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i] Outline for designing the alarm circuit:-

Steps:-

① Analyzing the Problem - Statement
② finding the inputs and outputs of the system
③ Relating the inputs and outputs.
④ Creating the truth table.
⑤ Forming a Standard expression from the truth table.
⑥ simplifying the expression using K-MAP.
⑦ Designing the system circuit by logic gates.
⑧ Implementing the system with CMOS logic.

Step-1:-

There one four sensor in a car. The ignition activation system of this car is attached to a digital system. If the driver seat is occupied and the driver seatbelt is fastend or the Passenger seat is occupied and the Passenger seatbelt is fastend, then the activation system turns on. There are appropriate sensor present for detecting the above.

Step-2:-

There are appropriate sensors present for detecting the activation, which are the inputs of the system.

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Where,

A = Senson for driver seat.

B = Senson for driver seatbelt.

C = Senson for passenger seat.

D = Senson for Passenger seatbelt.

An output Y will be generated for given conditions.

Step-3:-

when A and B is high or A and B and C also D is high, the output will be high otherwise the output will be low.

Step-4:-

	A	B	C	D	Y
0	0	0	0	0	0
1	0	0	0	1	0
2	0	0	1	0	0
3	0	0	1	1	0
4	0	1	0	0	0
5	0	1	0	1	0
6	0	1	1	0	0
7	0	1	1	1	0
8	1	0	0	0	0
9	1	0	0	1	0
10	1	0	1	0	0
11	1	0	1	1	0
12	1	1	0	0	1
13	1	1	0	1	1
14	1	1	1	0	1
15	1	1	1	1	1

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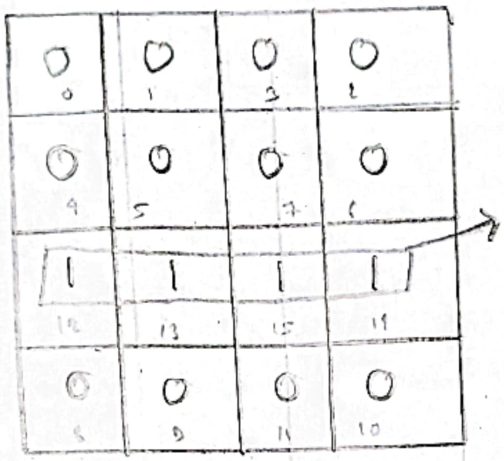
Step-5:-

$$Y = \Sigma (12, 13, 14, 15)$$
$$= AB\bar{C}\bar{D} + AB\bar{C}D + ABC\bar{D} + ABCD$$

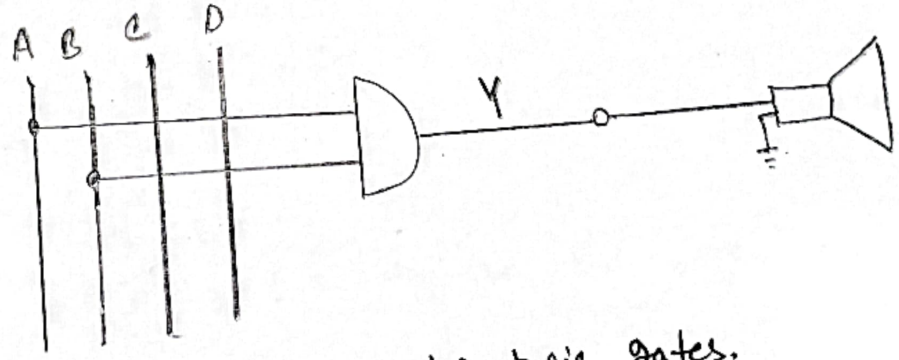
Step-6:-



A	B	C	D
1	1	0	0
1	1	0	1
1	1	1	0
1	1	1	1
A	B	x	x

$\therefore Y = AB$

Step-7:-



Design of the system using basic gates.

Here, when both A and B sensor inputs are high (1), then the output of the system will be high and the alarm speaker will get enough voltage to make or create a sound. Thus, in this way the alarm can be triggered.

