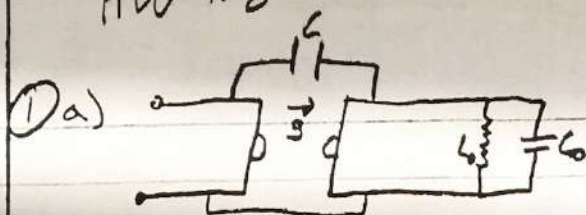


HW #8



$$Y_{\text{Right}} = \begin{bmatrix} sC & -sc-g \\ -sc+g & sC \end{bmatrix} \quad Y_L = sC_0 + \frac{1}{sL_0}$$

$$Y_L = \frac{\Delta Y_{11} - Y_{12} Y_{in}}{Y_{in} - Y_{11}} \Rightarrow Y_L Y_{in} - Y_{12} Y_{in} = \Delta Y - Y_{22} Y_{in}$$

$$Y_{in} = \frac{g^2 + (sC_0 + \frac{1}{sL_0})sC}{sC_0 + \frac{1}{sL_0} + sC}$$

$$Y_{in} = \frac{\Delta Y + Y_{12} Y_{11}}{Y_L + Y_{22}}$$

$$\Delta Y = (sC)^2 - (-sc-g)(-sc+g)$$

$$sC^2 - (sc^2 - scg + scg - g^2)$$

$$\Delta Y = g^2$$

$$Y_{in}(s) = \frac{g^2 + s^2 C_0 C + \frac{C}{L_0}}{sC_0 + \frac{1}{sL_0} + sC}$$

b) Zeros: $g^2 + s^2 C_0 C + \frac{C}{L_0} = 0$

$$s^2 = -\left(\frac{1}{L_0 C_0} + \frac{g^2}{C_0 C}\right)$$

$$s = j \sqrt{\frac{1}{L_0 C_0} + \frac{g^2}{C_0 C}}$$

Poles:

$$(s(L_0 + C) + \frac{1}{sL_0} = 0) s$$

$$s^2(L_0 + C) + \frac{1}{L_0} = 0$$

$$s^2 = \frac{-1}{L_0(L_0 + C)}$$

$$s = j \sqrt{\frac{1}{L_0(L_0 + C)}}$$

c) All poles & zeros on jw axis which is in contrast with an even lossless admittance which has no poles on the jw axis only on the σ axis. Even part of lossless admittance is 0

$$Ev(Y) = \frac{Y(s) + Y(-s)}{2} = \frac{s^2 L_0 C + \frac{C}{L_0} + g^2}{s(L_0 + C) + \frac{1}{sL_0}} + \frac{s^2(L_0 + \frac{C}{L_0}) - g^2}{-(s(L_0 + C) + \frac{1}{sL_0})}$$

$$= 0$$

2-a) Non-Inverting Schmitt Circuit

When the input signal is applied to the non-inverting terminals as in the circuit of Figure 16 the resulting circuit is the non-inverting Schmitt trigger.

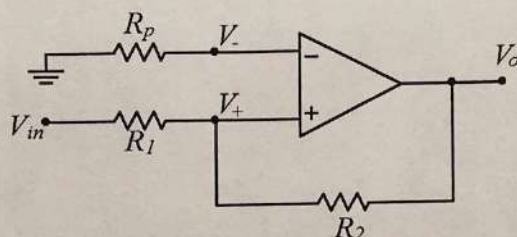


Figure 16. Non-inverting Schmitt trigger

The voltage V_+ at the non-inverting terminal is a combination of the output voltage, V_o , and the input voltage, V_{in} .

$$V_+ = V_{in} \frac{R_2}{R_1 + R_2} + V_o \frac{R_1}{R_1 + R_2} \quad (1.10)$$

Since $V_o = A(V_+ - V_-)$ the transitions will occur when V_+ crosses zero.

$$0 = V_T R_2 + V_o R_1 \quad (1.11)$$

Where V_T represents the transition voltage. Let's assume the initial state $V_o = V_L$. Then

$$V_T = -\frac{R_1}{R_2} V_L \quad (1.12)$$

And since $V_L < 0$, V_T is positive and we call it V_{TU} . This corresponding part of the characteristic plot is shown on Figure 17(a).

