EE230 MIDSEM

Name: **Roll No.**

Midsem Exam (25 marks) Date: February 17, 2024

Instructions:

- Write your name and roll no. on the question paper and answer sheet.
- **Make sure that you have tested all the equipments on your workstation and the components/ ICs provided to you.**
- **No help will be given in circuit debugging and handling the equipment.**
- Write your observations, input-output waveforms with proper labelling (x and y axis markings) in the answer sheet.
- **Show your waveforms, observations written on the answersheets to your TA and get signature with time stamp from the TA, wherever asked in the questions.**
- **No demo, no credit. TAs will evaluate you based on the answers written in the answer sheet and waveforms demonstrated to the TAs.**
- Submit your question paper and answer sheet to your TA.
- Use +/- 15 V as supply voltages for the OP-AMP.

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1. **Testing of IC TL071:**
You'll be using TL071 OPAMP IC to perform this experiment. Refer pinout diagram in Fig.[4]. Test both the TLO71 ICs in a unity feedback configuration as shown in Fig.[1]. Apply a sine wave of 1 KHz, 2V$_{pp}$ as the input signal V_{in}, power supply of $\pm 15V$ and check your output V_{out}. Once you are sure that V_{out} is as expected, show the output waveform to your TA for both the ICs and proceed for the next question. [2 Marks]

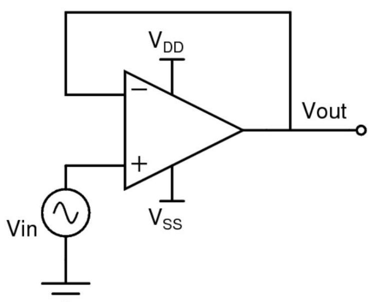

Figure 1: Buffer Circuit

2. **Triangular Wave Generator:**
In the given question you are going to design a Triangular Wave Generator as shown in Fig.[3]. The question is divided into three parts. In the first part you will be analyzing the given circuit. In the second part you will determine component values according to given specifications and in the last part you will build the circuit on the breadboard and show the results experimentally.

   1. **First Part: Analysis of the circuit:**
      (a) **Analysis of the sub-circuit 1:** [0.5+1+0.5+1+3 = 6 Marks]
         i. Identify the type of feedback?
         ii. What is this circuit commonly called as?
         iii. Is Virtual Ground applicable in this sub-circuit?
         iv. Draw sub-circuit 1. Consider input V_{in} and output V_{out1}. **Correctly mark the direction of current through the resistors R1 and R2** while deriving the expression for Upper Threshold Point (UTP) and Lower Threshold Point (LTP) .
         v. Test the circuit by considering R1= 1KΩ and R2= 2.2KΩ. Apply V_{in}=20V_{pp} and 1 KHz sine wave. Show the V_{out1} and V_{in} waveforms simultaneously on DSO. Determine UTP and LTP and verify with the expression derived by you.
      (b) **Analysis of the sub-circuit 2:** [0.5+1+0.5+3 = 5 Marks]
         i. What is the type of feedback?
         ii. What is the circuit commonly called?
         iii. Is Virtual Ground applicable in this sub-circuit?
         iv. Consider input V_{input} labelled as V_{out1} in Fig.[3] and output V_{output} labelled as V_{out2}. Derive the following:
            i) Current through the resistor R3 (**Assume direction as per your choice**) ?
            ii) Current through the capacitor C1 (**Assume direction as per your choice**) ?
            iii) V_{output} in terms of V_{input}.
      (c) **Analysis of the Integrated Circuit:** [2+4 = 6 Marks]
      In this section we will be analyzing the complete circuit given in the Fig.[3]. Consider the initial conditions of the circuit as:
         - V_{out1} = + V_{sat}.
         - V_{out2} = V_{UTP}.
         - V_{C1} = V_{UTP}. (Voltage across capacitor C1)
         i. Draw the waveform for V_{out1} and V_{out2} w.r.t. time in the plot given in Fig.[2] with proper annotations and relevant equations.
         ii. Derive the expression for frequency and peak to peak amplitude of V_{out1} and V_{out2}.

      (**HINT** : The comparator will switch from +V_{sat} to -V_{sat} when the applied feedback voltage makes the non-inverting terminal of the first OPAMP to 0 V. The behavior is similar for switching between -V_{sat} to +V_{sat}.

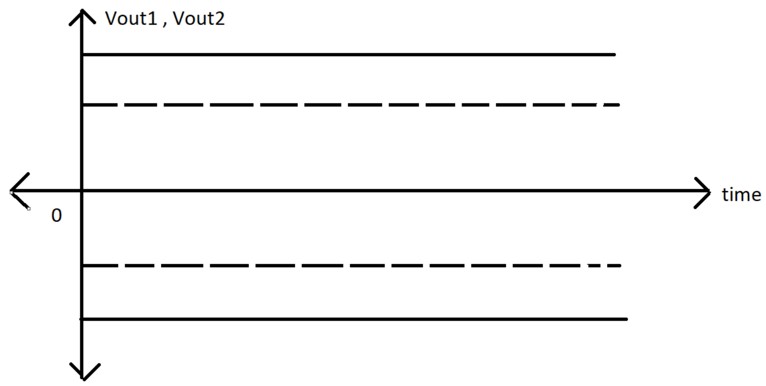

Figure 2: Template to draw waveforms for V_{out1} and V_{out2}

2. **Second Part: Determining component values** [2 Marks]
In this section we will calculate the component values to design triangular waveform generator circuit to meet required specifications.
   (a) Determine the component values for the circuit given in Fig.[3] such that the Triangular Wave has a frequency of 2.5 KHz and 20 V_{pp} amplitude.
   Design Constraints:
   You are provided with one 1 KΩ, one 10 KΩ potentiometer and a capacitor C1 of value 100 nF.

