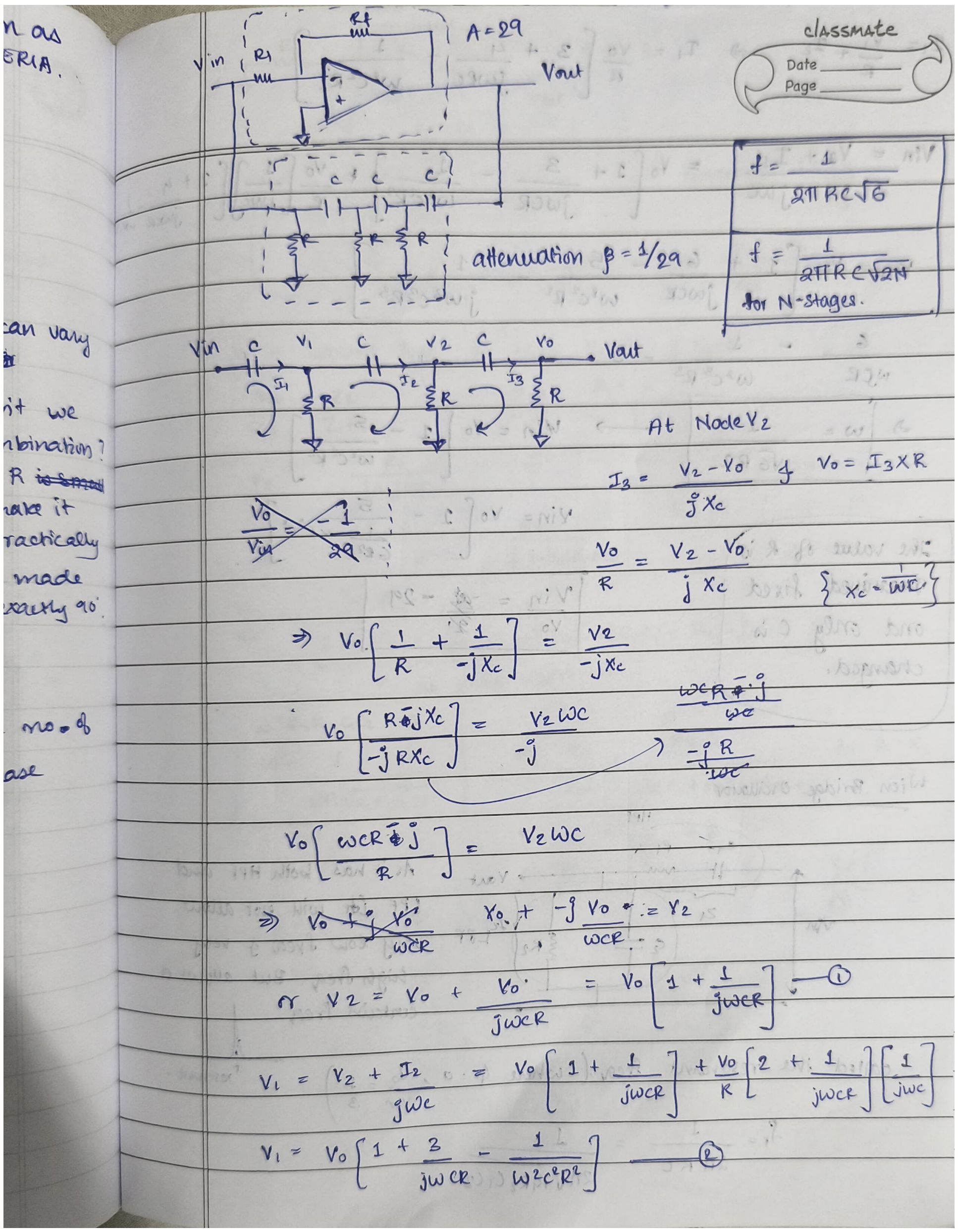
Analog Assignment 4

BY EE23BTECH11044 - Nimal Sreekumar

1) A RC phase shift oscillator (3 stage) for 50 kHz sin wave signal output.

ANSWER :



$A = 29$

V_{in}, R_1, R_f, V_{out}

attenuation $\beta = 1/29$

$$f = \frac{1}{2\pi RC\sqrt{6}}$$

$$f = \frac{1}{2\pi RC\sqrt{2N}}$$ for N-stages.

V_{in}, C, V_1, C, V_2, C, V_0, V_{out}, I_1, I_2, I_3, R

~~$\frac{V_0}{V_{in}} = \frac{-1}{29}$~~

At Node V_2

$$I_3 = \frac{V_2 - V_0}{jX_c} \quad \& \quad V_0 = I_3 \times R$$

$$\frac{V_0}{R} = \frac{V_2 - V_0}{jX_c} \qquad \left\{ X_c = \frac{1}{\omega C} \right\}$$

$$\Rightarrow V_0 \left[\frac{1}{R} + \frac{1}{-jX_c} \right] = \frac{V_2}{-jX_c}$$

$$V_0 \left[\frac{R - jX_c}{-jRX_c} \right] = \frac{V_2 \omega C}{-j}$$

$$\frac{\frac{\omega CR - j}{\omega C}}{\frac{-jR}{\omega C}}$$

$$V_0 \left[\frac{\omega CR - j}{R} \right] = V_2 \omega C$$

$$\Rightarrow \cancel{V_0 + \frac{V_0}{\omega CR}} \qquad V_0 + \frac{-jV_0}{\omega CR} = V_2$$

$$\text{or } V_2 = V_0 + \frac{V_0}{j\omega CR} = V_0 \left[1 + \frac{1}{j\omega CR} \right] \quad \text{— (1)}$$

$$V_1 = V_2 + \frac{I_2}{j\omega C} = V_0 \left[1 + \frac{1}{j\omega CR} \right] + \frac{V_0}{R} \left[2 + \frac{1}{j\omega CR} \right] \left[\frac{1}{j\omega C} \right]$$

