



Elektronics Homework 1 Report

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Part 1 – Wien Bridge Oscillator

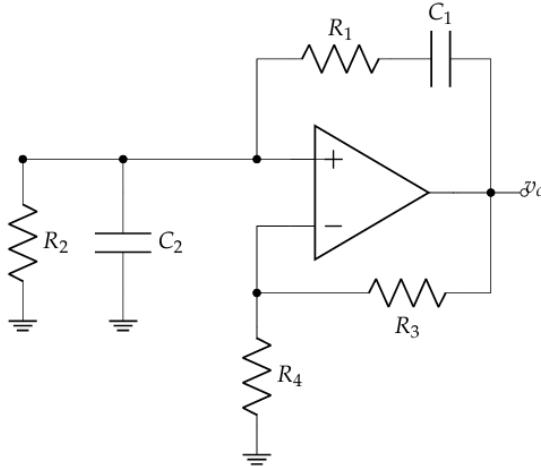


Figure 1

Objective of this part is to expressing oscillation frequency in terms of R_1 , R_2 , R_3 , R_4 , C_1 , and C_2 . And determining their values according to some specific conditions.

First of all, the expression of oscillation frequency is

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

Now we want $C_1 = C_2 = 1\text{nF}$, and 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

$$R_1 = 10K\Omega \quad (2)$$

$$R_2 = 10K\Omega \quad (3)$$

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

$$R_3 = 20K\Omega \quad (4)$$

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.

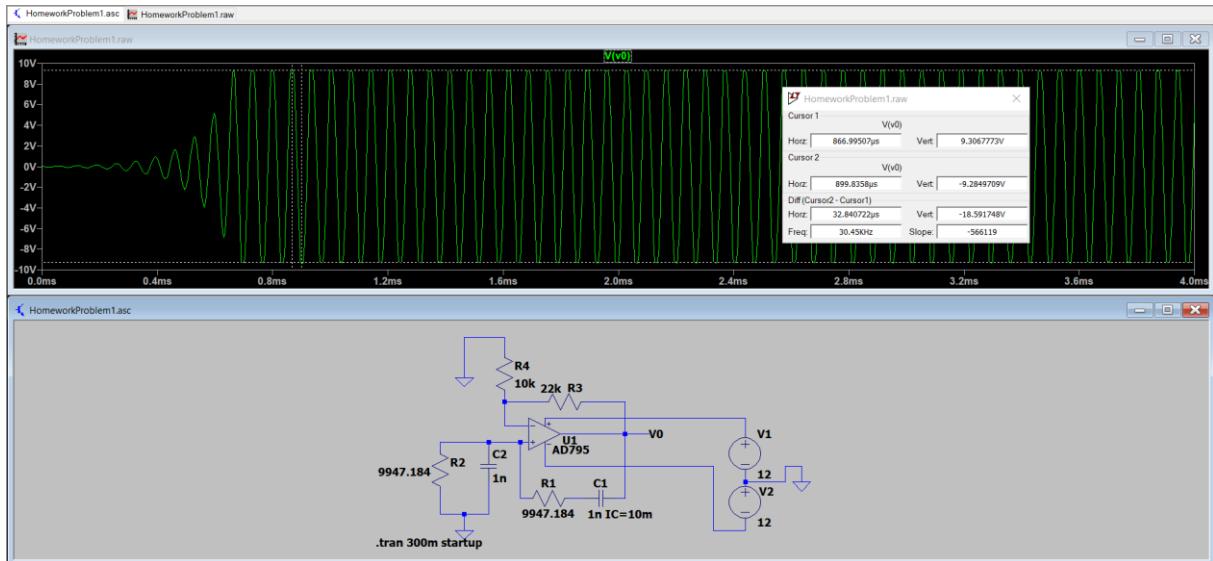


Figure 2: Simulation of Wien Bridge Oscillator

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

$$A(s) = \frac{R_3 + 1}{R_4}, \quad \beta(s) = \frac{sZ_2}{Z_1 + Z_2} \quad \text{so } Z_1 = R_1 + \frac{1}{sC_1} = \frac{R_1 s C_1 + 1}{s C_1}, \quad Z_2 = \frac{R_2 \cdot \frac{1}{sC_2}}{1 + sR_2 C_2} = \frac{R_2}{1 + sR_2 C_2}$$

