



Elektronics Homework 1 Raport

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Part 1 – Wien Bridge Oscillator

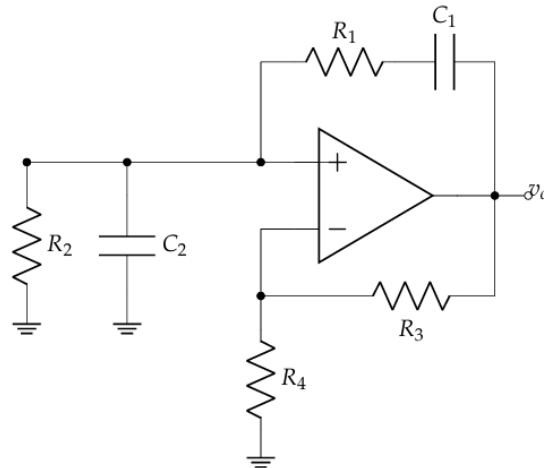


Figure 1

Objective of this part is to expressing oscillation frequency in terms of R1, R2, R3, R4, C1, and C2. And determining their values according to some specific conditions.

First of all, the expression of oscillation frequency is

$$\omega_0 = \frac{1}{\sqrt{R_1 \cdot R_2 \cdot C_1 \cdot C_2}} \quad (1)$$

Know we want $C_1 = C_2 = 1\text{nF}$, an we would like to get oscillation frequency as 16KHz. For this we are determining $R_1 = R_2$ for simplicity, then we can calculate them as

$$R_1 = 10\text{K}\Omega \quad (2)$$

$$R_2 = 10\text{K}\Omega \quad (3)$$

And if we say $R_4 = 10\text{K}\Omega$, we will find R_3 as,

$$R_3 = 20\text{K}\Omega \quad (4)$$

My calculations and simulation results are in below.

Note, In simulation I added a initial condition 10mV to C_1 capacitor for activating the oscillator. Since LtSpice is simulating at a very ideal condition this oscillator may not be working until we gave an initial condition.

Addition I made plot oscillation frequency of Wien Bridge oscillator as a function of R_2 and of this part.

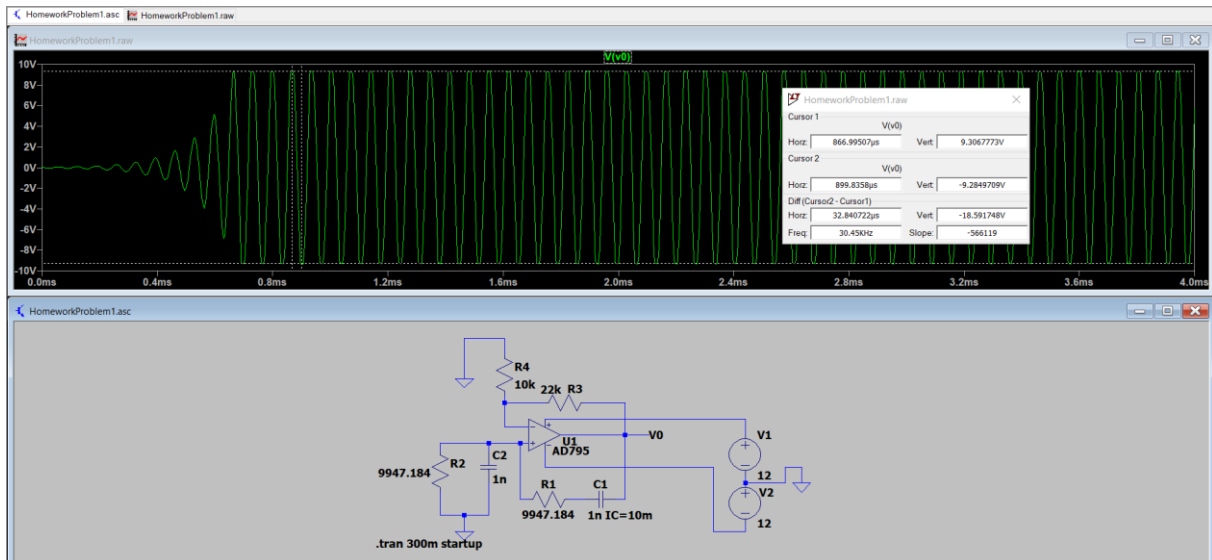


Figure 2: Simulation of Wien Bridge Oscillator

$$T(s) = A(s) \cdot \beta(s)$$

$$A(s) = \frac{R_3}{R_4} + 1, \quad \beta(s) = \frac{Z_2}{Z_1 + Z_2}, \quad Z_1 = R_1 + \frac{1}{sC_1} = \frac{R_1 s C_1 + 1}{s C_1}, \quad Z_2 = \frac{R_2 \cdot \frac{1}{sC_2}}{R_2 + \frac{1}{sC_2}} = \frac{R_2}{1 + s R_2 C_2}$$