Now the output is at V_H and will stay at this state until the voltage V_+ crosses zero. This will happen at the transition voltage V_T which must satisfy

$$0 = V_T R_2 + V_H R_1 \quad (1.13)$$

This is the lower transition voltage V_{TL} given by

2-a)

$$V_{TL} = -\frac{R_1}{R_2} V_H \quad (1.14)$$

For $V_H > 0$, $V_{TL} < 0$ and the corresponding path and transition voltage is shown on Figure 17(b). The complete voltage characteristic is shown on Figure 18.

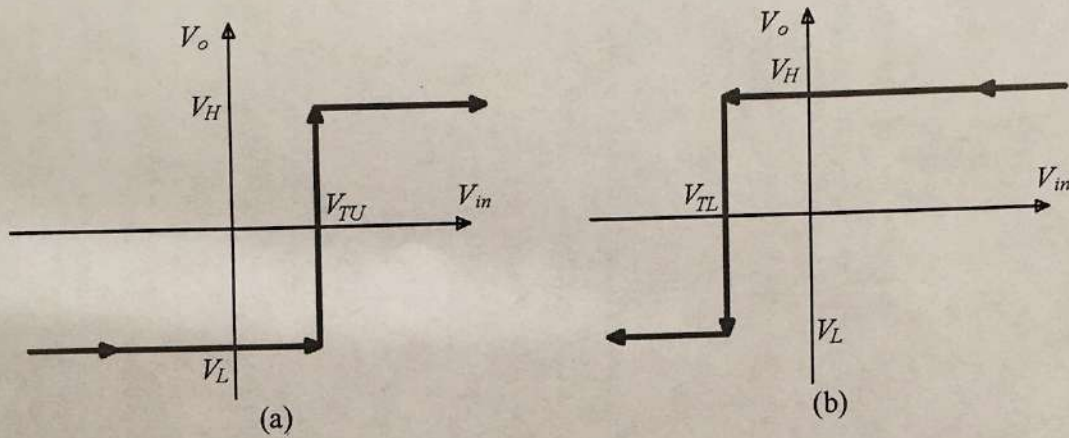


Figure 17.

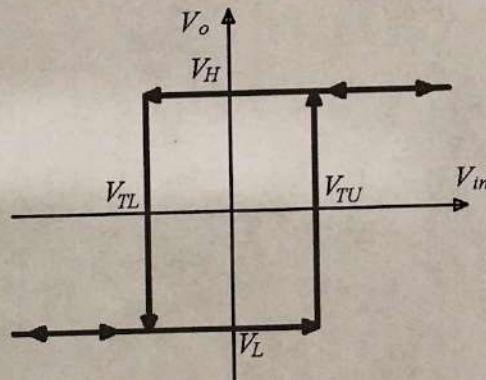


Figure 18

$$\begin{aligned} \checkmark \therefore \text{Hysteresis width} &= V_{TU} - V_{TL} \\ &= -\frac{R_1}{R_2} V_L - \frac{-R_1}{R_2} V_H \\ &= -g(-V_{dd}) + g(V_{dd}) \\ &= \underline{2g V_{dd}} \end{aligned}$$

2- b) Schmitt Trigger Oscillator: Astable Multivibrator

By combining negative and positive feedback and a capacitor for energy storage we can design a circuit that generates a square wave output. The circuit is shown on Figure 21.

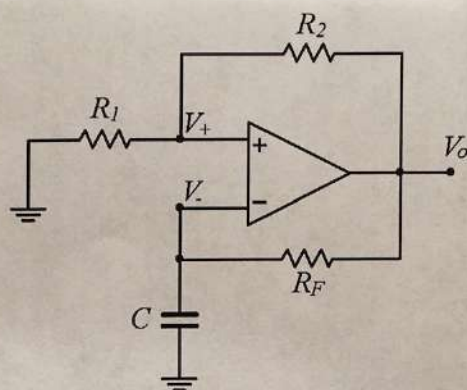


Figure 21. Astable Multivibrator

Let's analyze the operation of this circuit for $R_1 = R_2 = R$. Furthermore let's define the saturation voltages V_H and V_L which we take to be symmetric about zero: $V_H = -V_L$.