$$T(s) = \left(\frac{R_3}{R_4} + 1\right) \cdot \frac{\frac{R_2}{1 + sR_2 C_2}}{\frac{sR_1 C_1 + 1}{sC_1} + \frac{R_2}{1 + sR_2 C_2}} = \left(\frac{R_3}{R_4} + 1\right) \frac{\frac{R_2}{1 + sR_2 C_2} \cdot sC_1 \cdot (1 + sR_2 C_2)}{1 + sR_1 C_1 + sR_2 C_2 + s^2 R_1 R_2 C_1 C_2 + sC_1 R_2}$$

$$T(s) = \left(\frac{R_3}{R_4} + 1\right) \frac{1}{\frac{1}{sR_2 C_1} + \frac{sR_1 C_1}{sR_2 C_1} + \frac{sR_1 R_2 C_1 C_2}{sR_2 C_1} + \frac{sC_1 R_2}{sR_2 C_1}} = \left(\frac{R_3}{R_4} + 1\right) \frac{1}{1 + \frac{R_1}{R_2} + \frac{C_2}{C_1} + \frac{1}{sR_2 C_1} + sR_1 C_2}$$

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

$$\frac{1}{sR_2 C_1} + sR_1 C_2 = 0 \xrightarrow{s=j\omega_0} \frac{1}{j\omega_0 R_2 C_1} + j\omega_0 R_1 C_2 = 0 \rightarrow \omega_0 R_1 C_2 = \frac{1}{\omega_0 R_2 C_1} \Rightarrow \omega_0 = \sqrt{\frac{1}{R_1 R_2 C_1 C_2}}$$

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

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

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

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

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

Figure 3: Calculations of Part 1

Simulation outputs for different R_2 values:

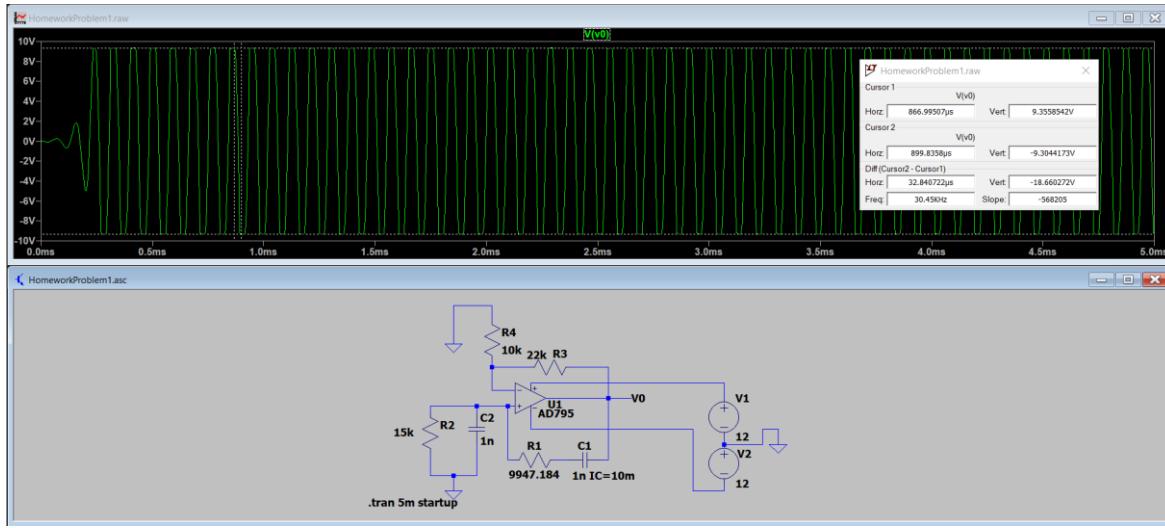


Figure 4: R_2 for $15\text{k}\Omega$

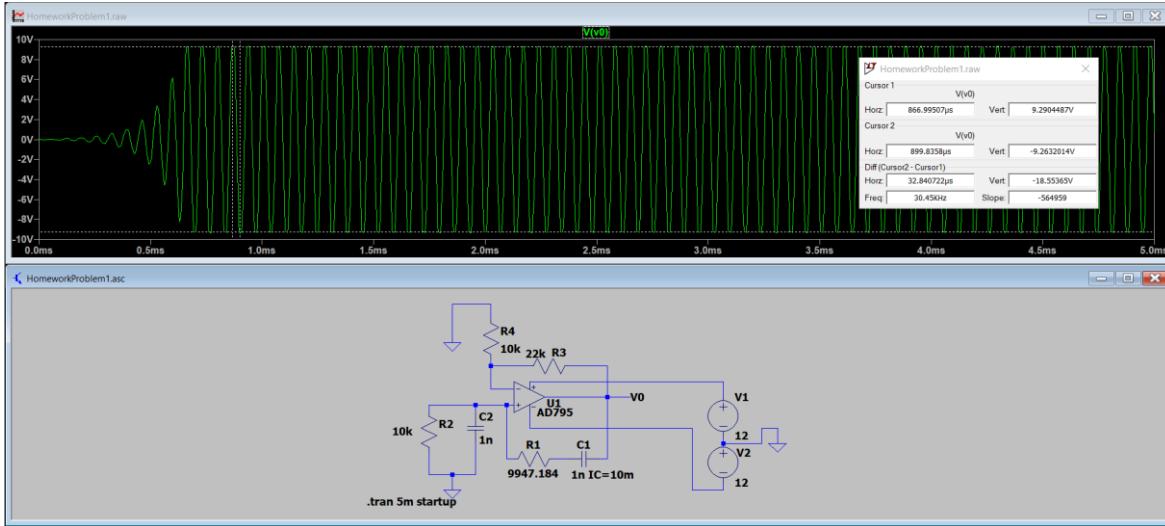


Figure 5 : R_2 for $12\text{ k}\Omega$

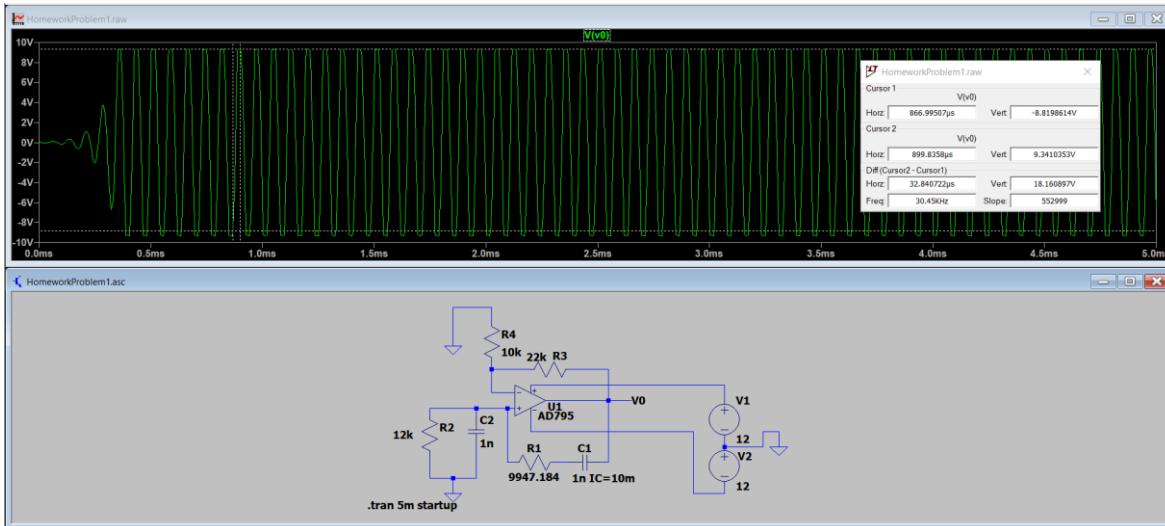