$$T(s) = \left(\frac{R_3}{R_4} + 1 \right) \cdot \frac{\frac{R_2}{1 + s R_2 C_2}}{\frac{s R_1 C_1 + 1}{s C_1} + \frac{R_2}{1 + s R_2 C_2}} = \left(\frac{R_3}{R_4} + 1 \right) \cdot \frac{R_2}{1 + s R_1 C_1 + s R_2 C_2 + s^2 R_1 R_2 C_1 C_2 + s C_1 R_2}$$

$$T(s) = \left(\frac{R_3}{R_4} + 1 \right) \cdot \frac{1}{\frac{1}{s R_2 C_1} + \frac{s R_1 C_1 + s R_2 C_2 + s^2 R_1 R_2 C_1 C_2 + s C_1 R_2}{s R_2 C_1 + s R_2 C_2 + s^2 R_1 R_2 C_1 C_2 + s C_1 R_2}} = \left(\frac{R_3}{R_4} + 1 \right) \cdot \frac{1}{1 + \frac{R_1}{R_2} + \frac{C_2}{C_1} + \frac{1}{s R_2 C_1} + s R_1 C_2}$$

$T(s)$ need to be real, so,

$$\frac{1}{s R_2 C_1} + s R_1 C_2 = 0 \xrightarrow{s = j\omega_0} \frac{1}{j\omega_0 R_2 C_1} + j\omega_0 R_1 C_2 = 0 \rightarrow \omega_0 R_1 C_2 = \frac{1}{\omega_0 R_2 C_1} \Rightarrow \omega_0 = \sqrt{\frac{1}{R_1 R_2 C_1 C_2}}$$

$$\omega_0 = 2\pi f_0 \rightarrow f_0 = 16 \text{ kHz}$$

$$2\pi \times 16 \cdot 10^3 = \sqrt{\frac{1}{R_1 R_2 C_1 C_2}} \xrightarrow{\text{since } C_1 = C_2 = 1 \text{ nF}} \sqrt{\frac{1}{R_1 R_2}} = 1 \times 10^{-4} \rightarrow R_1 R_2 = 10^8$$

$$R_1 = 10^4 \Omega \quad R_2 = 10^4 \Omega$$

$$T(j\omega_0) = \left(\frac{R_3}{R_4} + 1 \right) \cdot \frac{1}{1 + \frac{R_1}{R_2} + \frac{C_2}{C_1}} = \left(\frac{R_3}{R_4} + 1 \right) \cdot \frac{1}{3} = 1 \rightarrow \frac{R_3}{R_4} + 1 = 3 \rightarrow \frac{R_3}{R_4} = 2$$

$R_3 = R_4 \cdot 2 = 20 \text{ k}$
 Since $R_4 = 10 \text{ k} \Omega$

Figure 3: Calculations of Part 1

Simulation outputs for different R_2 values:

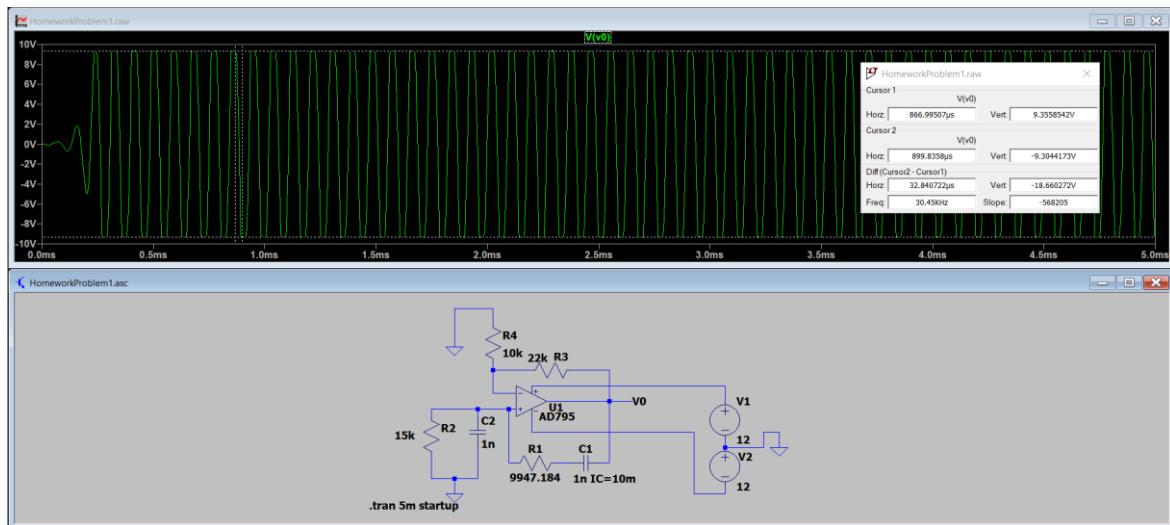


Figure 4: R_2 for 15K Ω

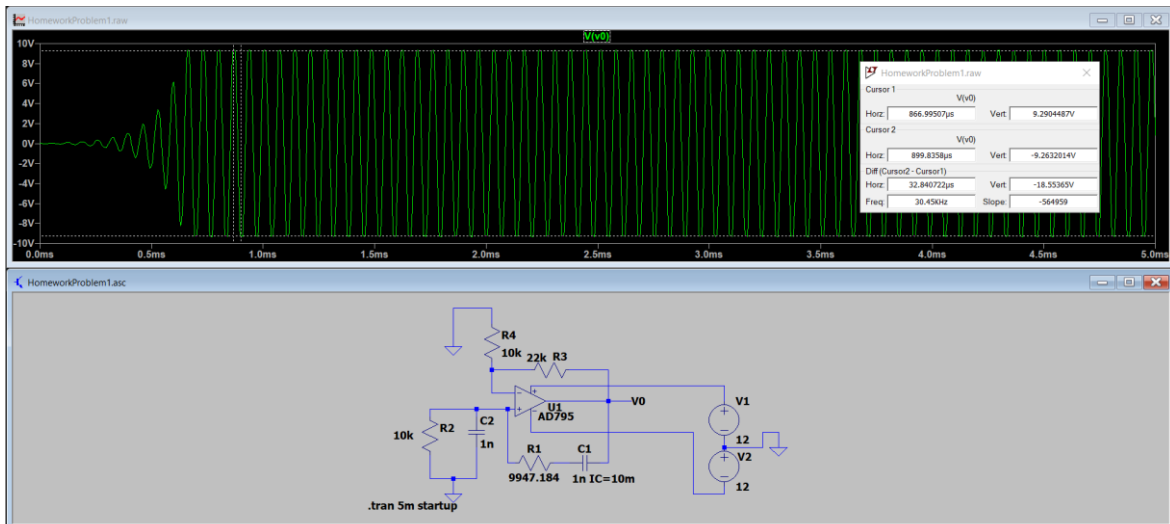


Figure 5 : R_2 for 12 K Ω

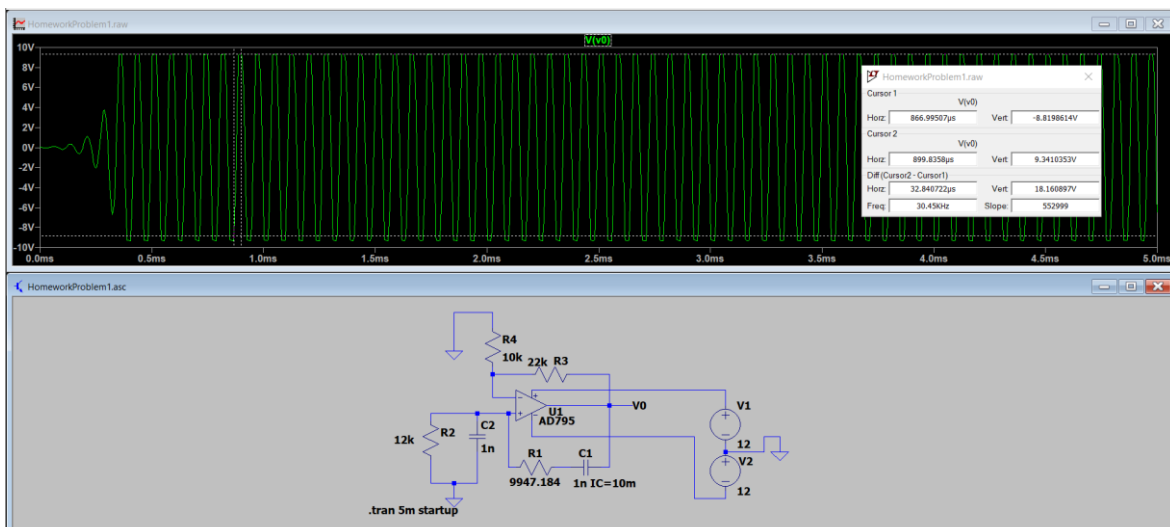


Figure 6: R_2 for 10K Ω

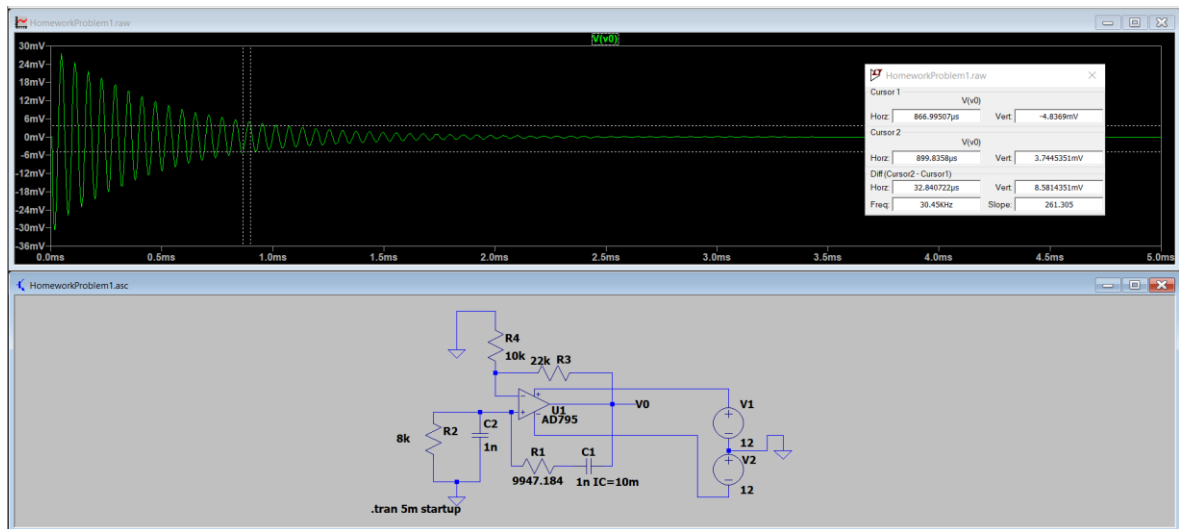


Figure 7: R2 for 8KΩ

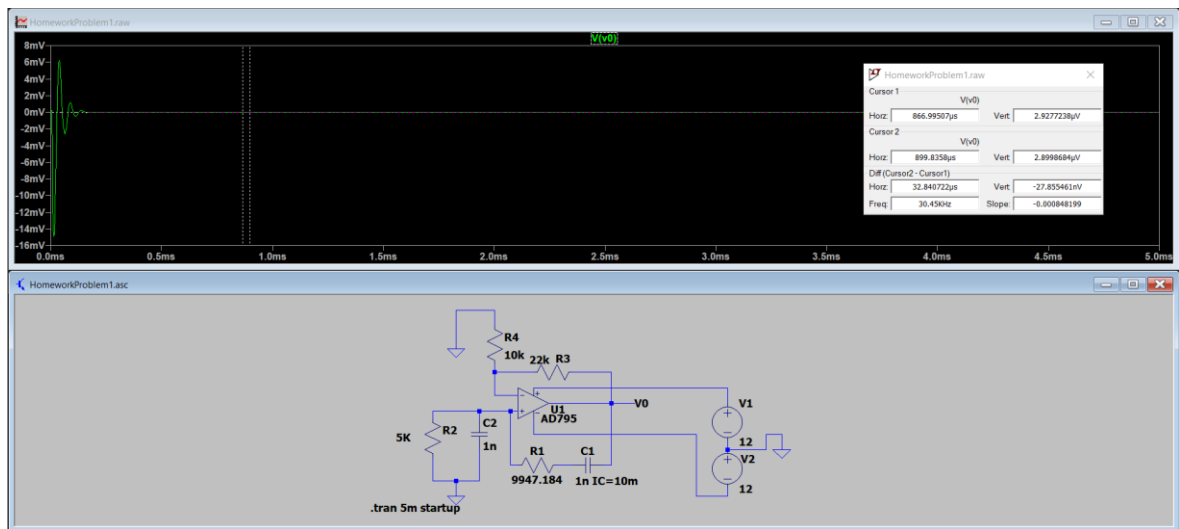


Figure 8: R₂ for 5KΩ