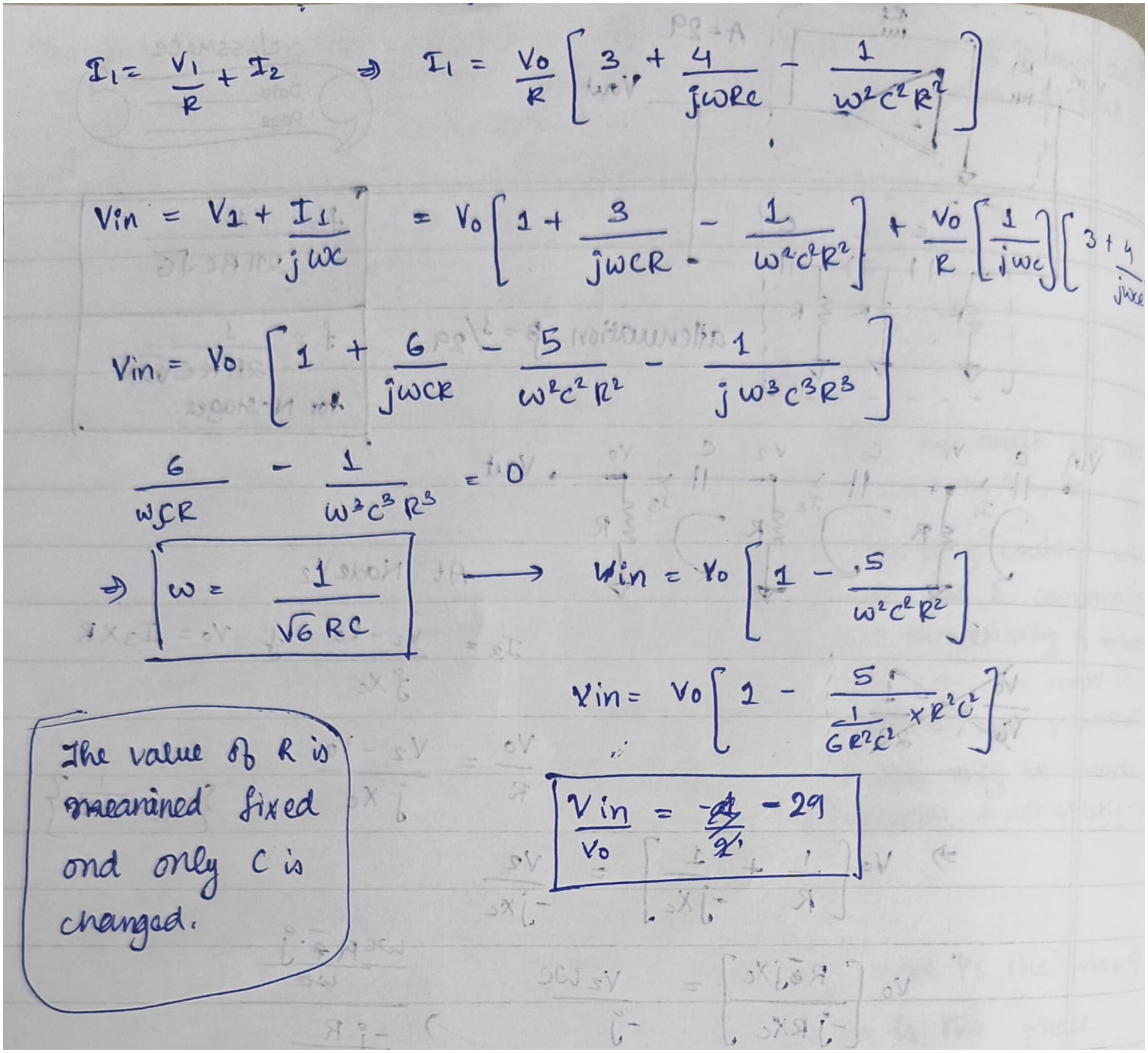
$$V_1 = V_0 \left[1 + \frac{3}{j\omega CR} - \frac{1}{\omega^2 C^2 R^2} \right] \quad \text{— (2)}$$

can vary

it we
combination?
R ~~is small~~
make it
practically
made
exactly 90°.

no. of

ase



$$I_1 = \frac{V_1}{R} + I_2 \Rightarrow I_1 = \frac{V_0}{R}\left[3 + \frac{4}{j\omega RC} - \frac{1}{\omega^2 C^2 R^2}\right]$$

$$V_{in} = V_1 + \frac{I_1}{j\omega C} = V_0\left[1 + \frac{3}{j\omega CR} - \frac{1}{\omega^2 C^2 R^2}\right] + \frac{V_0}{R}\left[\frac{1}{j\omega C}\right]\left[3 + \frac{4}{j\omega C\ldots}\right.$$

$$V_{in} = V_0\left[1 + \frac{6}{j\omega CR} - \frac{5}{\omega^2 c^2 R^2} - \frac{1}{j\omega^3 c^3 R^3}\right]$$

$$\frac{6}{\omega CR} - \frac{1}{\omega^3 C^3 R^3} = 0$$

$$\Rightarrow \boxed{\omega = \frac{1}{\sqrt{6} RC}} \longrightarrow V_{in} = V_0\left[1 - \frac{5}{\omega^2 C^2 R^2}\right]$$

$$V_{in} = V_0\left[1 - \frac{5}{\frac{1}{6R^2C^2} \times R^2 C^2}\right]$$

$$\boxed{\frac{V_{in}}{V_0} = -29}$$

The value of R is maintained fixed and only C is changed.

From the basics of an RC phase shift oscillator, we have to make a sine wave of frequency 50KHz

