EE204: Analog Circuits

Dept of Electrical Engineering, IITB

Autumn Semester 2023

Assignment 4 **Date: 02-10-2023**

Total Marks: 10

Submission Deadline: 11:59 p.m., 07-10-2023

Mode of submission: Scan your assignment and upload on Moodle as a single pdf file.

Consider ideal op-amps for both questions.

Q1*:* The Circuit shown in Figure 1(a) uses a thermistor to indicate

- If temperature(T) is already below T_{MIN} or above T_{MAX} and
- will generate a falling edge or rising edge when temperature is going below T_{MIN} or going above T_{MAX} .

D_1 and D_2 are LEDs (light emitting diodes). R_{TH} is the resistance of the thermistor of which the thermal characteristic is expressed as $R_{TH}(T) = R_{TH}(T_0)e^{B\left(\frac{1}{T}-\frac{1}{T_0}\right)}$, where T is absolute temperature in Kelvin (K). T_0 = 298 K (25^{0}C), $R_{TH}(T_0)$ = 25kΩ, B = 4000 K.

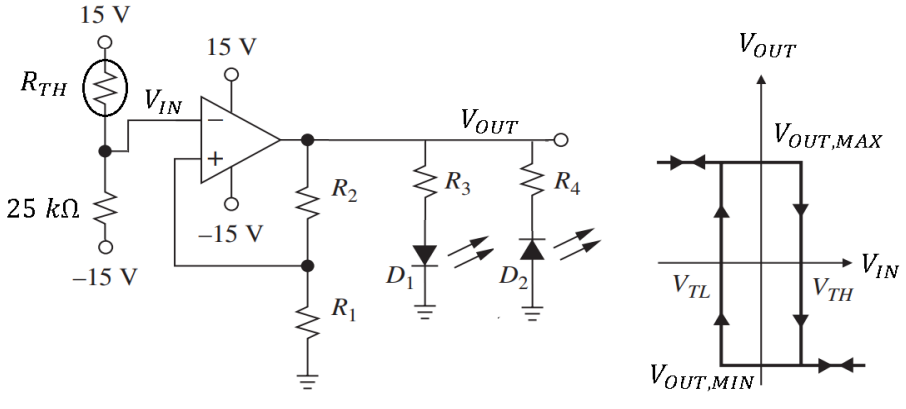
- When the temperature rises above T_{MAX} then V_{IN} exceeds V_{TH} $i.e.$ $V_{IN} > V_{TH}$ D_2 should turn on(emitting light).
- When the temperature falls below T_{MIN} and V_{IN} is lower than V_{TL} $i.e. V_{IN} < V_{TL}$ D_1 should turn on(emitting light).
- Op-Amp output saturates at ± 13V.

Figure 1(b) shows the V_{OUT} vs V_{IN} hysteresis transfer characteristic for the circuit in Figure 1(a).

You will design the schmitt trigger as per following requirements

(1) Choose R1 and R2 for your design according to limits: $1k\Omega \leq R1, R2 \leq 25k\Omega$.
(2) V_{TH} = 1.x and V_{TL} = -1.x, where x is last digit of your roll number.
(3) LED D_1 has safe forward current between 1 mA and 5 mA and forward drop is 1V.
(4) LED D_2 has safe forward current between 1 mA and 5 mA and forward drop is 2V.

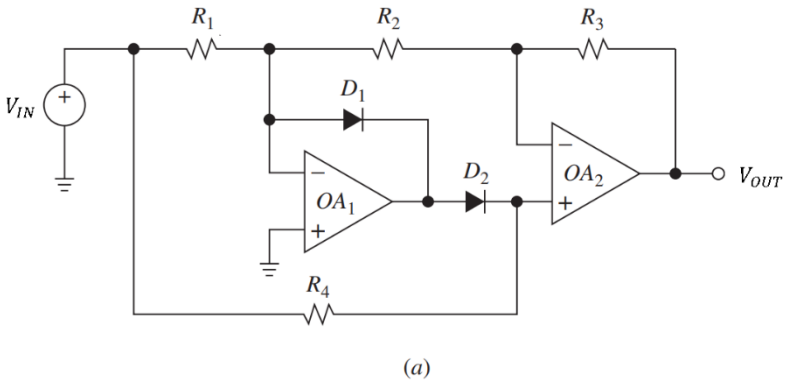
(a) Determine V_{TH} and V_{TL} for your roll number. [0.5 Marks]
(b) Determine R_1 and R_2 for above V_{TH} and V_{TL}. [1.5 Marks]
(c) Determine R_3 and R_4 as per instructions (3) and (4). [1.5 Marks]
(d) Calculate T_{MAX} and T_{MIN}. [1.5 Marks]



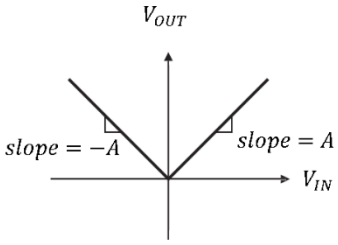
(a) *Figure 1* (b)

Q2: For the circuit shown in Figure 2(a), Op-Amps are dual supply Op-Amps and turn on voltages for D_1 and D_2 are equal to 0.7V .

(a) Derive an expression for V_{OUT} when $V_{IN} > 0$. [1 Marks]
(b) Derive an expression for V_{OUT} when $V_{IN} < 0$. [1 Marks]
(c) To achieve relation $V_{OUT} = A|V_{IN}|$, where A represents slope in Figure 2(b), what should be the relation between R1, R2 and R3. [1 Marks]
(d) Consider condition for R_1, R_2, R_3 and R_4 as $1k\Omega \leq R_1, R_2, R_3, R_4 \leq 10k\Omega$, design the full wave rectifier for A=3. [2 Marks]



(a)



(b)

Figure 2