

Note:

This part is for 2 hours, and carries maximum of 40 points.

1. Construct the circuit given below on your breadboard: (**Note: Do not connect $-12V$ to LM358. Only use $+12V$ and ground.**)

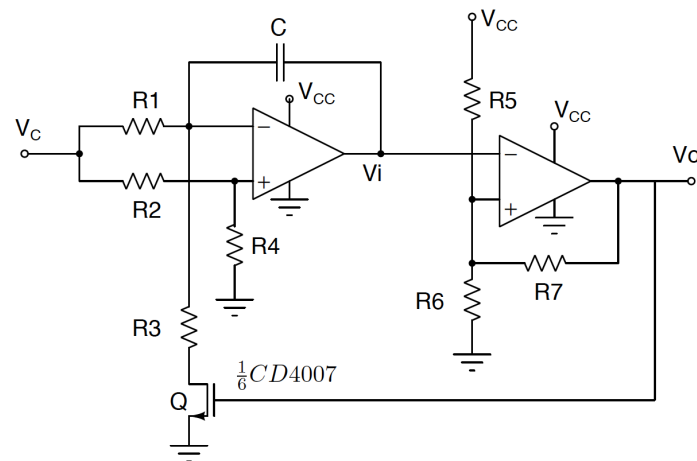


Figure 1: Use $R1=R5=R6=R7=100k\Omega$, $C=470pF$, $R2=R3=R4=50k\Omega$. Use two $100k\Omega$ resistors in parallel to get $50k\Omega$ resistors.

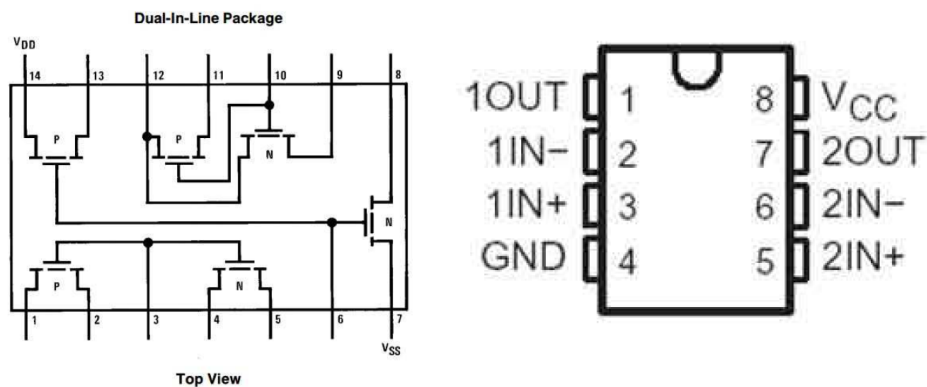


Figure 2: Pin diagram for CD4007 and LM358 (2 op-amps internally)

- (a) (10 points) Apply $V_c = 1V$ DC, $2V$ DC, and a $2Vp-p$, $50Hz$ square wave with DC offset of $+2V$, and test the circuit. Show all V_i and V_o waveforms to the TA.

For TA use, Q1(a): Please circle one of the options below and sign.

- Demo **IS** successful. :)
- Demo **IS NOT** successful. :(

- (b) (4 points) Connect DC voltage source to V_c . Vary the voltage from 1V DC to 10V DC and observe how the output V_o varies. Decide which parameters must be recorded for the waveforms, and record the key parameters (measurement table) of the output for each case in your answersheet.
- (c) (4 points) Draw the observed oscilloscope waveforms in answer paper at V_o and V_c with voltage levels and frequency clearly mentioned, for $V_c = 1V$.
- (d) (2 points) Explain your observations (in words).
2. Construct a circuit that can generate square waves of different frequencies (any frequency range, max. frequency not exceeding $10kHz$) controlled by an user using switches. The user could then simply change the switch combination to generate different frequencies instead of using a function generator to obtain frequency response.
- (a) (10 points) Using the 4-position slider switch provided to you, and the inventory (6 quantities of $1k\Omega$, 1 each of 100Ω , $1.2k\Omega$, $3.9k\Omega$ and $6.8k\Omega$ - you may use series and/or parallel combinations; and one TL072 IC, which can use $\pm 12V$ supplies), design a circuit that can generate 16 equi-spaced DC voltage values to be used with circuit of part B-Q1 (at node V_c). You may use appropriate fixed DC voltage input to your circuit (must be a constant value). **You are not allowed to use a function generator.** Draw the circuit diagram of your proposed circuit, and **justify your answer with analysis/derivation**. (Note that V_c can only take values between 0V to 12V)

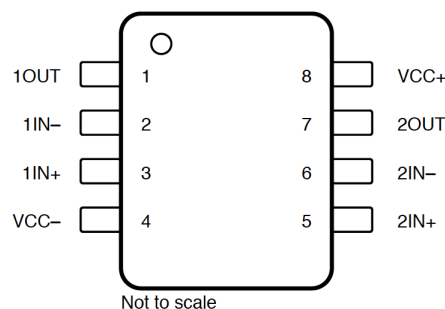


Figure 3: Pin diagram for TL072

- (b) (10 points) Collect the required components from your TA and construct your proposed circuit. Connect its output to the input V_c of circuit in part B-Q1. Use the slider switch to obtain square wave output, whose frequency can be changed by changing the switch combinations. The frequencies could be in any range of your choice, provided the upper limit is $10kHz$. Show the square waves, and voltage at node V_i to your TA and have them sign in the space below. Record your measurement table (switch combination, DC voltage V_c , and frequency of square wave).

For TA use, Q2(b): Please circle one of the options below and sign.

- Demo **IS** successful. :)
- Demo **IS NOT** successful. :(