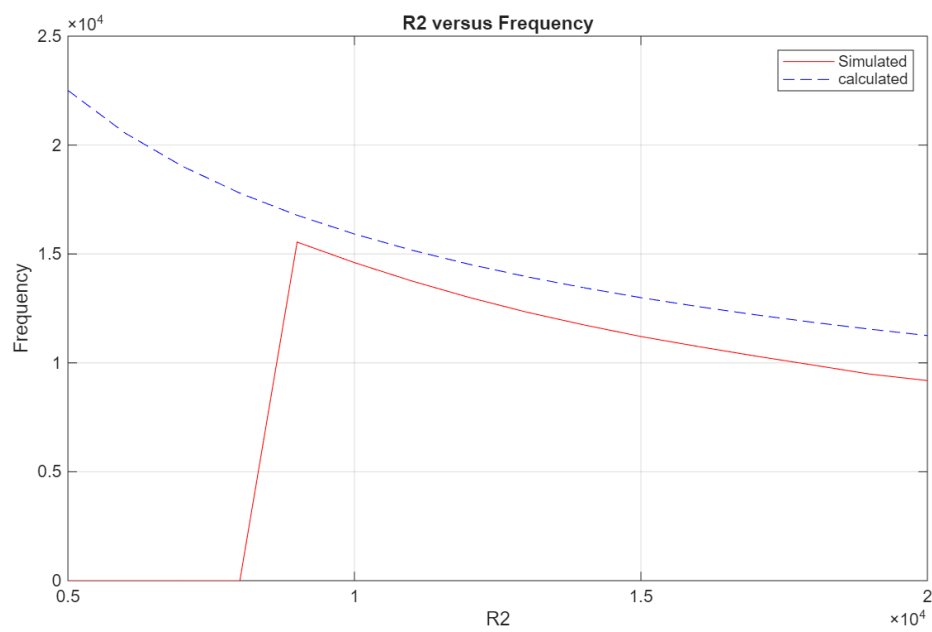


Figure 9: R₂ versus Frequency graph

Part 2 – Schmitt Trigger Oscillator

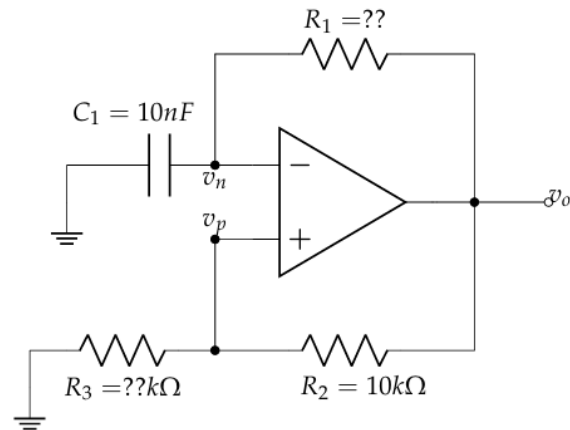


Figure 10

Objective of this part is to designing and simulating a Schmitt trigger oscillator in some conditions.

The first information is the there is $4V_{p-p}$ amplitude at v_n and we need to calculate as v_o changes between +10V to -10V.

For calculating R_3 we find,

$$R_3 = 2.5K\Omega \quad (5)$$

The second information is the equality of oscillation frequency is 1KHz.

From here we can find R_1 and $T(\tau)$ as,

$$R_1 = 123304.56\Omega \quad (6)$$

$$T = R_1 \cdot C_1 = 1.23ms \quad (7)$$

All calculations and plots are below.