In order to proceed we must assume an initial state for the output voltage V_o . Let's start with $V_o = V_L$ which gives

$$V_+ = \frac{1}{2}V_L \quad (1.21)$$

Recall that we are operating with the positive feedback and thus the output is given by

$$V_o = A(V_+ - V_-) \quad (1.22)$$

The voltage $V_+ = \frac{1}{2}V_L$ is determined by the characteristics of the capacitor C and the resistor R_F . The form of V_- is the standard exponential function of a transient RC circuit.

$$V_o = \frac{R_F}{R_1} \left[\frac{1}{2}V_L - V_H - \left(\frac{1}{2}V_L - V_H \right) e^{-t/R_F C} \right] \Rightarrow$$

$$= \frac{R_F}{R_1} \left[\frac{1}{2}V_L - V_H - \left(\frac{1}{2}V_L - V_H \right) e^{-t/R_F C} \right]$$

The voltage V_o will change state (i.e. switch from $V_o = V_L$ to $V_o = V_H$) when V_- becomes less than $\frac{1}{2}V_L$.

The general form of the voltage V_- is given by

2-6)

$$V_- = V_{final} + (V_{initial} - V_{final})e^{-t/R_F C} \quad (1.23)$$

The evolution after the first transition (V_o going from V_L to V_H) which happens when

$V_- = \frac{1}{2}V_L$ is found from Equation (1.23) with $V_{initial} = \frac{1}{2}V_L$ and $V_{final} = V_H$

$$V_- = V_H + \left(\frac{1}{2}V_L - V_H\right)e^{-t/R_F C} \quad (1.24)$$

V_- starts to increase exponentially towards V_H . The function that describes the

relationship between the inputs and the output of the op-amp is $V_o = A\left(\frac{1}{2}V_H - V_-\right)$ and

when V_- crosses $\frac{1}{2}V_H$ the output will switch from V_H to V_L and the process continuous

The time evolution of the voltages of interest are shown on Figure 22 where $V_H = +5V$,

$V_L = -5V$ and $R_1 = R_2$. Assuming that the initially $V_o = V_H = +5V$ and

$V_- = \frac{1}{2}V_L = -\frac{5}{2}Volts$, the equation that describes the evolution of V_- for $t > 0$ is

