Abu Dhabi University

Electric Circuits

Design Project
Problem 7.89

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Section 1

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Abstract

The design project is to solve Problem 7.89 (page 281) of the text book. I solved the problem analytically and also using the MULTISIM.

1 Question

The voltage pulse shown in *Figure 1* is applied to the ideal integrating amplifier shown in *Figure 2*. Derive the numerical expressions for v(t) when v(0) = 0 for the time intervals

a) $t < 0$.

b) $0 \leq t \leq 250$ ms.

c) 250 ms $\leq t \leq$ 500 ms.

d) 500 ms $\leq t < \infty$.

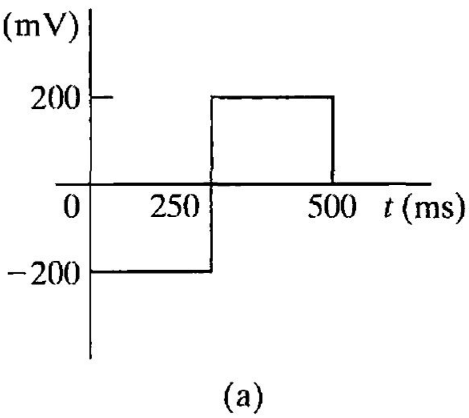


Figure 1: Voltage Pulse

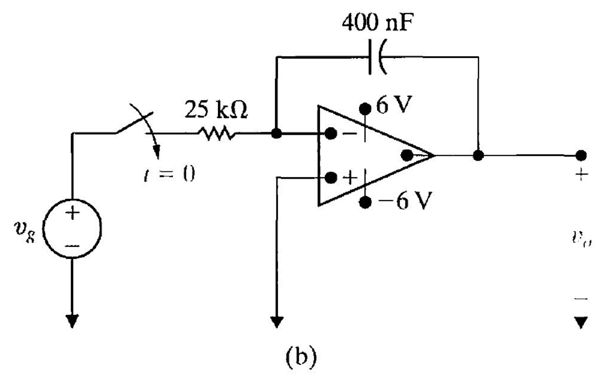
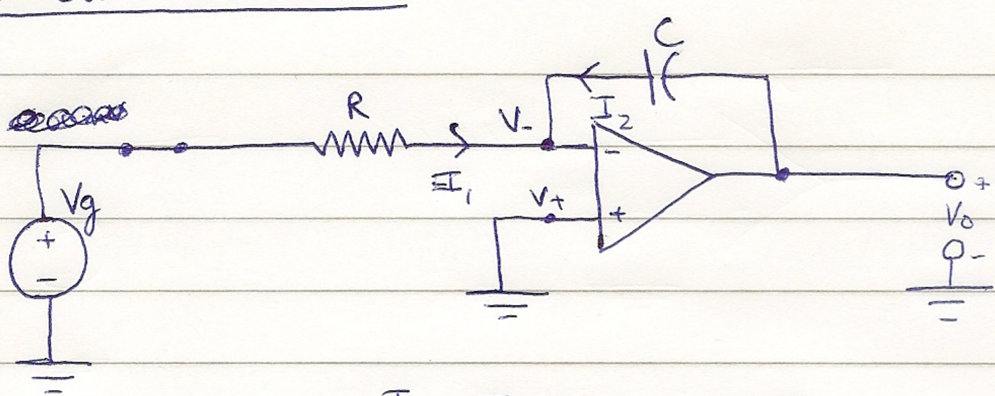


Figure 2: Integrating Amplifier

2 Answer

When switch is closed



$$I_1 + I_2 = 0 \rightarrow (1)$$

$$\therefore V_- = V_+ = 0$$

$$I_1 = \frac{V_g}{R} \rightarrow (2)$$

$$I_2 = C\frac{dV_o}{dt} \rightarrow (3)$$

By (2) & (3) & (1)

we get
$$\frac{V_g}{R} + C\frac{dV_o}{dt} = 0$$

$$C\frac{dV_o}{dt} = -\frac{V_g}{R}$$

$$\frac{dV_o}{dt} = -\frac{V_g}{RC}$$

$$dV_o = -\frac{V_g\,dt}{RC}$$

$$\int_0^t dV_o = -\frac{1}{RC}\int_0^t V_g \cdot dt$$

$$\boxed{V_o = -\frac{1}{RC}\int_0^t V_g\,dt}$$

a) Switch is open, therefore no current is passing through V_- terminal and also $V_+ = 0V = V_-$ so V_o at any time $< 0s$ is $V_o = 0$.

b) $0 \leq t \leq 250ms$

$V_g = -200\ mV$ in this interval

Using formula on previous page

$$V_o = -\frac{1}{25\times10^3 \times 400\times10^{-9}} \int_0^t -200\times10^{-3}\, dt$$

$$\therefore \boxed{V_o = +100 \int_0^t +200\times10^{-3}\, dt}$$

↖ for any time between 0 and 250ms

c) $250ms \leq t \leq 500ms$

$V_g = +200mV$ for this interval

At $t = 250ms$ what is V_o?