3. **Third Part: Hardware Implementation** [4 Marks]
   (a) Build the circuit as shown in Fig.[3]. Choose the appropriate values from the available components. You can connect the two potentiometers to tweak the circuit if needed, to get frequency very close to 2.5 KHz and peak to peak amplitude of 20 V_{pp} at V_{out2} .
   (b) Tabulate the frequency and peak to peak voltage of Triangular and Square Wave.

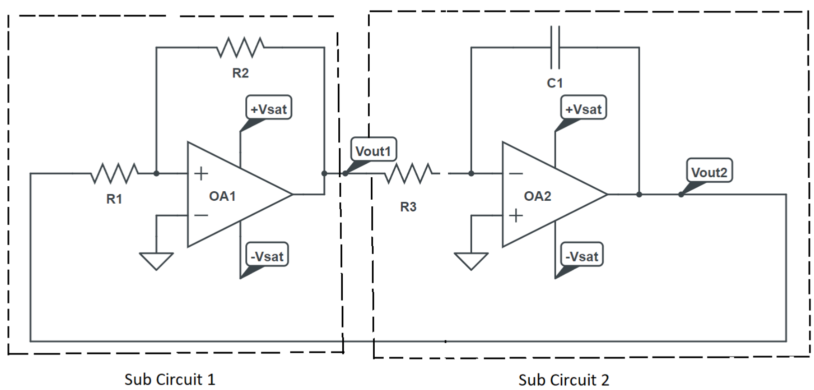

Figure 3: Triangular Wave Generator

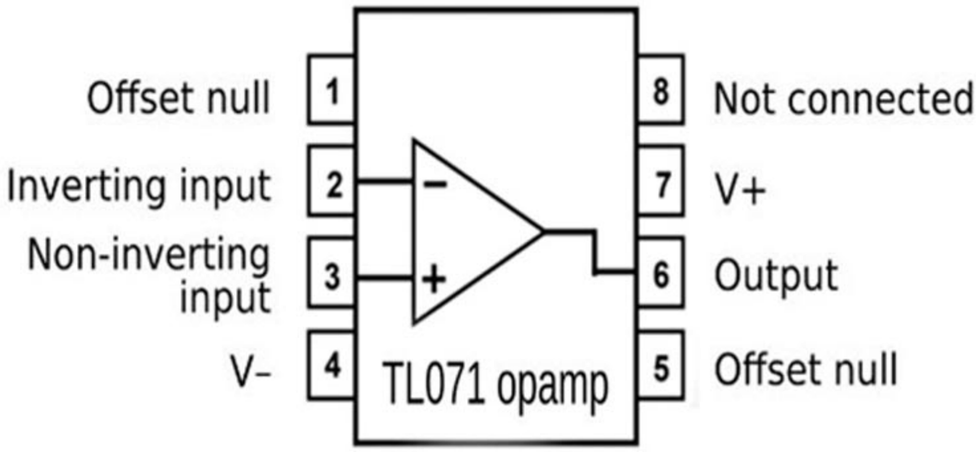

Figure 4: Pinout of TL-071 IC

Value	Value	Value	Value	Value	Value	Value
1 Ω	10 Ω	100 Ω	1 kΩ	10 kΩ	100 kΩ	1 MΩ
1.2 Ω	12 Ω	120 Ω	1.2 kΩ	12 kΩ	120 kΩ	1.2 MΩ
1.5 Ω	15 Ω	150 Ω	1.5 kΩ	15 kΩ	150 kΩ	1.5 MΩ
1.8 Ω	18 Ω	180 Ω	1.8 kΩ	18 kΩ	180 kΩ	1.8 MΩ
2.2 Ω	22 Ω	220 Ω	2.2 kΩ	22 kΩ	220 kΩ	2.2 MΩ
2.7 Ω	27 Ω	270 Ω	2.7 kΩ	27 kΩ	270 kΩ	2.7 MΩ
3.3 Ω	33 Ω	330 Ω	3.3 kΩ	33 kΩ	330 kΩ	3.3 MΩ
3.9 Ω	39 Ω	390 Ω	3.9 kΩ	39 kΩ	390 kΩ	3.9 MΩ
4.7 Ω	47 Ω	470 Ω	4.7 kΩ	47 kΩ	470 kΩ	4.7 MΩ
5.6 Ω	56 Ω	560 Ω	5.6 kΩ	56 kΩ	560 kΩ	5.6 MΩ
6.8 Ω	68 Ω	680 Ω	6.8 kΩ	68 kΩ	680 kΩ	6.8 MΩ
8.2 Ω	82 Ω	820 Ω	8.2 kΩ	82 kΩ	820 kΩ	8.2 MΩ

Figure 5: Standard Resistors values with a tolerance of $\pm 10\%$