$$f = \frac{1}{2\pi RC\sqrt{6}}$$

Assume a reasonable value for R (i.e., R4/R5/R2), lets take 1K. Therefore,

$$C = \frac{1}{2\pi \times 1 \times 10^3 \times \sqrt{6}}$$
$$C = 1.3nF$$

Now for getting a gain A =29

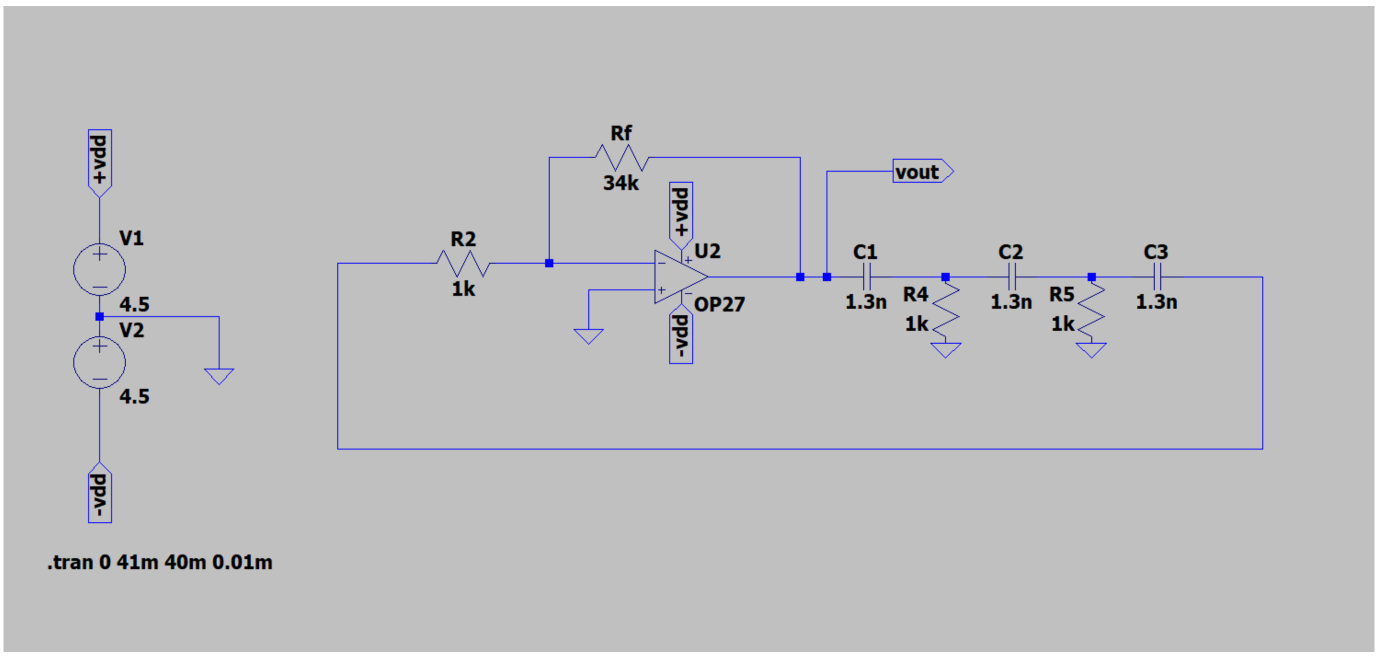
$$\frac{R_f}{R_2} = 29$$

$$R_f = 29k$$

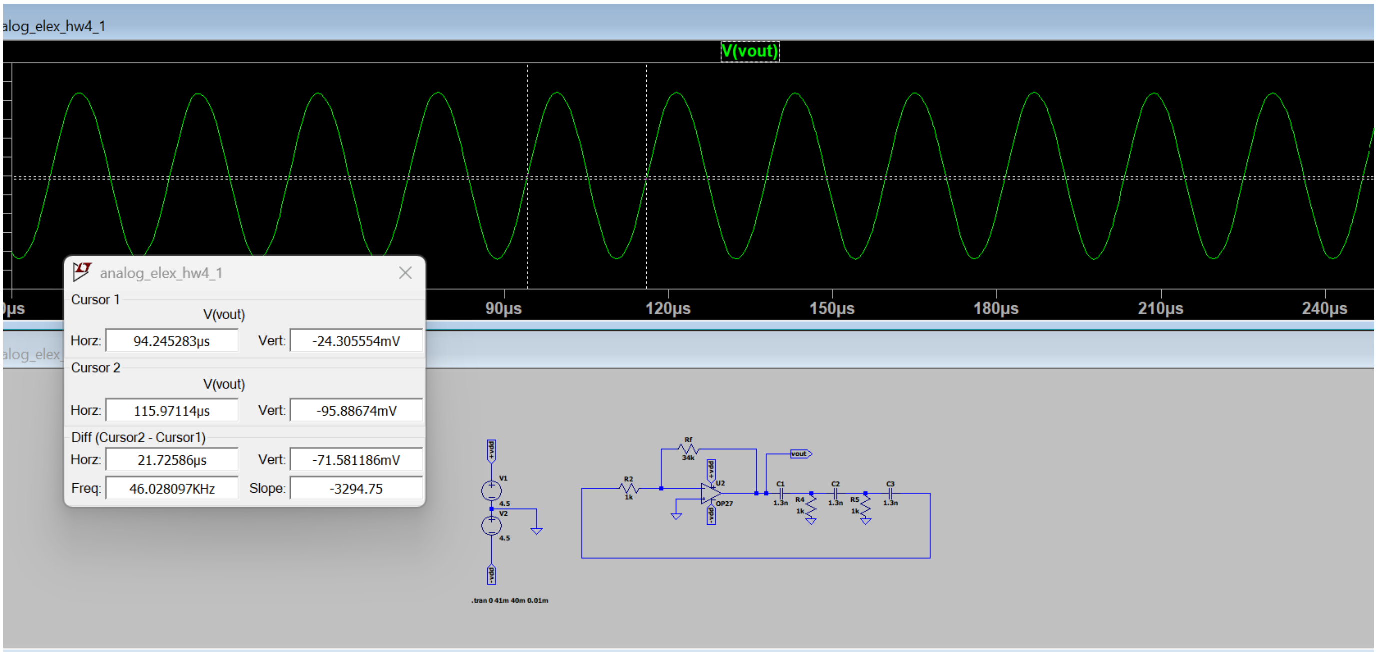
But instead, we take a value slightly higher than 29K so that we can reduce the noise components.

Circuit diagram:

From the output plot we can see that T (time period) = $21\mu s \implies f = 47KHz$.

