Analog Lab
Midsem solutions & Marking Scheme
Total 25 marks

1. Testing of the IC TL071 (2 marks)

give +1 mark each of both of the IC's successfully tested.

Vout = Vin

2. Triangular Wave generator.

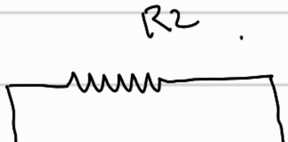
1. First Part: Analysis of Circuit

(a) Analysis of Sub circuit 1 (6 Marks)

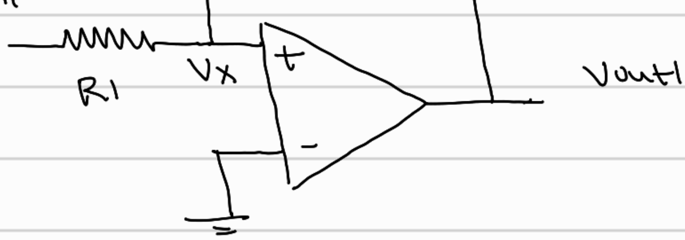
1) Positive FeedBack (0.5 mark)

2) if Schmitt trigger → 0.5 Marks
if Non-inverting Schmitt trigger → 1 mark
} 1 Marks

3) Virtual ground → Not applicable (0.5 Marks)



4) Derivation   Vin



Using KCL

$$\frac{V_x - V_{in1}}{R1} + \frac{V_x - V_{out}}{R2} = 0$$

when $V_x = 0$ the Vout would change.

@ $V_x = 0$

$$V_{in1} = \frac{R1}{R2}(-V_{out})$$

LTP

$$V_{in1} = \frac{-R1}{R2} V_{SAT} \Big\} \; 0.5M$$

UTP

$$V_{in} = \frac{R1}{R2} V_{SAT}. \Big\} \; 0.5M,$$

5) +1 marks for making the circuit
+1 marks for plotting Vin & Vo/p simultaneously on DSO
+1 marks for verifying the theoretical expression with experimental ($\pm 0.3V$)

$$V_{UTP} = \frac{R_1}{R_2} \times 15 = \frac{15}{2.2} = 6.818$$

$$V_{LTP} = \frac{-15}{2.2} = -6.818$$

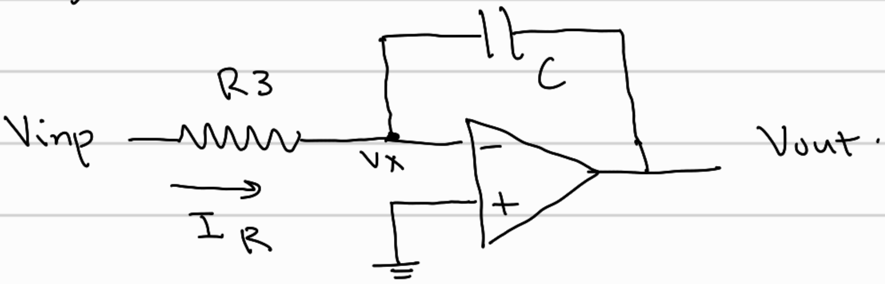
b) Analysis of Subcircuit 2 (5 Marks)

i. Negative Feedback (0.5 Marks)

ii. Integrator Circuit (1 Mark)

iii Yes (0.5 Marks)

iv).



$$I_R - I_c = 0 \quad (KCL)$$

$$q = CV$$

$$I_c = C\frac{dV}{dt} = C\frac{d(V_x - V_{out})}{dt} = \frac{-C\,dV_{out}}{dt} \quad \{\because V_x = 0\}$$

$$\boxed{I_c = -C\frac{dV_{out}}{dt}} \qquad \boxed{I_R = \frac{V_{inp} - V_x}{R_3} = \frac{V_{inp}}{R_3}}$$