$V_o = +100\,(200\times10^{-3} \times 250\times10^{-3})$

$\boxed{V_o = 5V}$ at 250ms

Applying formula

$$V_o = -100 \int_0^t V_g\, dt$$

$$V_o = -100 \int_{t_0}^t V_g\, dy + V_o(t_0)$$

$$\therefore \boxed{V_o = -100 \int_{250\times10^{-3}}^t 200\times10^3\, dy + 5}$$

d) $500\,ms \leq t < \infty$

$V_g = 0\,mV$ for this interval

At time = 500ms what was V_o?

$$V_o = -100 \int_{250\times10^{-3}}^{500\times10^{-3}} 200\times10^{-3}\,dy + 5$$

$$V_o = -100\left(200\times10^{-3}\left(500\times10^{-3} - 250\times10^{-3}\right)\right) + 5$$

$$V_o = -100\,(0.05) + 5$$

$$V_o = -5 + 5$$

$$V_o = 0$$

V_o at 500 ms = 0V

Applying formula

$$V_o = -100 \int_{500\times10^{-3}}^{t} 0 + 0$$

$\therefore V_o = 0$ for any time between ∞ and 500ms

This is true because capacitor has fully discharged.

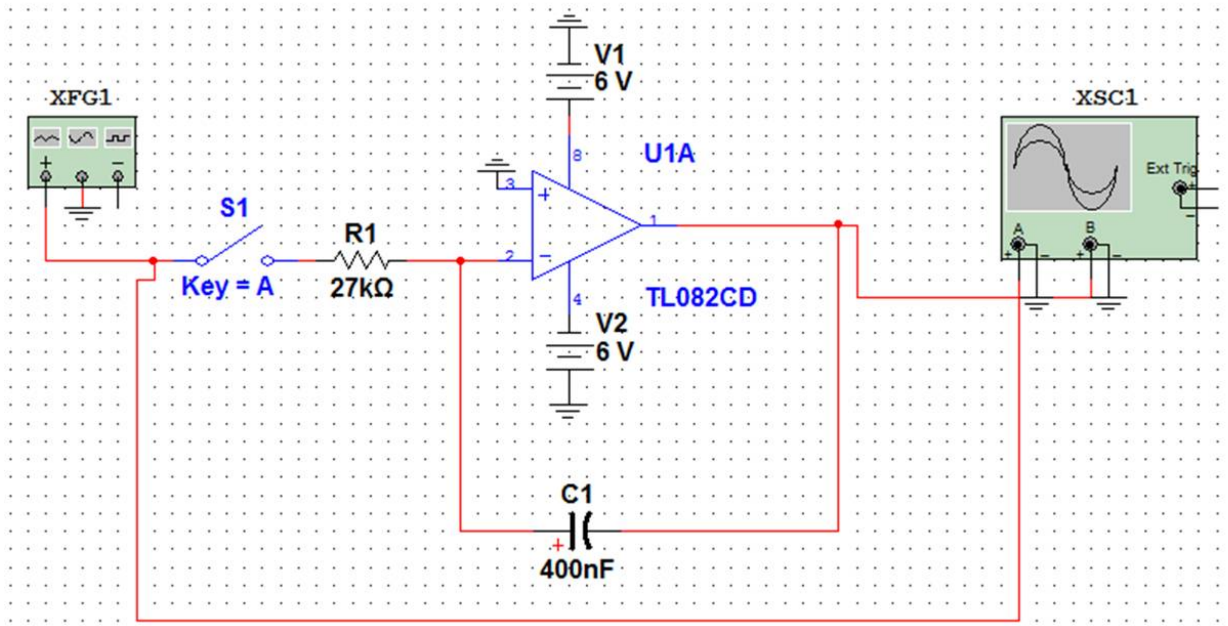


Figure 3: The following circuit was drawn and simulated in Multisim XFG1 is the function generator set according to figure 4. XSC1 is an oscilloscope to compare input and output signals

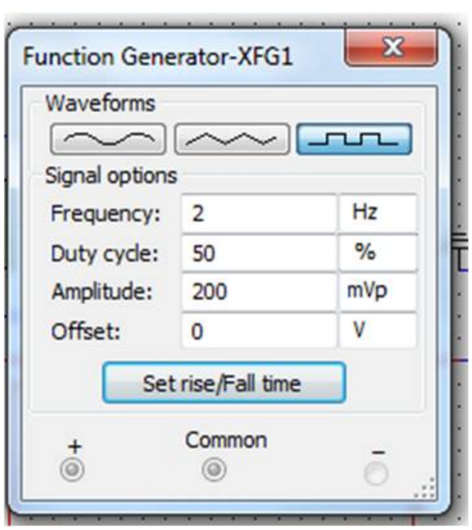


Figure 4: The Frequency Generator producing square wave of these features was provided as Vg to Negative input of Amplifier