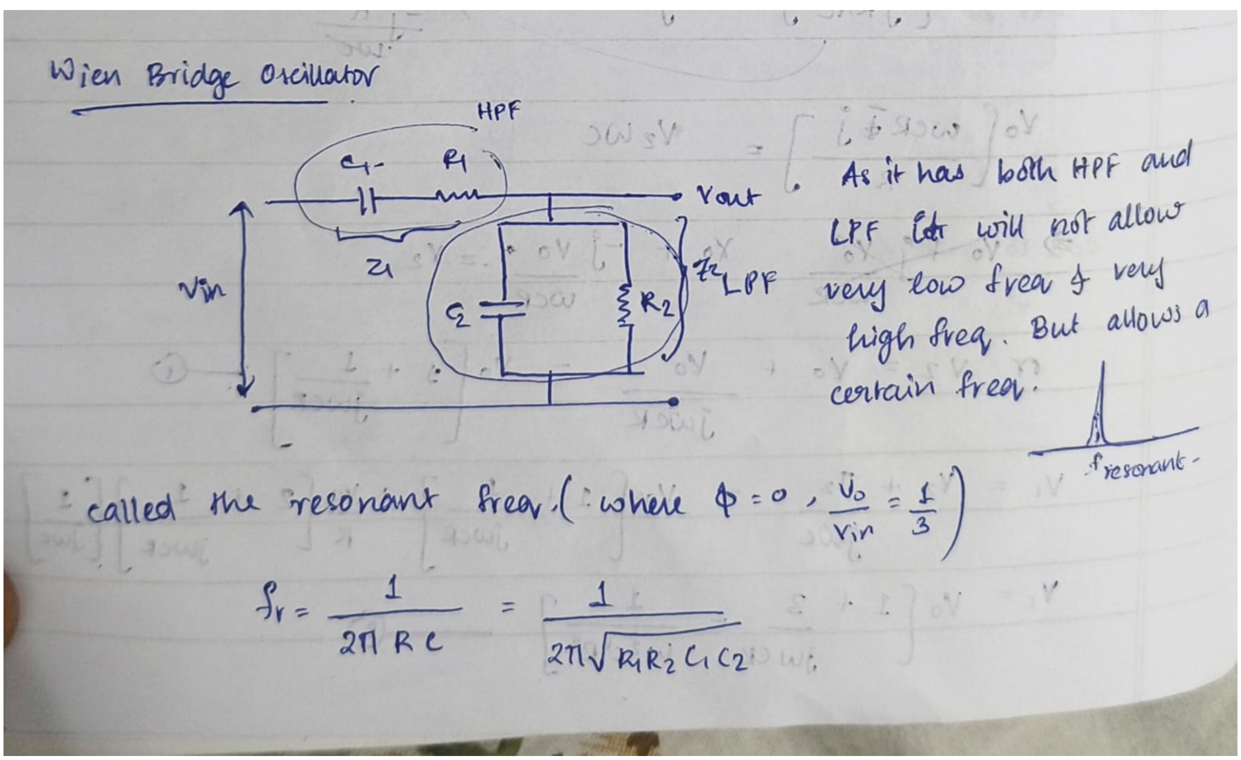


Plot of Vout:



2)A Wien bridge oscillator for 50 kHz sin wave signal output.

ANSWER :



Taking

$$f = \frac{1}{2\pi\ \sqrt{R3R3C1C2}}$$

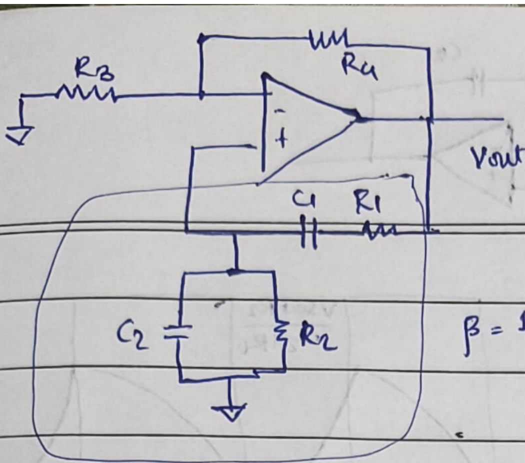
Taking R3= R4= 1k and C1 = C2 ,

$$C = \frac{1}{2\pi \times 1 \times 10^3 \times 50 \times 10^3}$$
$$C = 3.18nF$$

Now to obtain a gain A =3

$$1 + \frac{R_f}{R_2} = 3$$
$$R_f = 2k$$

But instead we take a value slightly higher than 2K so that we can reduce the noise components.



$\Rightarrow A = 3$

where $A = 1 + \frac{R_4}{R_3}$

$\beta = 1/3$

$\frac{R_4}{R_3} = 2$

for a wanted freq. fr take $R_1 = R_2$ & $C_1 = C_2$.

$$\frac{V_o}{V_{in}} = \frac{Z_2}{Z_1 + Z_2} \qquad Z_1 = R_1 + \frac{1}{j\omega C_1}$$

$$\frac{V_o}{V_{in}} = \frac{\frac{R_2}{1 + j\omega R_2 C_2}}{R_1 + \frac{1}{j\omega C_1} + \frac{R_2}{1 + j\omega C_2 R_2}} = \frac{R_2 (j\omega C_1)}{R_1 (j\omega C_1)(1 + j\omega C_2 R_2) + 1 + j\omega C_2 R_2 + j\omega R_2 C_1}$$

$$\frac{V_o}{V_{in}} = \frac{j\omega R_2 C_1}{\underbrace{1 - \omega^2 R_1 R_2 C_1 C_2}_{0} + j\omega (R_1 C_1 + R_2 C_2 + R_2 C_1)}$$

as phase shift = 0

$\omega^2 R_1 R_2 C_1 C_2 = 0$

$$\boxed{\omega = \frac{1}{2\pi \sqrt{R_1 R_2 C_2 C_1}}}$$

$$\Rightarrow \frac{V_o}{V_{in}} = \frac{R_2 C_1}{R_1 C_1 + R_2 C_2 + R_2 C_1} \quad \text{for } R_1 = R_2,\ C_1 = C_2$$