$$V_- = V_H - \frac{3}{2}V_H e^{-t/R_F C} \quad (1.25)$$

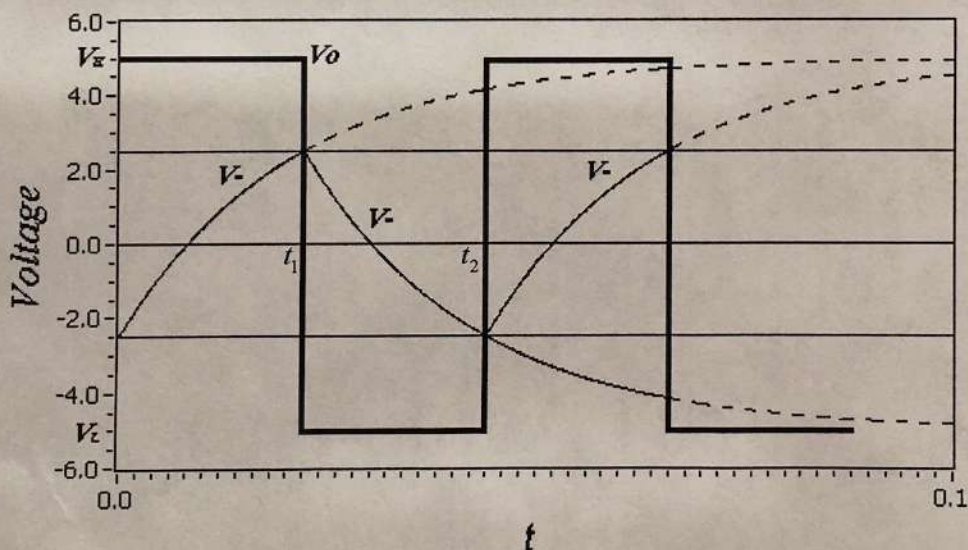
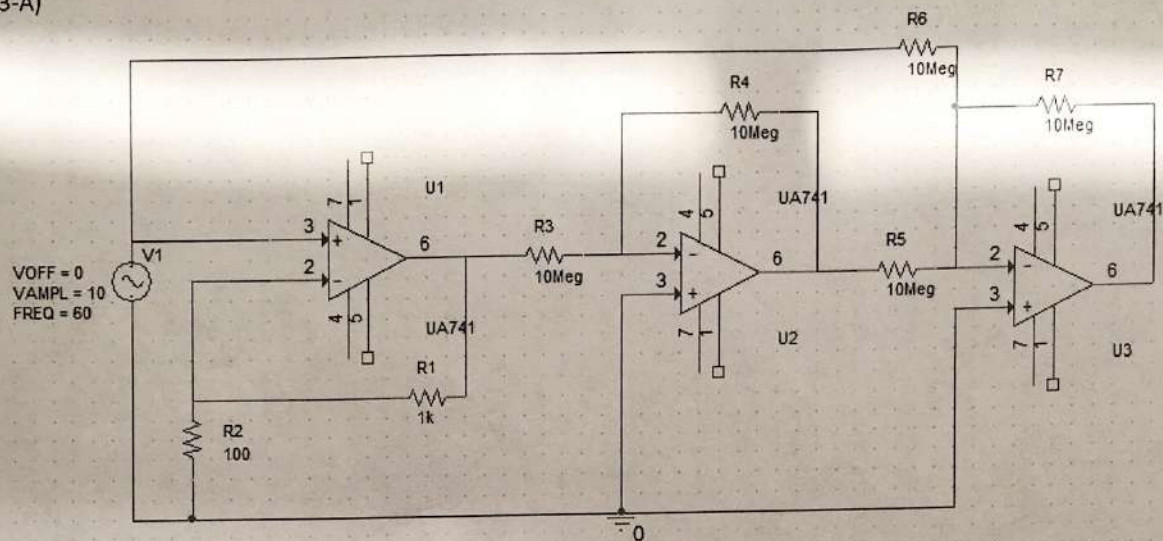
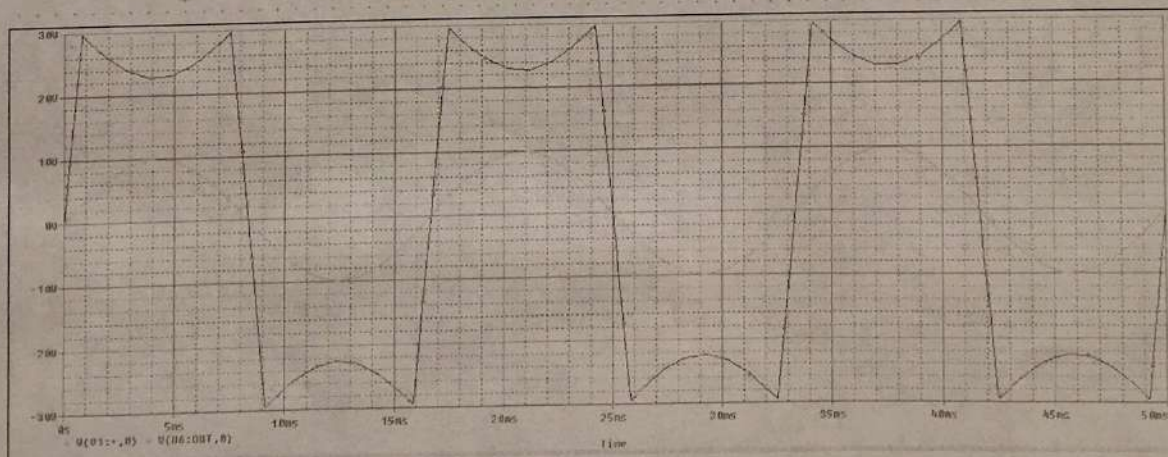
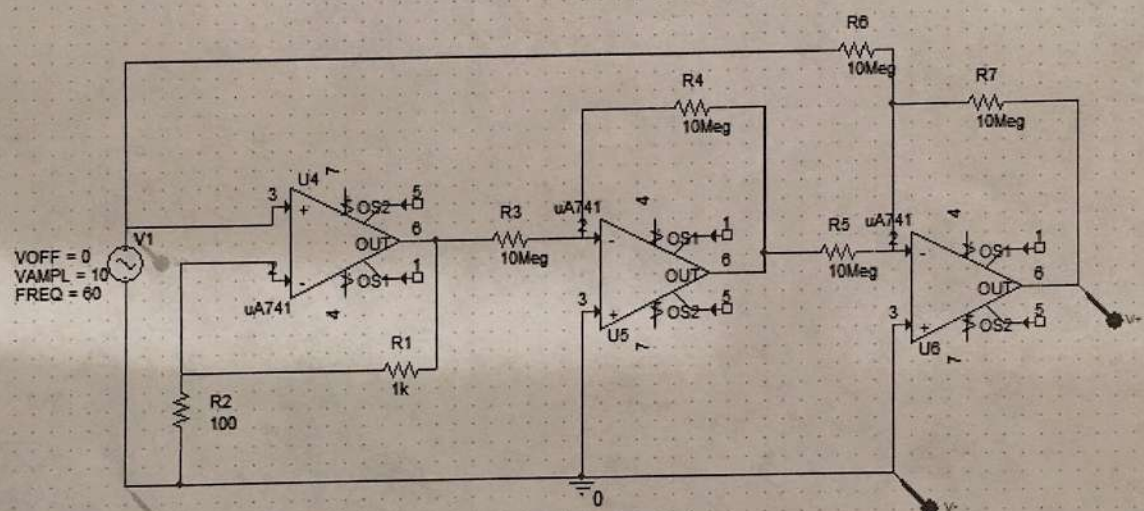