$$I_R - I_c = 0$$

$$\frac{V_{inp}}{R_3} + C\frac{dV_{out}}{dt} = 0$$

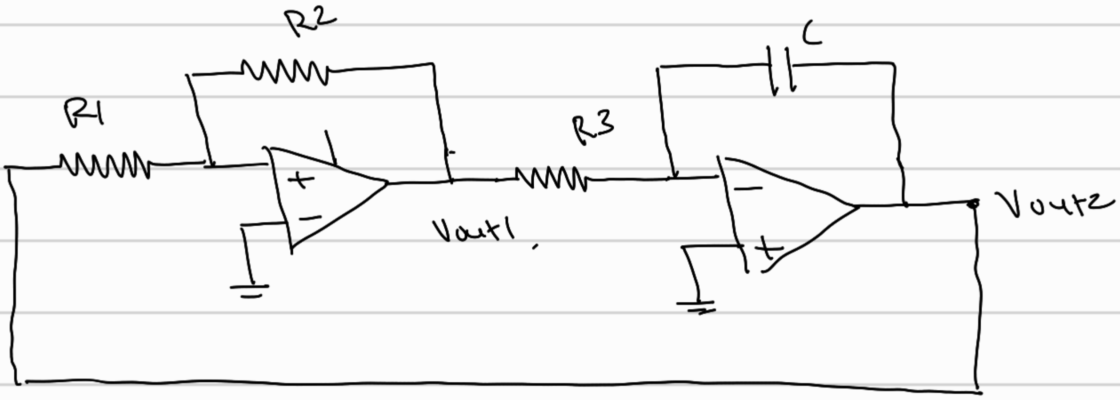
$$\boxed{V_{out} = -\frac{1}{R_3 C}\int V_{in}\,dt}$$

+1 for I_R

+1 for I_C

+1 for Vout Vs Vin

c) Analysis of Integrated Circuit (6 marks)



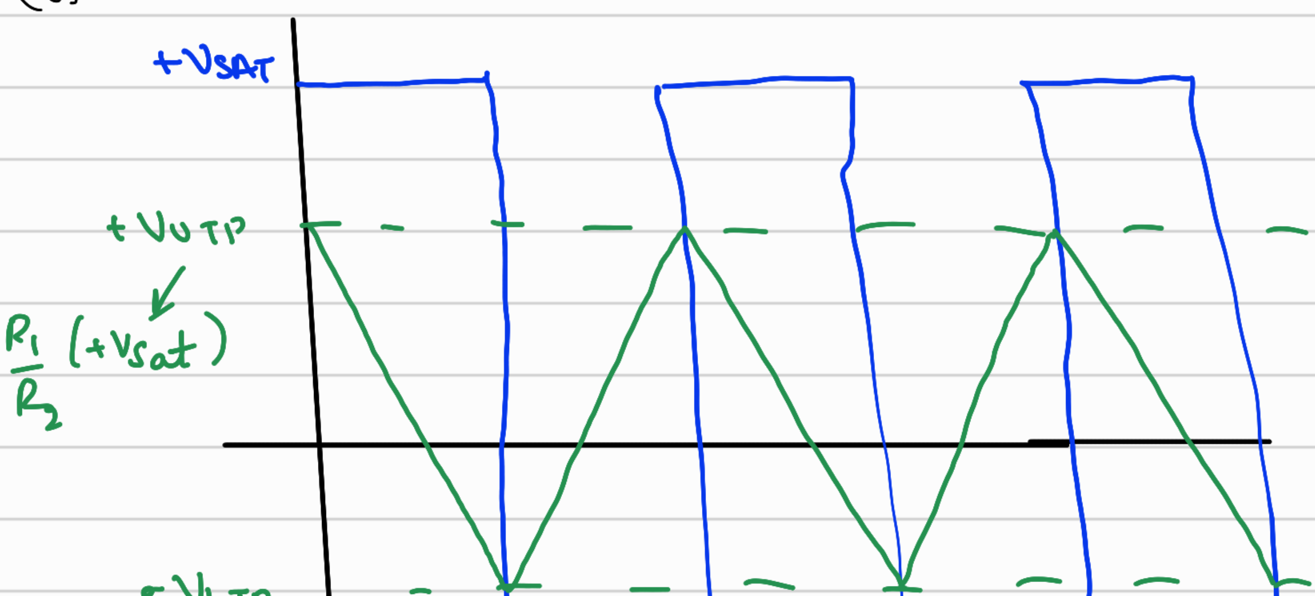
initial condition

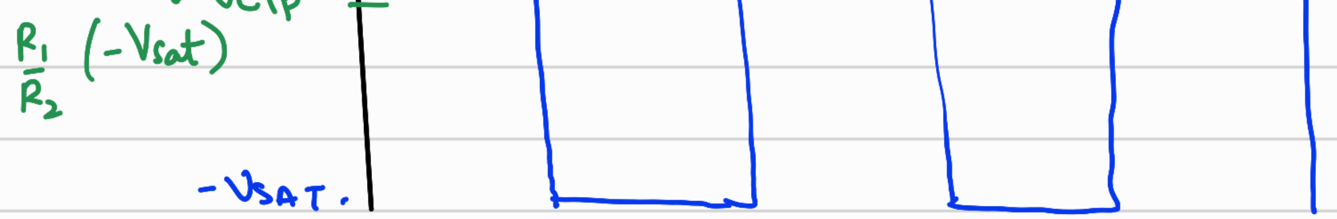
$V_{out1} = +V_{SAT}$

$V_{out2} = V_{UTP}$

$V_{C1} = V_{UTP}$.