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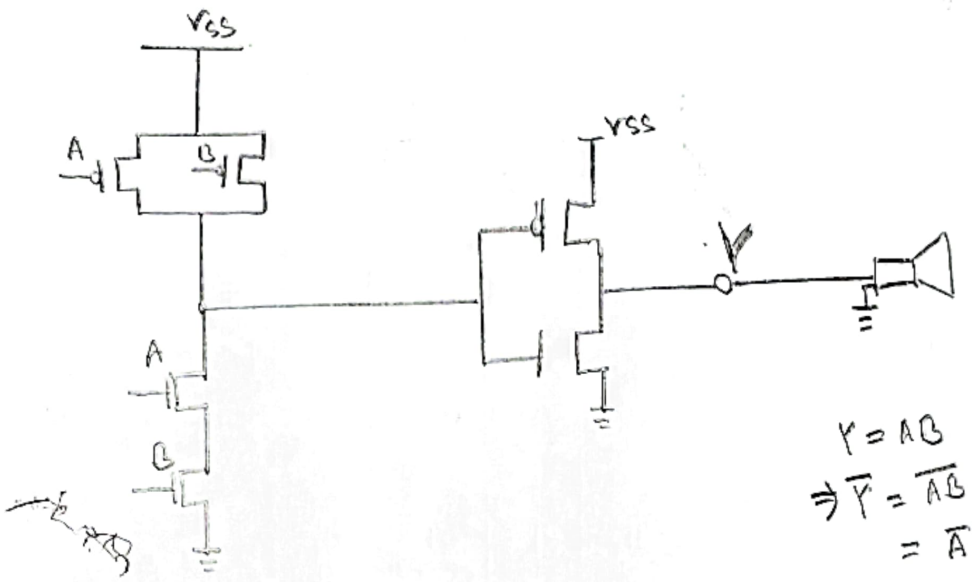
Step-8:-



$Y = AB$

$\Rightarrow \overline{Y} = \overline{AB}$ → NMOS

$= \overline{A} + \overline{B}$ → PMOS

Implementation of the system using cmos logic.

ii

ii) Given,

$P = N + O + I + S + E$

$= 9 + 7 + 0 + 4 + 8$

$= 23$

$\therefore P * 20\,Hz = 23 \times 20$

$= 460\,Hz$ [within the soothing hearing limits]

