110703056 - 資料四 - 徐宏宇

Electronic Circuits
Term exam and demo: Spring 2025
(Design, Take home) May 14, 2025, 8:00 ~ May 28, 2025 23:59
(Lab Demo, On site) June 04, 2025, 9:10 ~ June 04, 2025 12:00.

Design problem. You should explain to me how you find out the answer except only values. Grading will depend on if you can convince me that you know how the circuit works. You can refer to the note in lab04 and lab07.

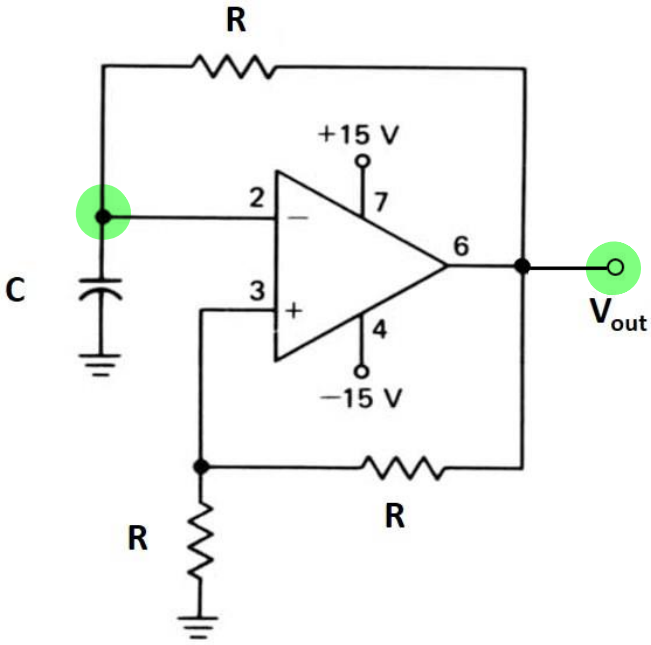
1. The 1st circuit is a relaxation oscillator, which uses RC circuit with positive feedback.

(a) What is the waveform of the output signal (pin6)?

(b) Derive the relationship between the output signal frequency and the values of R and C.

(c) Calculate the peak voltage (V_p) and frequency (f) of the output signal (V_{out} at pin6) Given R=10 kΩ and C=0.1 uF.

(d) Explain how to adjust the frequency of the output signal?



(a) square wave (b) $f = \frac{0.455}{RC}$ (Hz)

(c) $V_p = V_{SAT}$ if the op-amp is rail-to-rail 15 (V)

$f = \frac{0.455}{(10 \cdot 10^3)(0.1 \times 10^{-6})} = 455$ (Hz)

(d) Adjust the C or R

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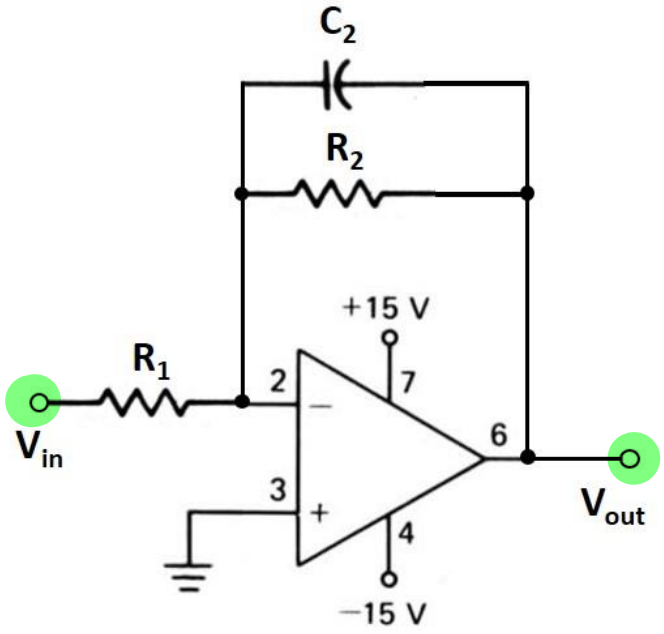
2. The 2nd circuit is an integrator. → { W2: integrator & differentiator / W7: op-amp integrator

(a) When the input of the circuit is a square wave, what is the resulting waveform of the output signal (V_{out} at pin6)?

(b) Under what condition can resistor R_2 be neglected in the circuit analysis? Please explain

(c) Derive the relationship between the peak value of the output and the peak value of the input signal.

(d) Given R_1=10 KΩ, R_2=1MΩ, and C_2=0.1uF, calculate the peak voltage (V_p) and frequency (f) of the output signal (V_{out} at pin6), assuming the input is the output from the 1st circuit?



(a) triangular wave

(b) When $X_c \to \infty$

$$\left(X_c = \frac{1}{2\pi f C} \right)$$

$\Rightarrow$ when $f \to 0$

(c) $$V_{out} = \frac{Q}{C} = \frac{i_{out}\, t}{C} \quad \left(i_{out} = -\frac{V_{in}}{R} \right) = -\frac{V_{in}}{CR} t$$

$$\Rightarrow V_{out(max)} = \frac{V_{in(max)}}{CR} \frac{T}{4} = \frac{V_{in(max)}}{4fCR}$$

(d) $$V_p = \frac{15}{4\left(\frac{0.455}{RC}\right)RC} = \frac{15}{4 \cdot 0.455} \approx 8.24 \text{ (V)}$$

f is same as the 1st circuit = 455 (Hz)

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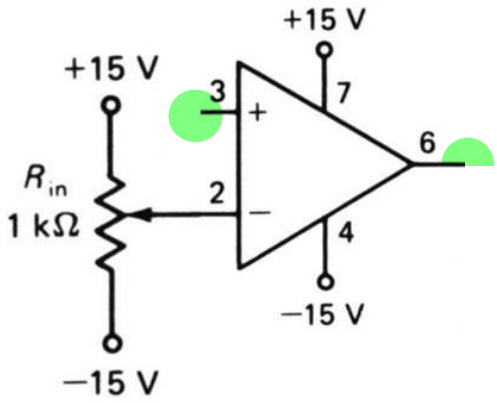
3. The 3rd circuit is a comparator. Using 1st, 2nd and 3rd circuit, please design a circuit to generate a **square wave** with **80% duty cycle.**

(a) Draw the circuit of your design.