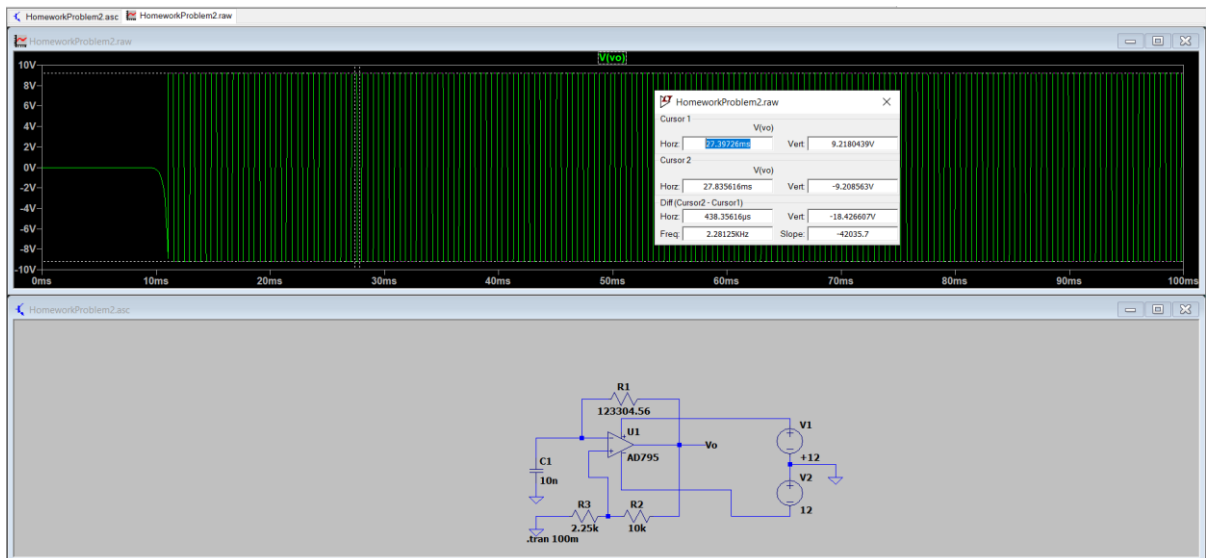


Figure 11: Simulation plot of v_o

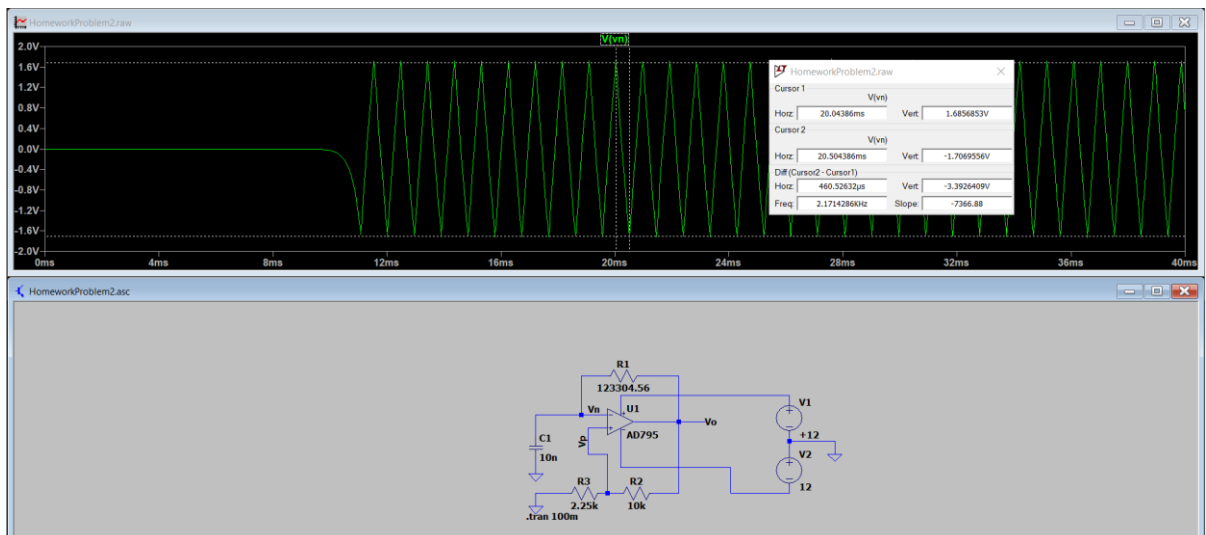


Figure 12: Simulation plot of v_n

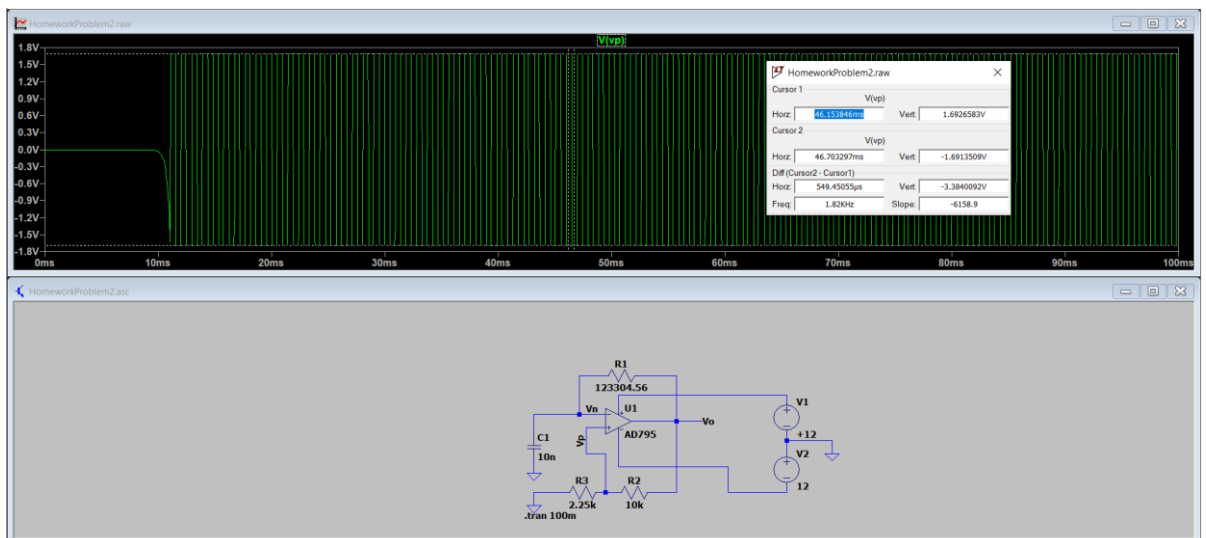


Figure 13: Simulation plot of v_p

$$\text{for } 4V \text{ p-p} \rightarrow V_{max} = 2V = \frac{R_3}{R_2 + R_3} \cdot V_o \Rightarrow \frac{R_3}{10 + R_3} \cdot 10 = 2 \Rightarrow \frac{R_3}{10 + R_3} = \frac{1}{5}$$

$$V_p = \frac{R_3}{R_2 + R_3} \cdot V_p = \frac{1}{5} V_p$$

$$\tau = R_1 C_1$$

$$5R_3 = 10 + R_3$$

$$4R_3 = 10$$

$$R_3 = 2.5 \text{ k}\Omega$$

$$V_n = V_{final} + (V_{initial} - V_{final}) \cdot e^{-t/\tau}$$

$$V_n = V_p + \left(-\frac{V_p}{5} - V_p\right) e^{-t/R_1 C_1}$$