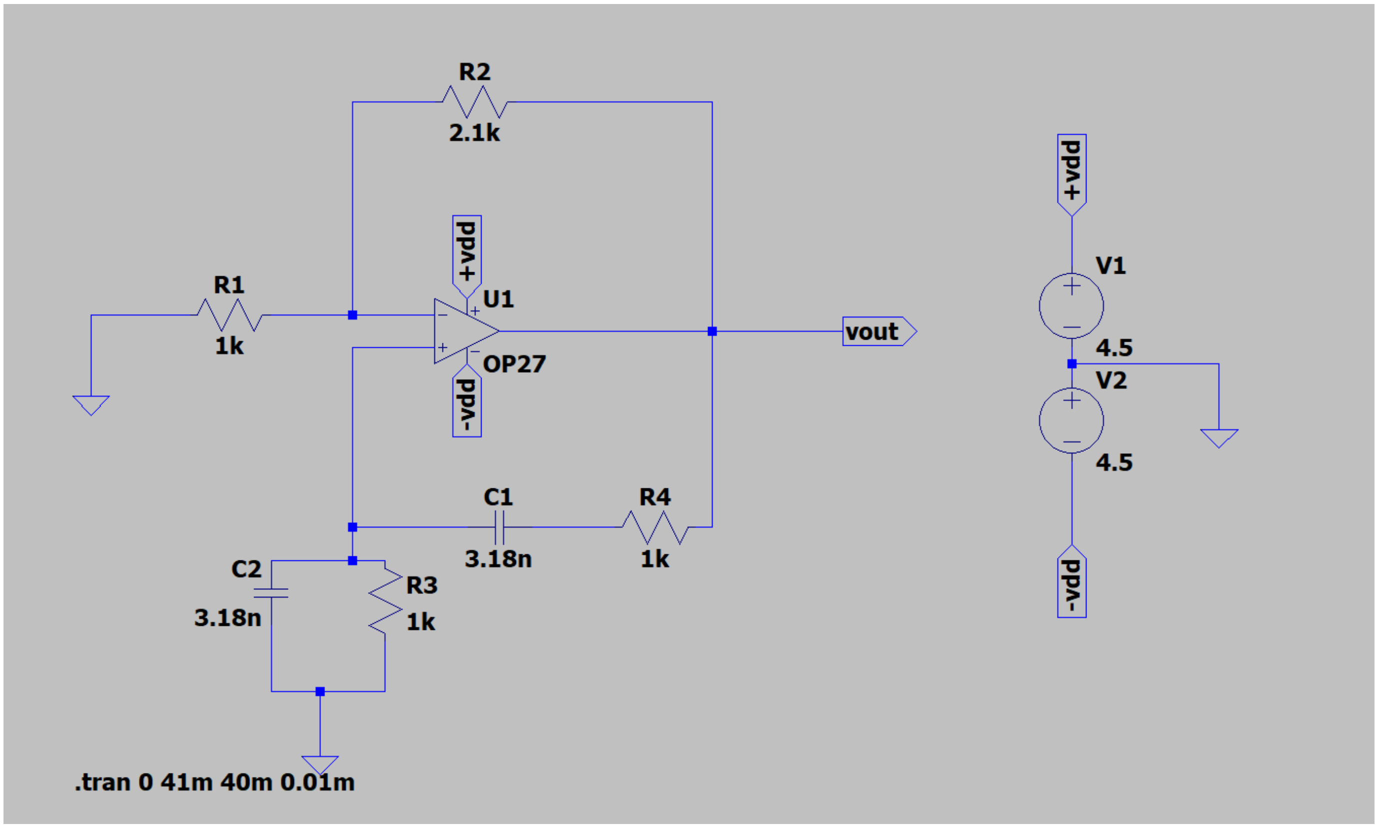
$$\frac{V_o}{V_{in}} = \boxed{\frac{1}{3} = \beta}$$

$A\beta = 1 \Rightarrow \boxed{A = 3}$

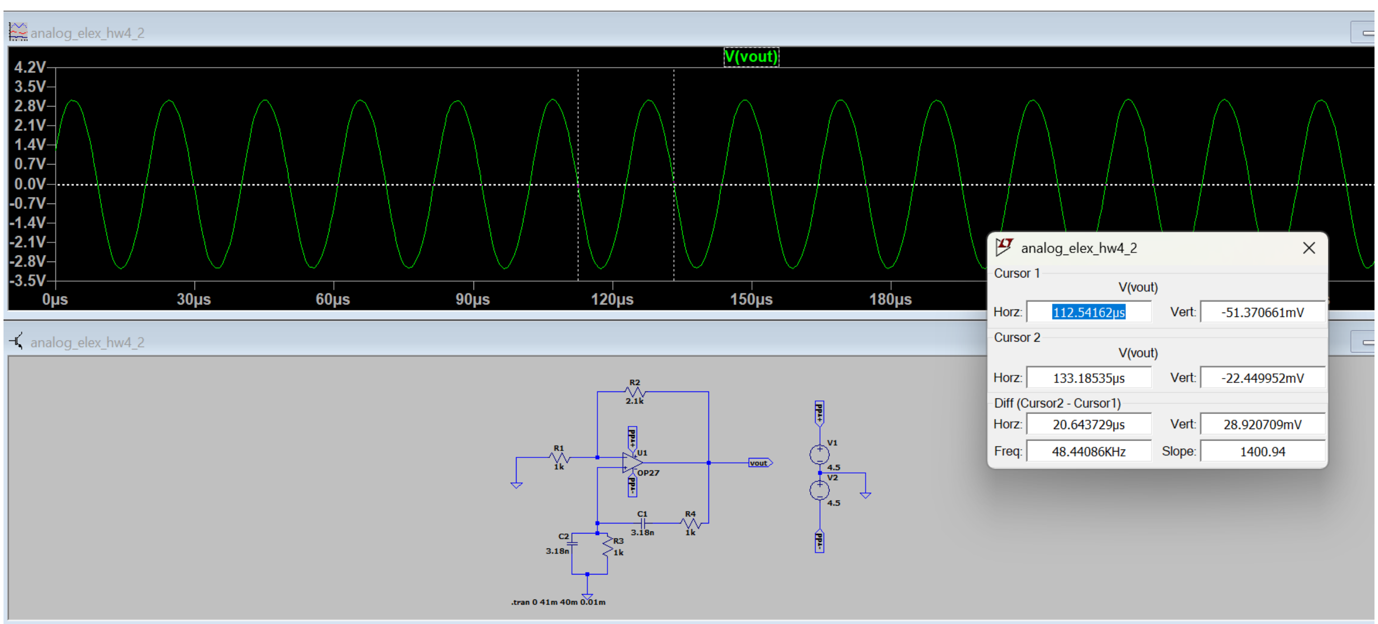
$RC = \frac{1}{2\pi\, 50k}$

$C = \frac{1}{2\pi\, 50 \times 10^{3}}$

$\approx 3.18\, n$



Plot of vout:



3)A Square wave generator for a fundamental frequency of 10 kHz signal output. Use an integrator and convert the square wave signal into a triangular wave.

ANSWER :