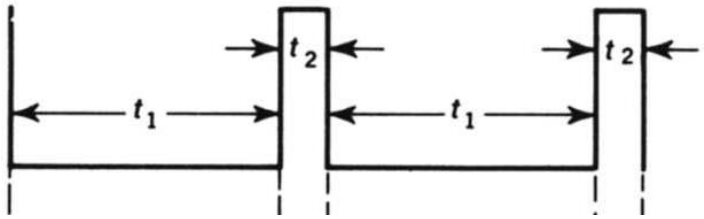
(b) Explain how the duty cycle can be adjusted?

(c) Can the circuit be modified to generate a square wave with a 30% duty cycle? Please explain how.



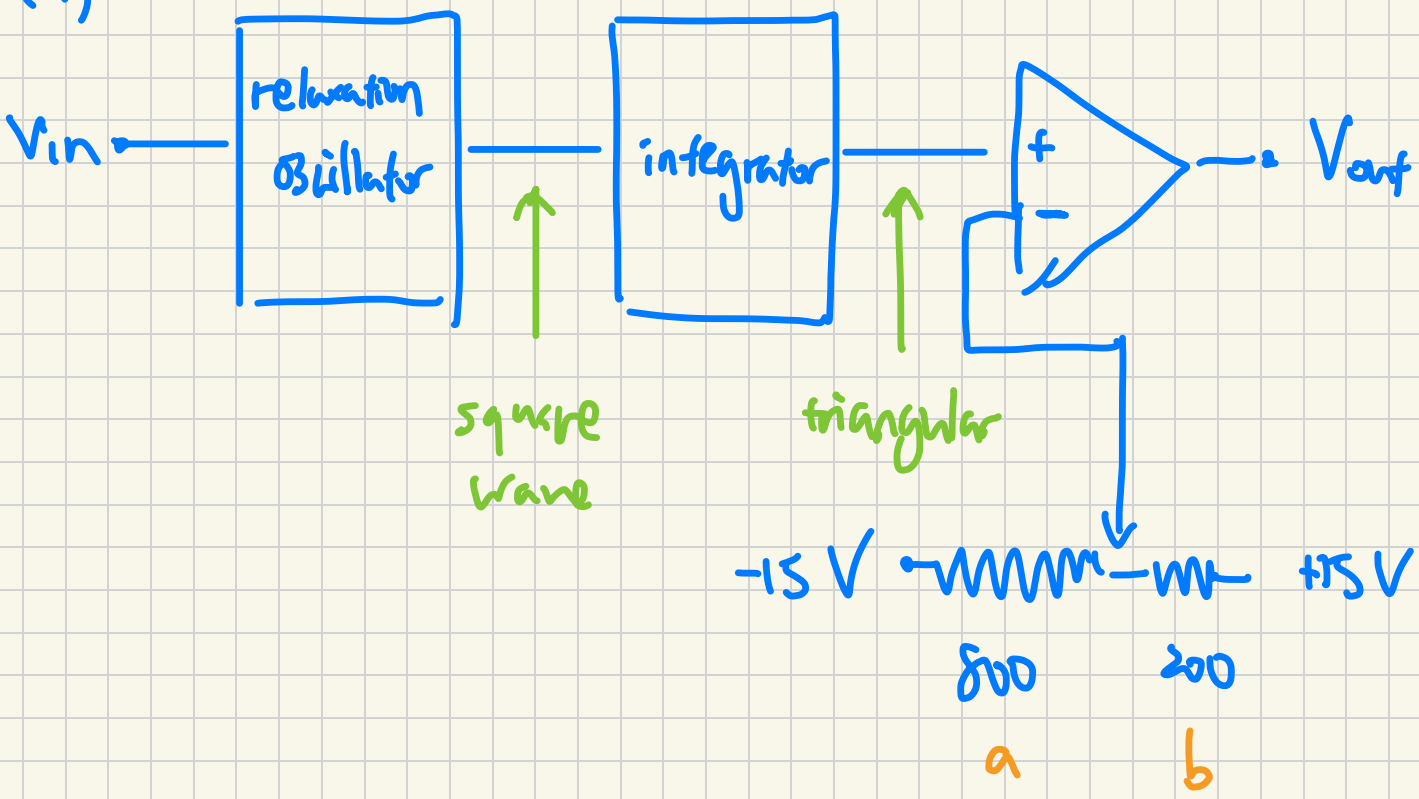
NOTE: The duty cycle of a square wave is defined as the ratio of high period to the total period of the square wave. The formula of duty cycle is

$$\text{Duty cycle} = \frac{t_2}{t_1+t_2}$$



Lab demo. The lab demo is scheduled for 6/04, 9:10~12:00 in the classroom.
Please complete the circuit required in Design Problem 3 and demonstrate that the experimental results observed on the oscilloscope match your calculated values. During the lab demo, you may either use your own design or follow the example circuit provided on the board. I will verify the following aspects of your circuit: waveform, peak voltage (Vp) and frequency of 1st, 2nd circuits, the final 80% duty cycle square wave.

1. (a)



(b) Adjust the potentiometer in the comparator

(c) Yes, adjust the potentiometer to $a = 300\ (\Omega)$