Figure 22. Oscillator voltage characteristics

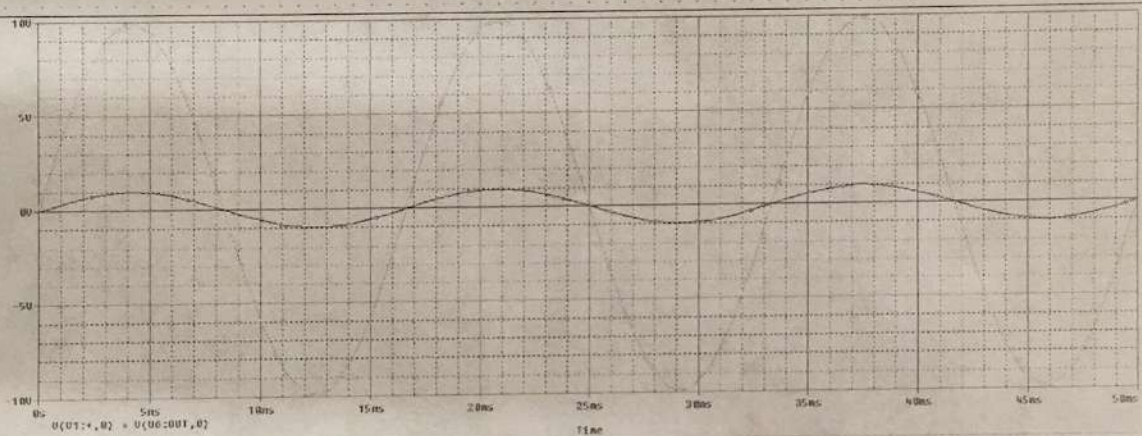
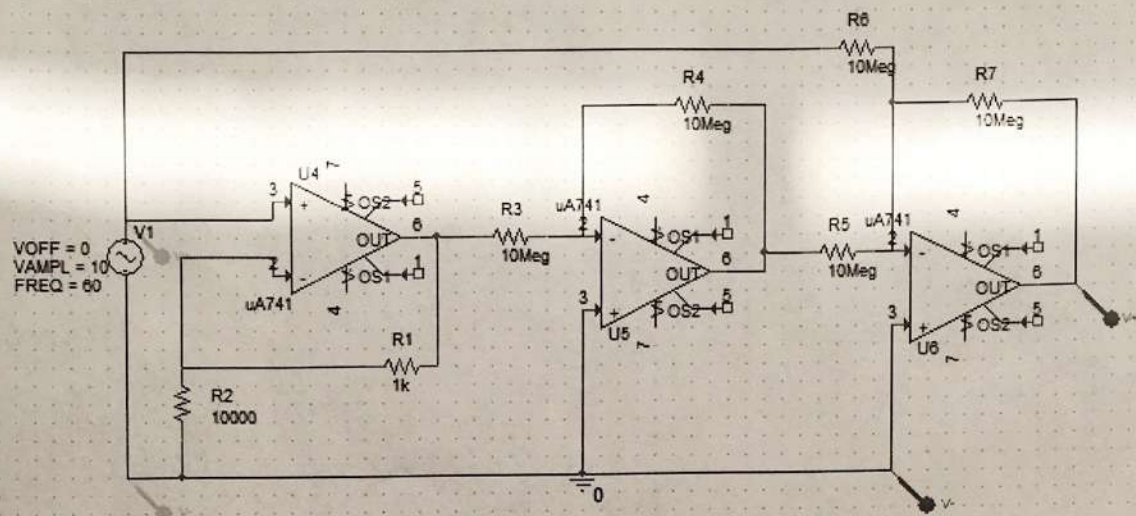
3-A)