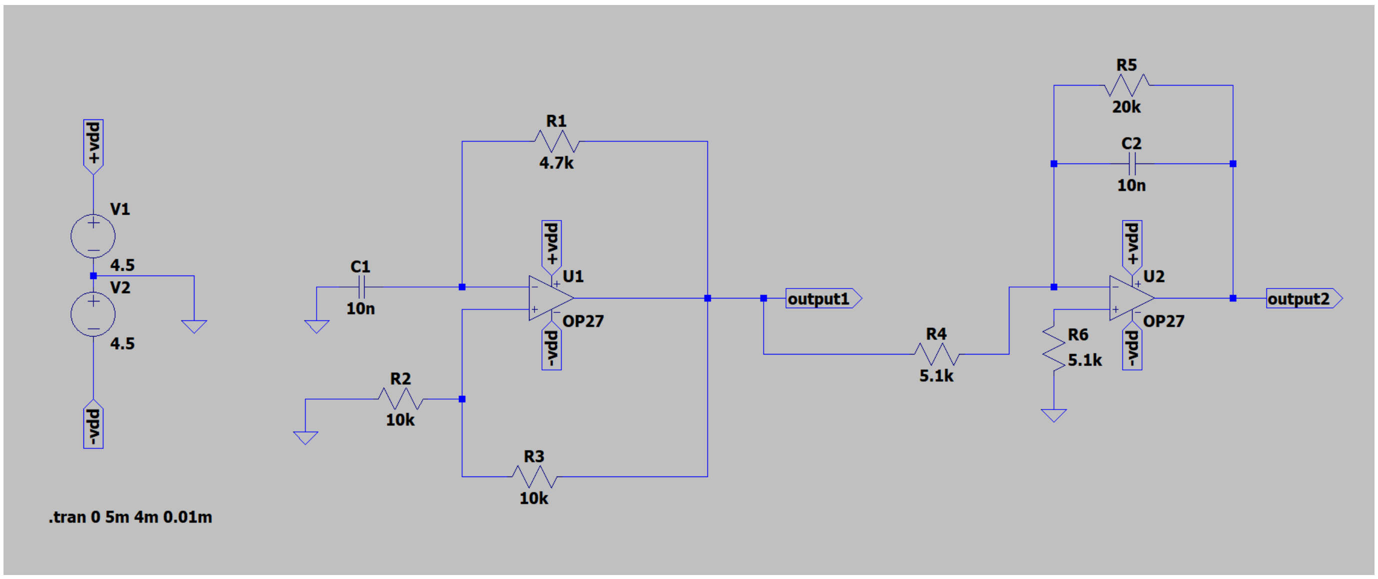
It uses the concepts of the Schmitt trigger. Calculating the time period,

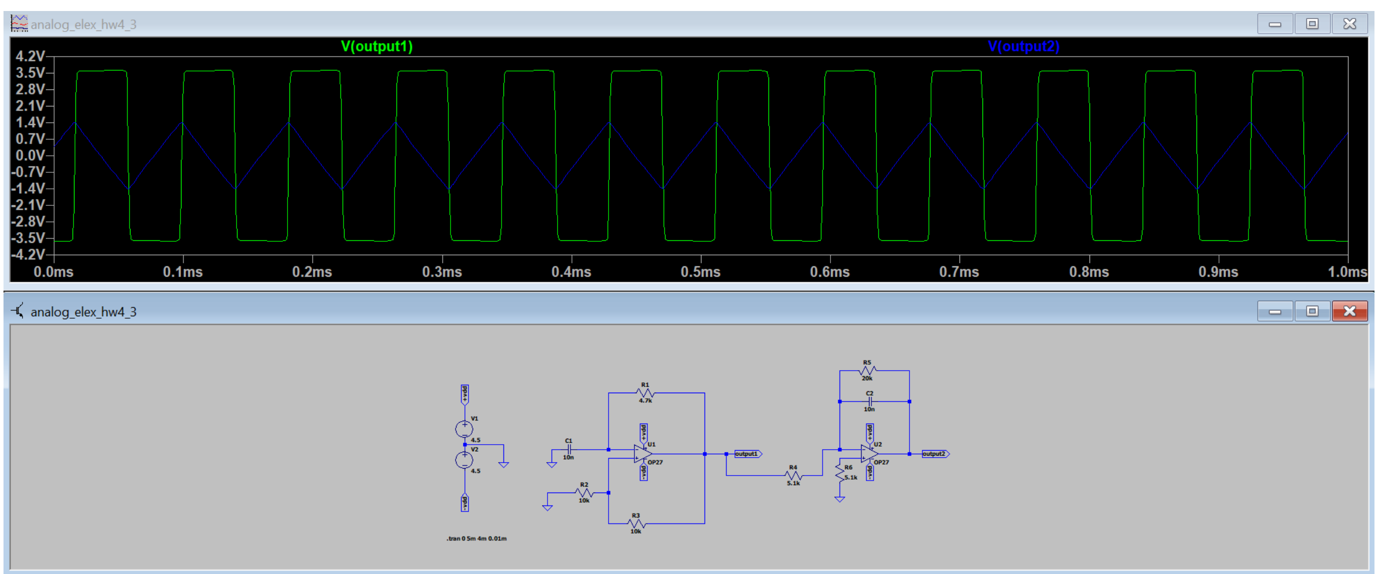
$$T = 2R1C1\ln(\frac{2R2+R3}{R3})$$

take R2 = R3 = 1k and C1 as 10nF,

$$0.1m = 2R1 \times 10 \times 10^{-9}\log(3)$$

$$R1 = 4.7k$$





4)A Square wave generator for a fundamental frequency of 10 kHz signal output. Use an integrator and convert the square wave signal a sawtooth wave with rise time = 1/2 fall time.

ANSWER :

at tripping point

$$V_{sat}R2 = -VoR3$$

–(1)

applying KCL at the node where R1 is situated,

$$\frac{V_{sat} - Vin}{R1} = -\frac{C1d(Vo - Vin)}{dt}$$

$$Vo = -\frac{Vsat - Vin}{CR1}$$

substituting (1)

$$t = \frac{Vsat \times R1R2C1}{R3(Vsat - Vin)}$$

for Vsat = +Vsat the time is rising and when Vsat = -Vsat time was falling

$$\implies t_{rise} = 2\frac{Vsat \times R1R2C1}{R3(Vsat + Vin)}$$

$$\implies t_{fall} = 2\frac{Vsat \times R1R2C1}{R3(Vsat - Vin)}$$

Given rise = 1/2 fall

$$Vin = \frac{Vsat}{3}$$

Vsat is 4.5V $\implies$ Vin = 1.5V.

