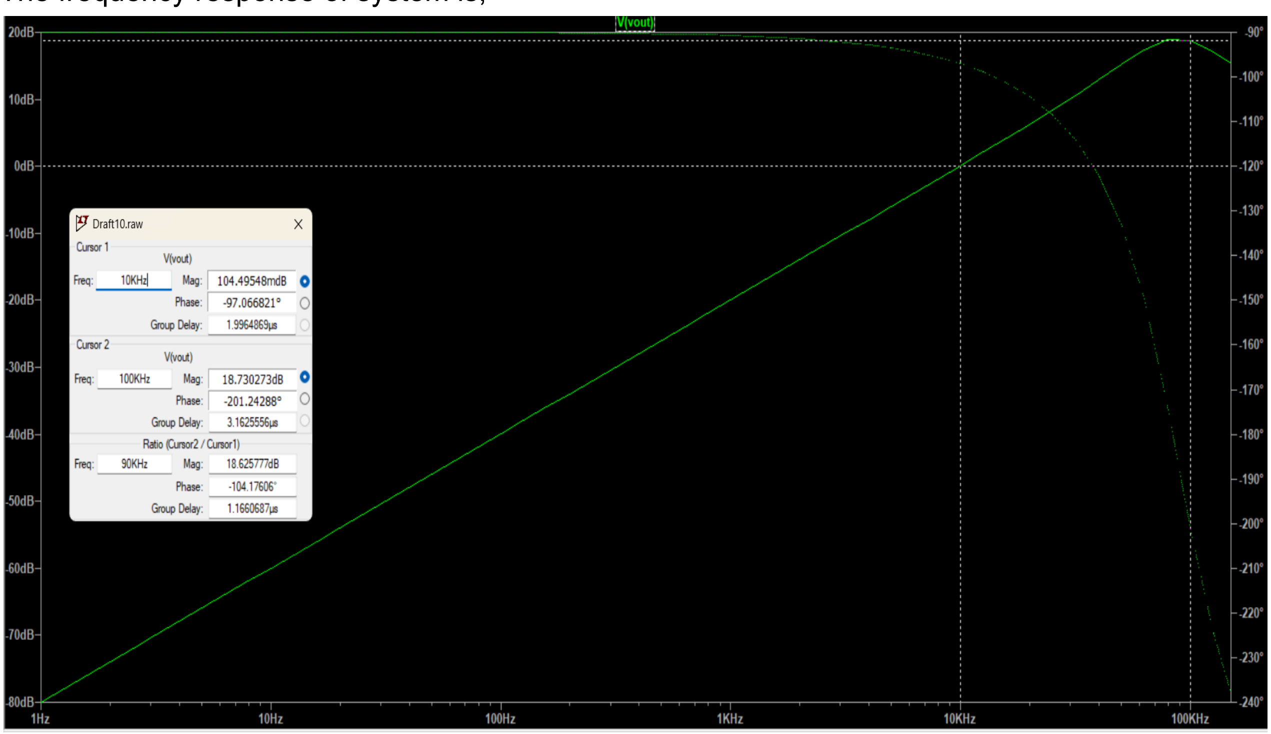

C1
.01n
R2
16k
Vin
Vin
R1
C2
V1
1.6k
1n
+15
U1
AC 1 0
Vout
OP07
.ac dec 10m 1 150k
V2
-15



Again we see due to the transient effect, there is some instability in the system initially.

For a sine wave , a shifted cos wave is obtained in the differentiator.

The frequency response of system is,



The value of R and C are again decided the same way as done in Question (1f).

Reference :--
https://www.analog.com/media/en/technical-documentation/data-sheets/op07.pdf