Figure 6: R_2 for $10\text{k}\Omega$

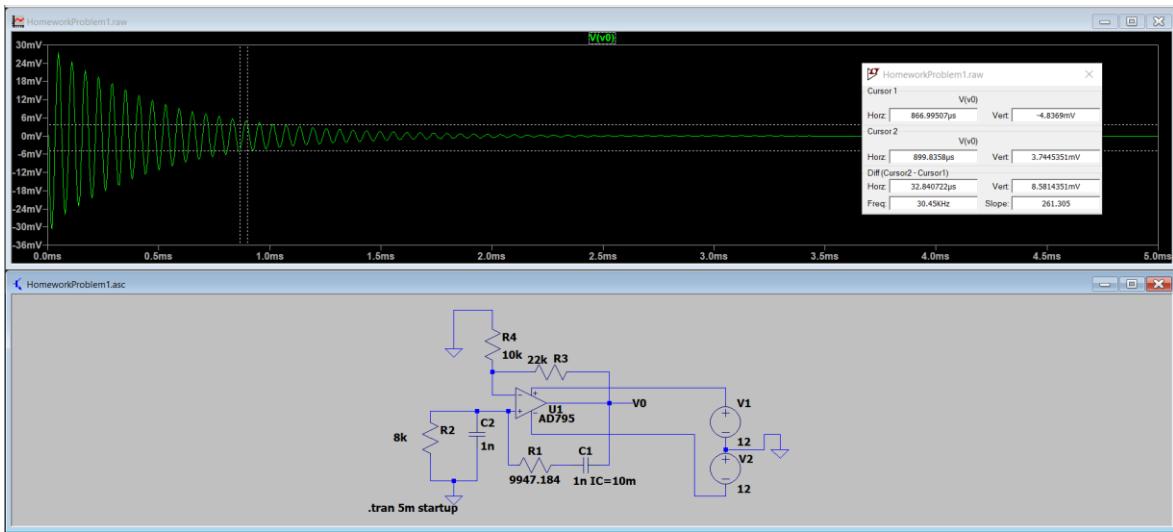


Figure 7: R₂ for 8KΩ

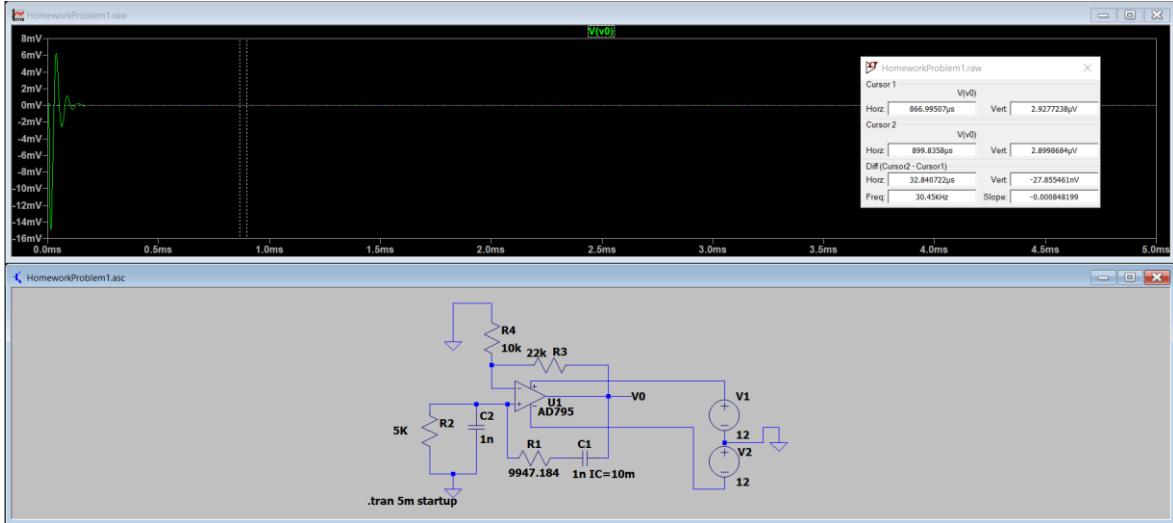


Figure 8: R₂ for 5KΩ

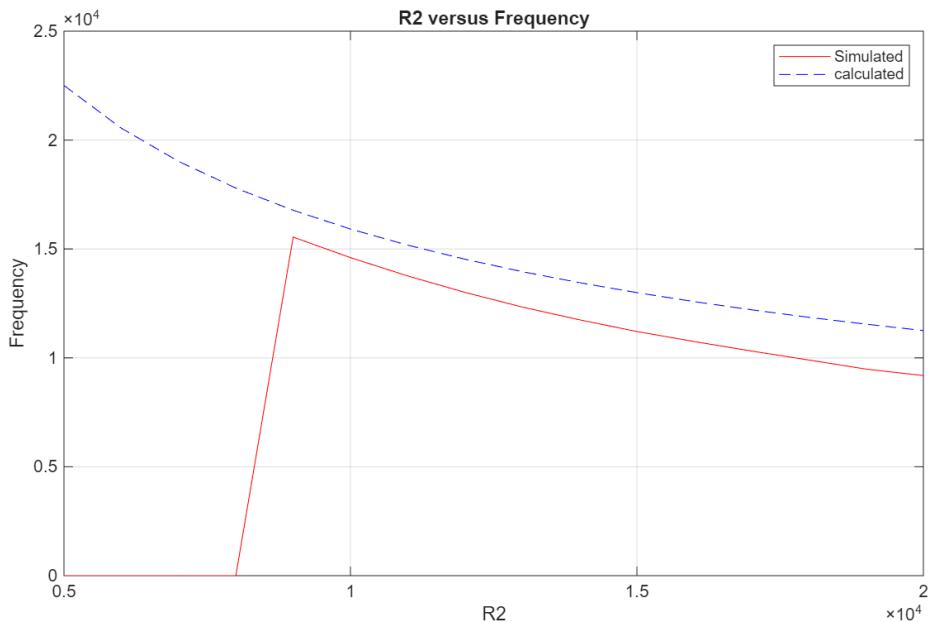


Figure 9: R₂ versus Frequency graph

Part 2 – Schmitt Trigger Oscillator

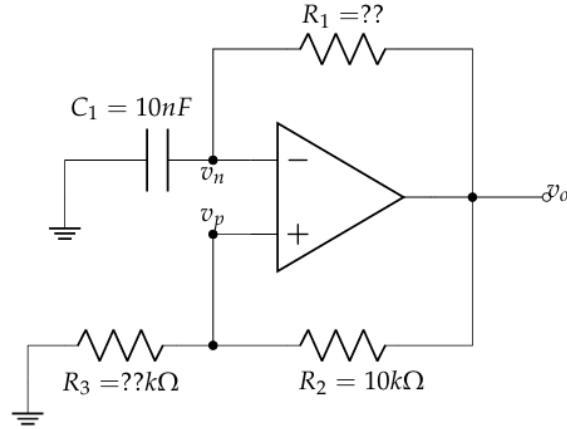


Figure 10

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.