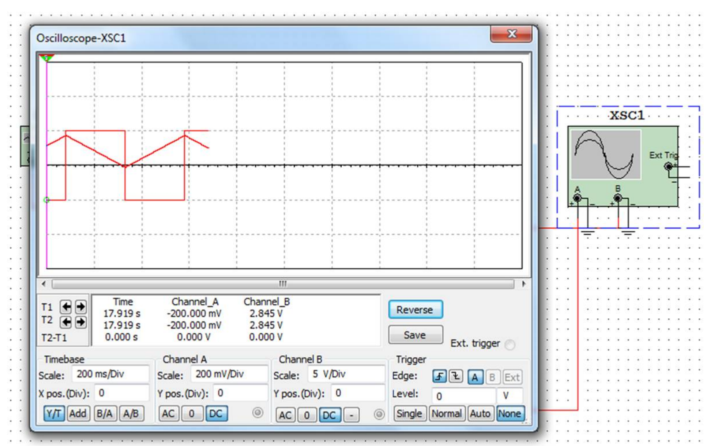


Figure 5: Seeing input Vg from Channel A and output Vo from Channel B

Detailed Analysis of the input voltage Vg and output voltage Vo showed that my equations resulted in close approximations

For Example:

Vo at time t = 0 ms is Approximately 0 V.

Vo at time t = 250 ms is Approximately 5 V.

Vo at time t = 500 ms is Approximately 0 V.

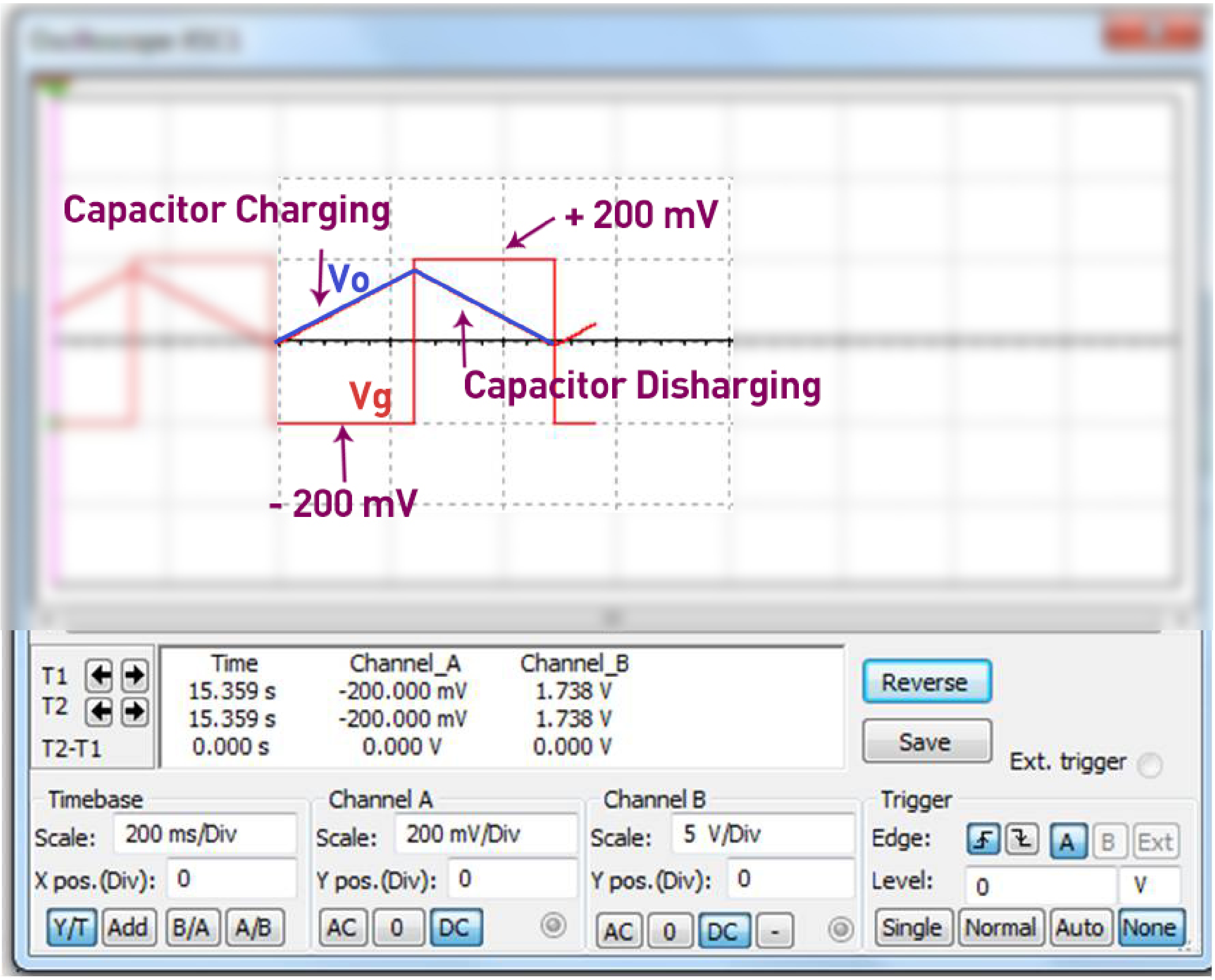


Figure 6: Detailed Explanation of the results using one portion of the signal at input Vg