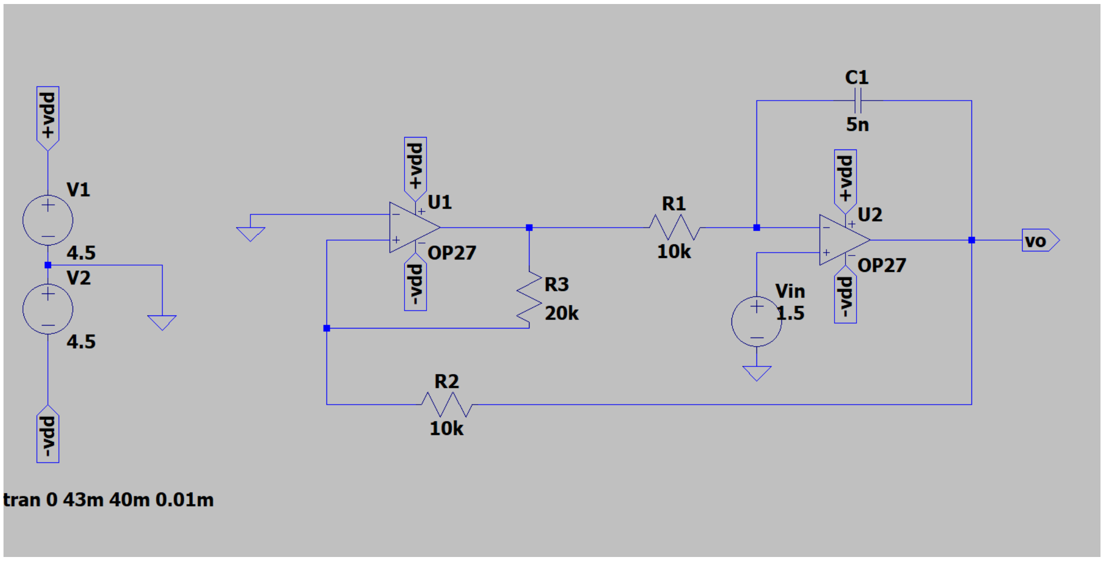
also, the total time period

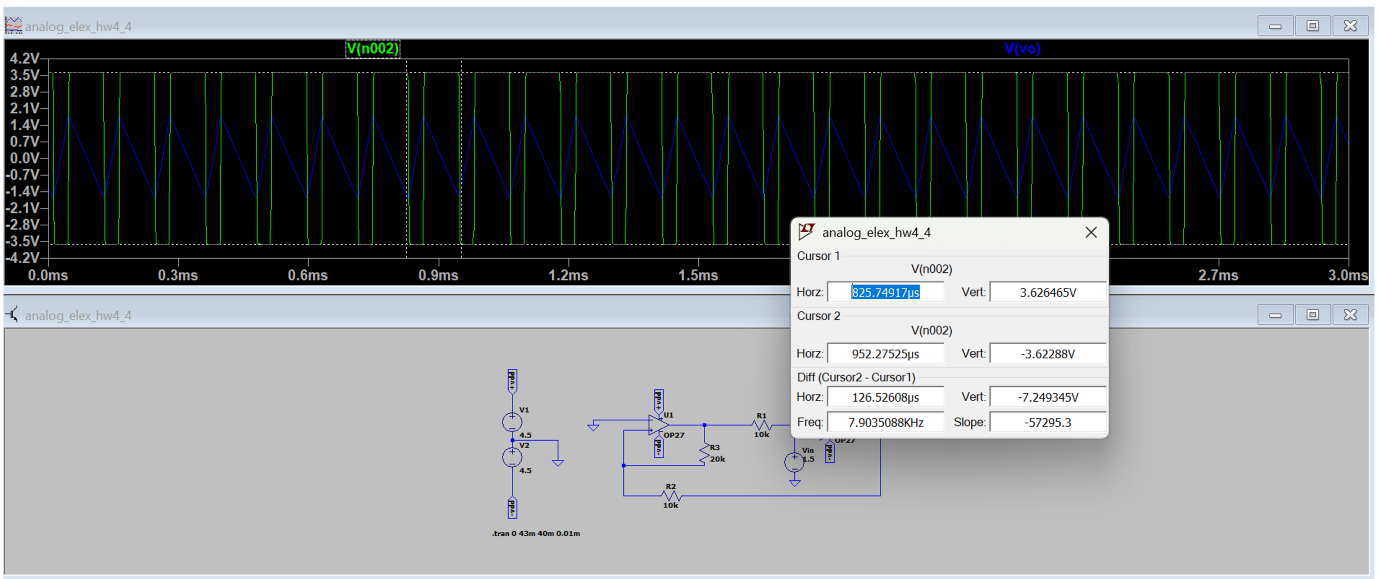
$$T = \frac{4R1R2C1}{R3}$$

R2 = R1 = 10k, R3 = 20k

$$10^{-4} = \frac{4 \times 10k \times 10k \times C1}{20k}$$

$$C1 = 5n$$





5)Design a schimitt trigger circuit and show the hesteresis curve with Vth (+ and -ve) = +- 200mV.

ANSWER :