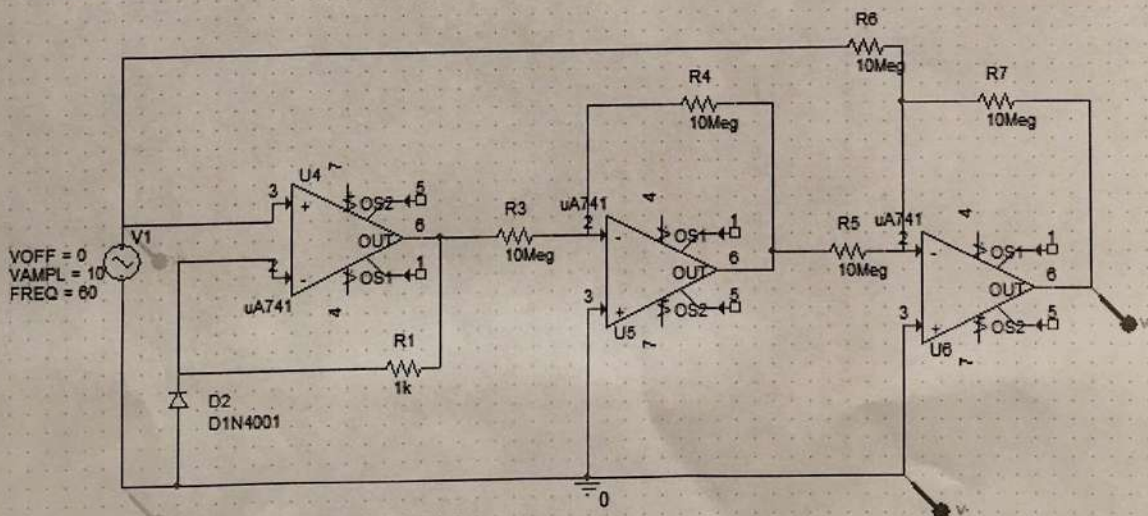
3-B1) (100 Ohm resistor)

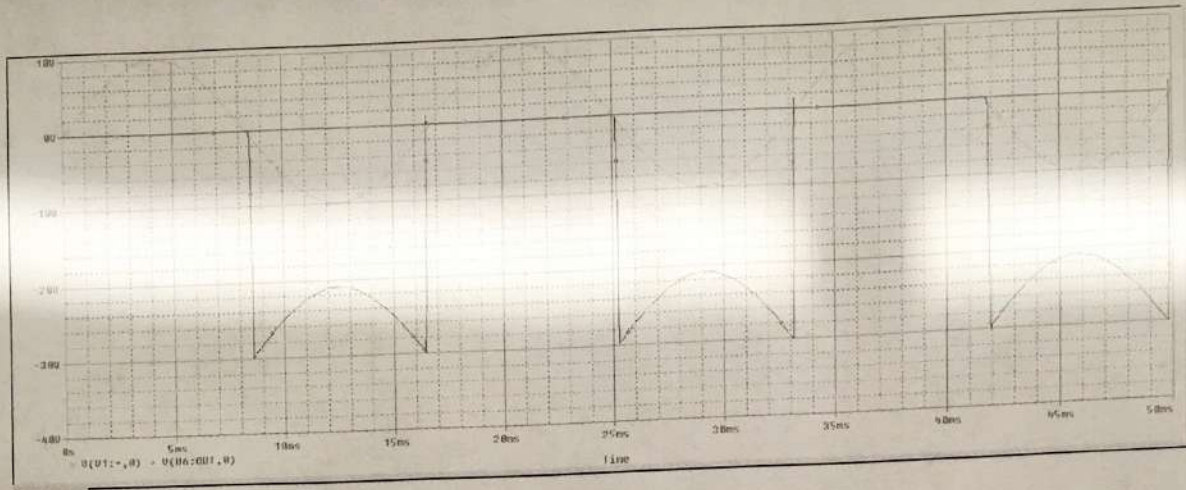


(10K Ohm resistors)



3- B2) D1N4001





3-B3) D1N5765