(i)





+1 for drawing triangular wave
+1 for drawing square wave

(ii) Assuming initial condition, & also the fact that when non-inverting terminal voltage of First Op-Amp reaches zero we switch from $V_{SAT} \rightarrow -V_{SAT}$ we get.

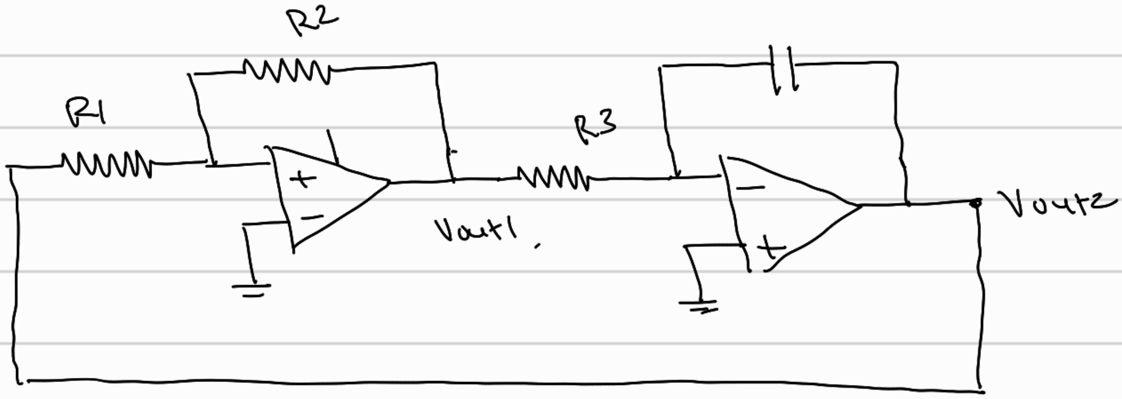
$$V_{UTP} = \frac{R_1}{R_2} V_{SAT}$$

$$V_{LTP} = -\frac{R_1}{R_2} V_{SAT}$$

$$V_{pp} = \frac{2R_1}{R_2} V_{SAT}$$

(+1 for getting peak to peak)

Also, assuming initial conditions.



$V_{out1} = +V_{SAT}$.

$$V_{out2} = -\frac{1}{R_3 C}\int_0^t + V_{out1} \cdot dt.$$

from 0 to $T/2$ the output swings from.

$V_{UTP} \rightarrow V_{LTP}$.

$$V_{out2} = -\frac{1}{R_3 C}\int_0^{T/2} V_{SAT} \cdot dt$$

$$V_{pp} = -\frac{1}{R_3 C}\int_0^{T/2} V_{SAT} \cdot dt.$$

$$\frac{2R_1}{R_2} \cancel{V_{SAT}} = -\frac{1}{R_3 C} \cancel{V_{SAT}} \frac{T}{2}$$

$$T = \frac{4 R_1 C R_3}{R_2}$$

$$f = \frac{R_2}{4 R_1 R_3 C}$$

+3 for getting expression of frequency

2. Determining the Component Values (2 marks)

(a) $V_{pp} = 20.$ +1 for getting Amp value.

$$\frac{2R_1}{R_2} V_{SAT} = 20$$

$$\frac{R_1}{R_2} = \frac{10}{15} = \frac{2}{3}$$

$$\frac{R_1}{R_2} = \frac{2}{3}$$ e.g $R2 = 1k$

$R1 = \frac{2}{3} \times 1 = 667\,\Omega$

(b) $f = 2.5kHz$

$$2.5k = \frac{R_2}{4R_1R_3C}$$

$$R_3 = \frac{R_2}{4R_1 \times 2.5\times10^3 \times 100\times10^{-9}}$$

$$R_3 = \frac{3}{4\times2\times2.5\times10^3\times100\times10^{-9}}$$

$$R_3 = \frac{3}{10\times10^3\times100\times10^{-9}\times2}$$

$$R_3 = \frac{1.5}{10^6\times10^{-9}}$$

$$R_3 = \frac{1.5}{10^{-3}}$$

$R_3 = 1.5k$

$C = 0.1\,\mu F$

+1 for getting appropriate values of R_3 & C

+1 for getting appropriate ratio from R_1 & R_2

* STUDENTS MAY USE DIFFERENT COMBINATIONS *

3. Hardware Implementation. (4 marks)

+1 for correct peak to peak values of square wave

+1 for correct frequency of square wave

+1 for correct peak to peak value of triangular wave

+1 for correct frequency of triangular wave

freq Tol = ± 100 Hz

Amp = ± 0.1 V