$\therefore$ frequency, $f = 400\,Hz$

Here,

$\theta = 100 - P$

$= 100 - 23$

$= 77$

$\therefore$ Duty cycle, $\theta = 77\%$

$\therefore \theta = 77\%$

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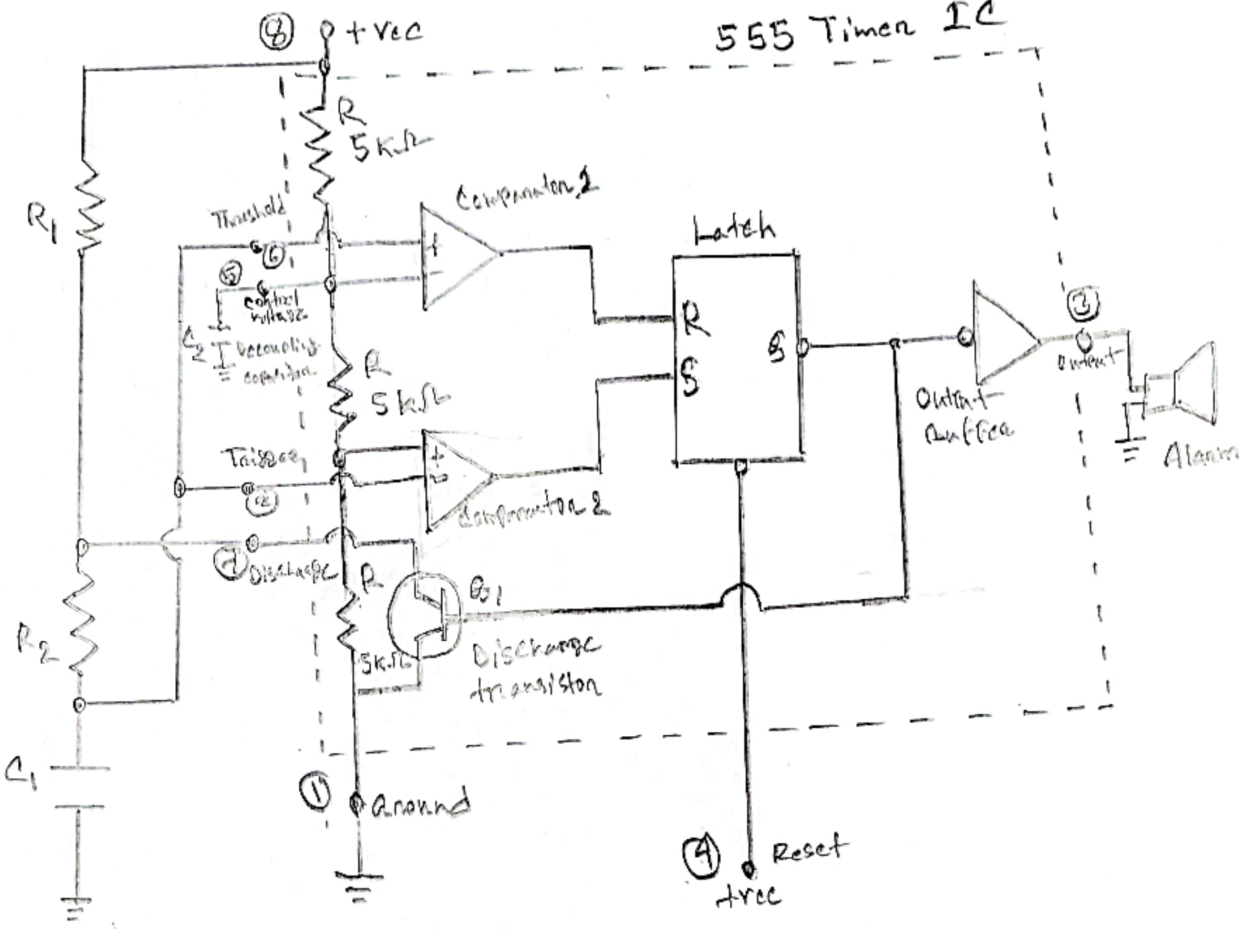
→ Now, we can design the alarm timer circuit with 555 timer IC is Astable mode.



Here,

400 Hz is not a very high frequency, so, we need a 250 μF (C_1) and a 50 μF (C_2) as decoupling capacitor.

So, Time Period, $T = \frac{1}{f} = \frac{1}{400} = 0.0025\,s$

we know, Duty cycle, $\Theta = \frac{T_H}{T}$

$\Rightarrow T_H = \Theta \times T = 0.77 \times 0.0025$

$= 0.00192\,s$

$T_L = T - T_H = 0.0025 - 0.00192$

$= 0.0006\,s$

And, $T_L = 0.693\, R_2 C_1$

$\Rightarrow R_2 = \frac{T_L}{0.693 \times C_1} = \frac{0.0006}{0.693 \times 250 \times 10^{-6}}$

$= 3.463\,\Omega$

Now, $T = 0.693\, C_1 (R_1 + 2R_2)$

$\Rightarrow R_1 = \frac{T}{0.693 \times C_1} - 2R_2$

$= \frac{0.0025}{0.693 \times 250 \times 10^{-6}} - (2 \times 3.463) = 7.504\,\Omega$