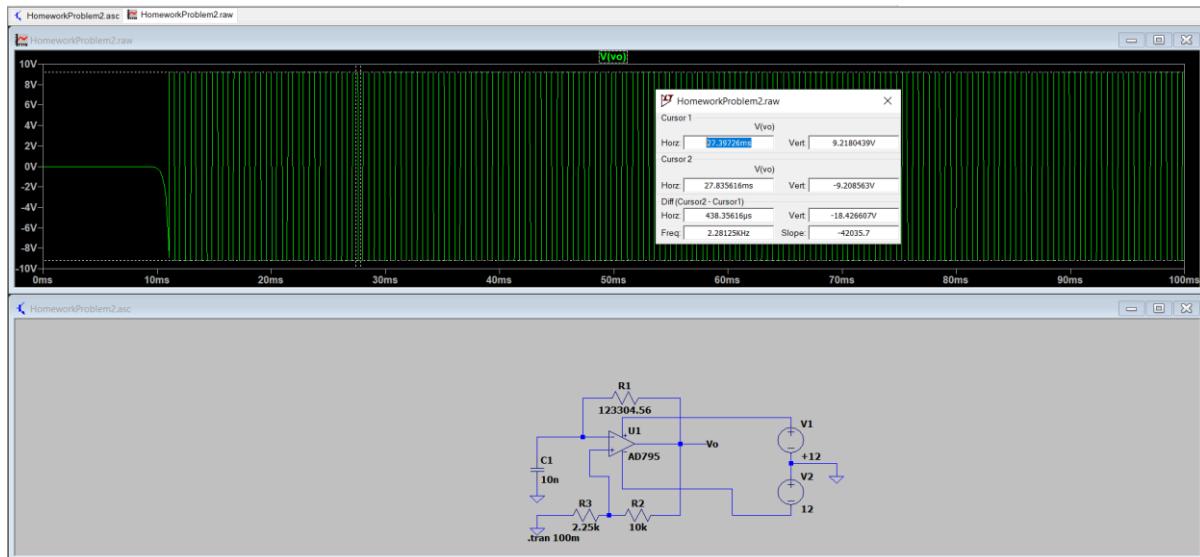


Figure 11: Simulation plot of V_o

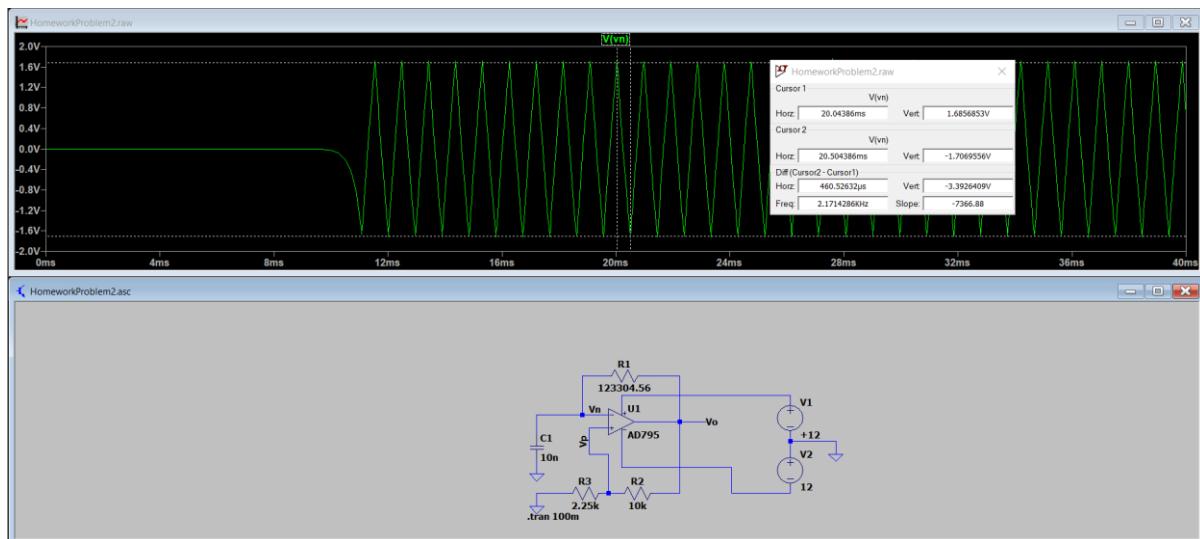


Figure 12: Simulation plot of V_n

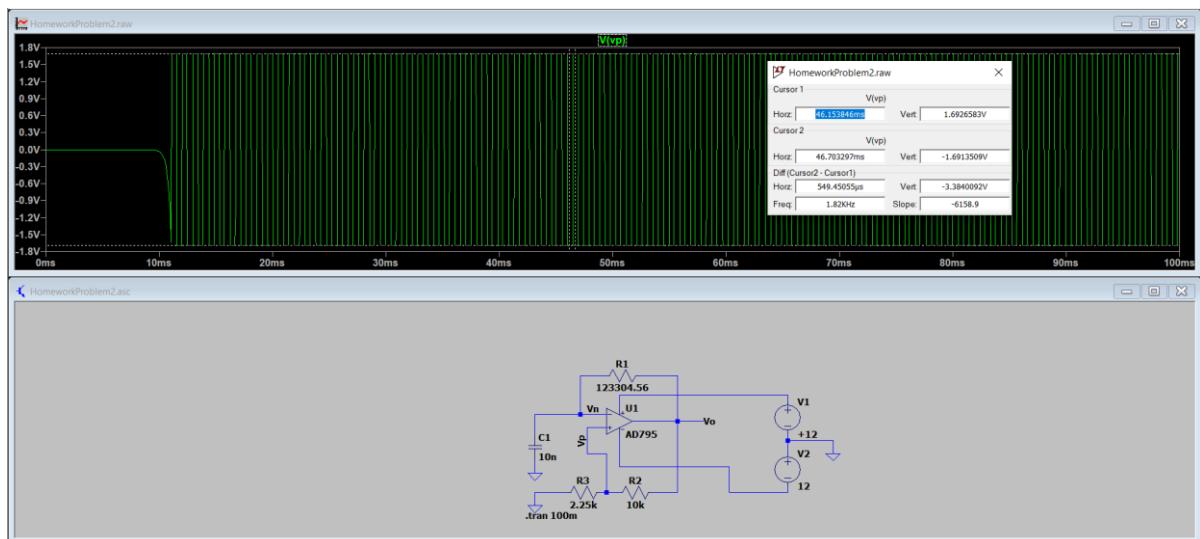


Figure 13: Simulation plot of V_p

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

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

$$\tau = R_1 C_1$$

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

$$5R_3 = 10 + R_3$$

$$4R_3 = 10$$

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

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

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

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

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

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

$$t_1 = (0.4055) R_1 C_1$$

$$V_n = V_L + (-2 - V_L) \cdot e^{-(L_2 + V_L)/\tau}$$

$$-2 = -(10 + (-2 + 10)) \cdot e^{-(L_2 + t_1)/\tau}$$

$$+8 = 8 \cdot e^{-(L_2 + t_1)/\tau}$$

$$t_2 = t_1$$

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

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

$$10^{-3} = (0.8 + 1) R_1 (10 \times 10^{-9}) \rightarrow R_1 = 123304.56 \text{ }\Omega$$

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

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

Figure 14: Calculations of Part 2