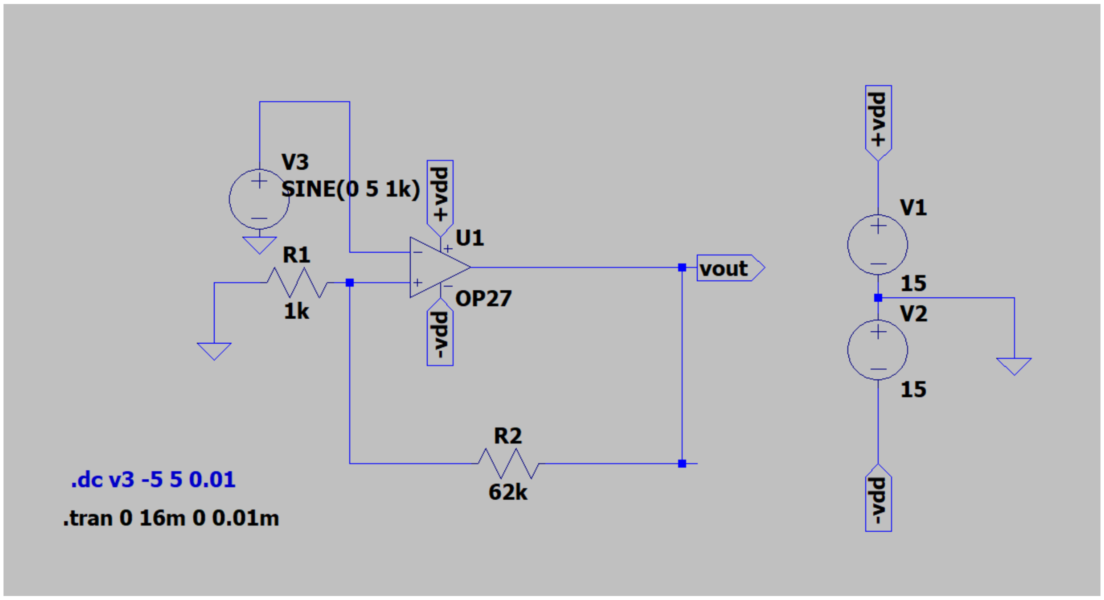
Calculations for R1 and R2,

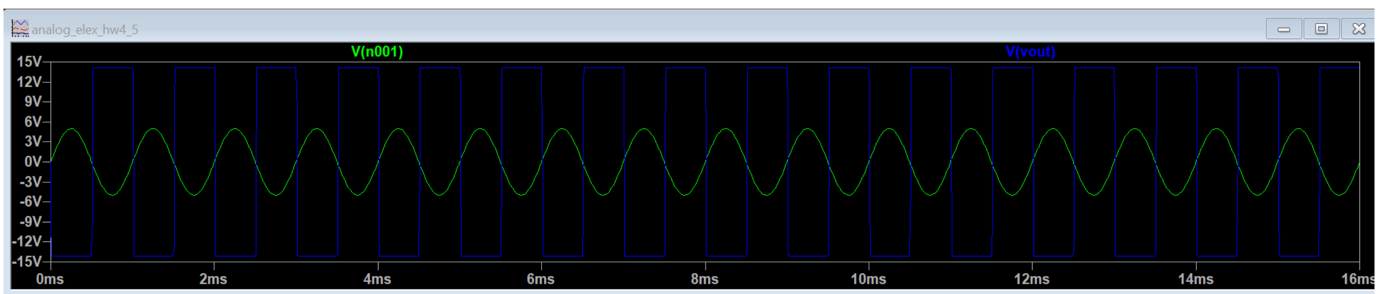
$$V_{th} = \frac{V_{Sat} \times R1}{R1 + R2}$$

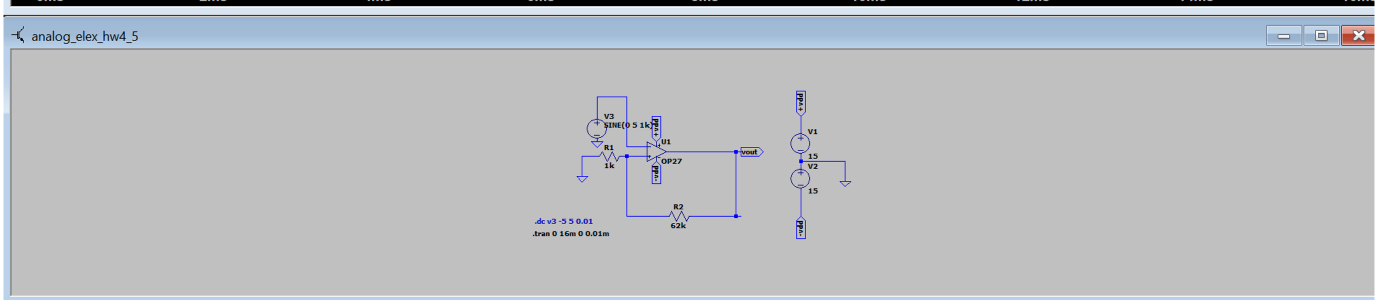
Lets take R1 =1k

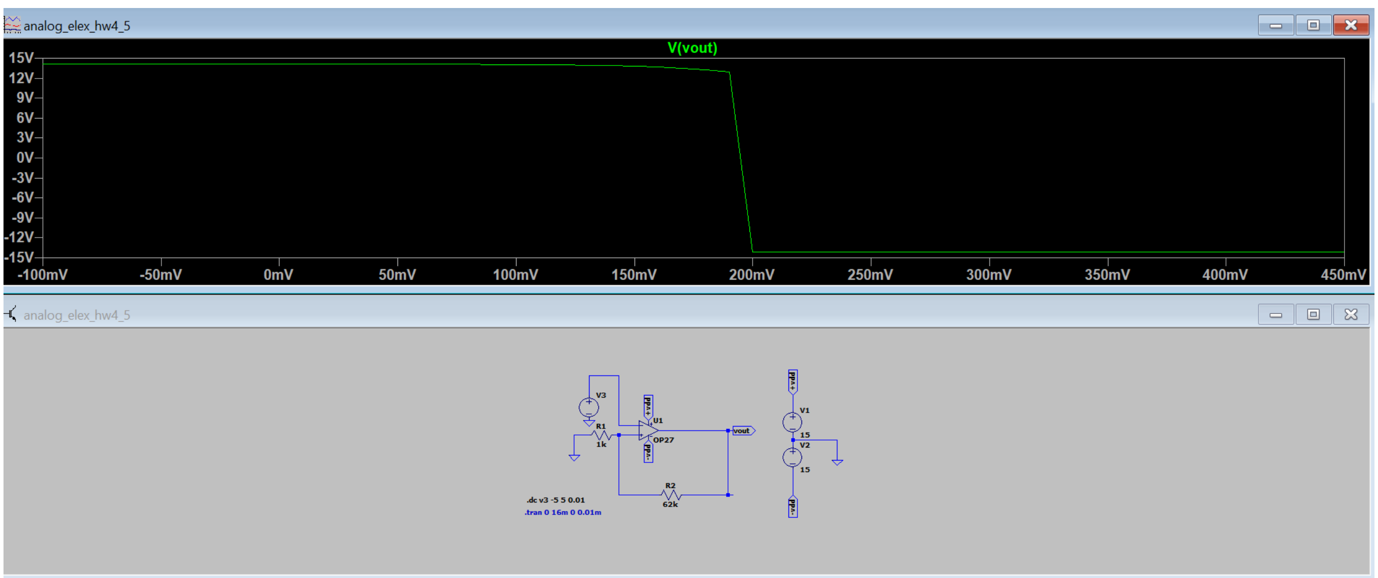
$$200mV = \frac{15 \times 1K}{1K + R2}$$

$$R2 = 62K$$


V3
SINE(0 5 1k)
R1
1k
U1
OP27
+vdd
-vdd
vout
R2
62k
V1
15
V2
15
.dc v3 -5 5 0.01
.tran 0 16m 0 0.01m


analog_elex_hw4_5
V(n001)
V(vout)
15V
12V
9V
6V
3V
0V
-3V
-6V
-9V
-12V
-15V
0ms
2ms
4ms
6ms
8ms
10ms
12ms
14ms
16ms


analog_elex_hw4_5


analog_elex_hw4_5
V(vout)
15V
12V
9V
6V
3V
0V
-3V
-6V
-9V
-12V
-15V
-100mV
-50mV
0mV
50mV
100mV
150mV
200mV
250mV
300mV
350mV
400mV
450mV
analog_elex_hw4_5