$$V_n = V_p - \frac{6}{5} V_p \cdot e^{-t/R_1 C_1}$$

$$V_n = V_L + (-2 - V_L) \cdot e^{-(t_2 - t_1)/\tau}$$

$$V_n = 2 = 10 - 12 e^{-t/R_1 C_1}$$

$$-2 = -10 + (-2 + 10) \cdot e^{-(t_2 - t_1)/\tau}$$

$$-8 = -12 e^{-t_1/R_1 C_1}$$

$$+8 = 8 \cdot e^{-(t_2 - t_1)/\tau}$$

$$\frac{t_1}{R_1 C_1} = 0.4055$$

$$t_2 = t_1$$

$$t_1 = (0.4055) R_1 C_1$$

$$\tau = 2 \cdot (0.4055) R_1 C_1$$

$$f = 1 \text{ kHz} \rightarrow \tau = 10^{-3} \text{ s}, \text{ since } C_1 = 10 \text{ nF}$$

$$10^{-3} = (0.811) R_1 (10 \times 10^{-9}) \rightarrow R_1 = 123304.56 \Omega$$

$$\tau = R_1 C_1 = 1.23 \text{ ms}$$

peak values of $V_n = \pm 2V$, $V_o = \pm 10V$

Figure 14: Calculations of Part 2