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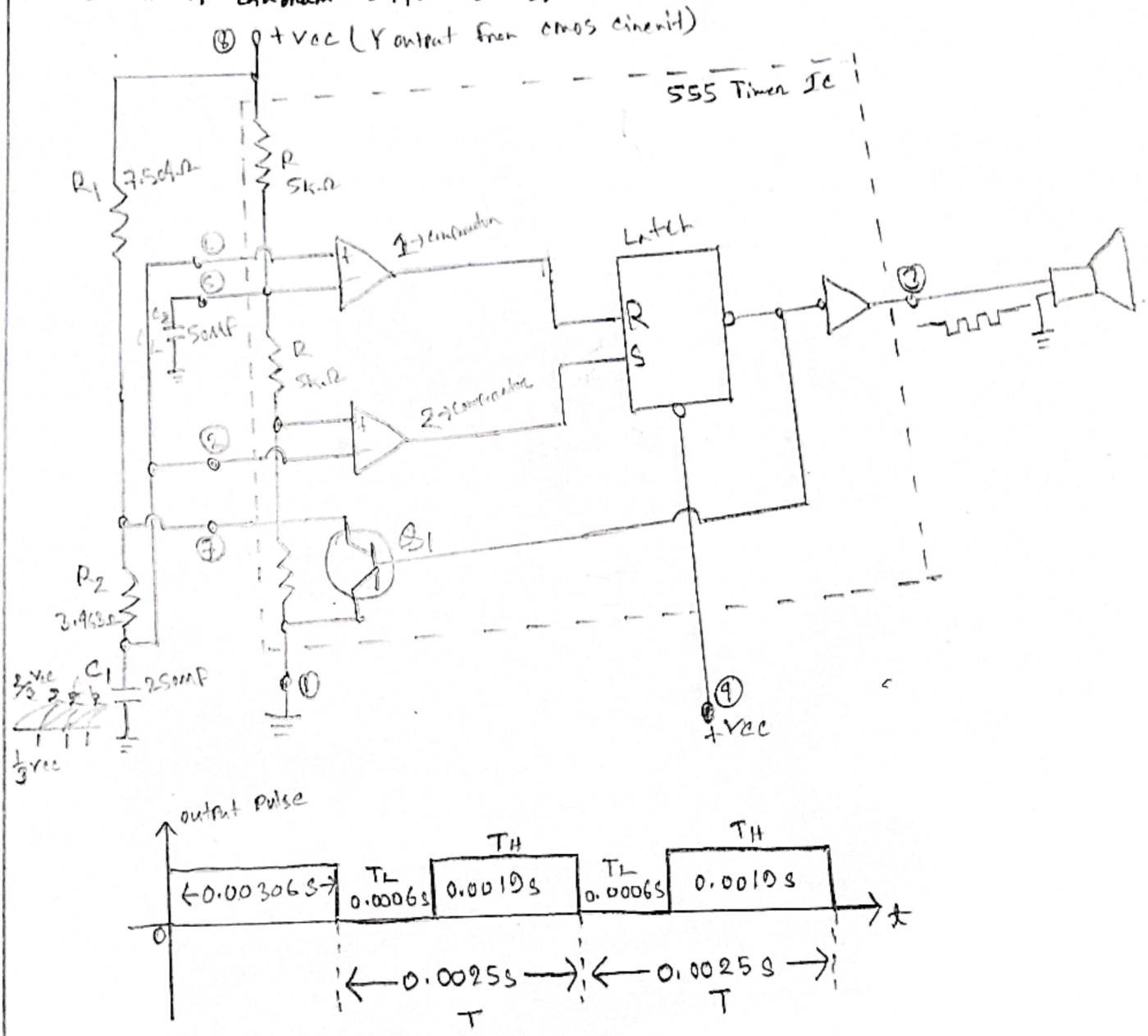
Final Circuit diagram with values:-



Initially, the capacitor takes 0.00306 s to charge from $0 - \frac{2}{3}$ Vcc.

So, we get output time period of 0.0025s after the initial 0.00306 s. That's why the alarm will be buzz for 0.0019 s - and stop for 0.0006s and it will maintain the frequency which is 400 Hz.

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iii

iii) Limitations:-

① The system heavily relies on accuracy and reliability of sensors. Any inaccuracies in these sensors can lead to false readings and incorrect activation of ignition.

② It may generate false alarms if sensors detect incorrect information.

③ It's functionality is limited to detecting driver and passenger seat occupancy and seatbelt status. It does not account for others factors that could influence safe driving condition, such as the condition of the driver, vechile speed or road conditions.

④ Any failure in the car's electrical system, such as a dead battery or other component failure could affect the function of the systems

Effect of increasing frequency above 9500Hz:-

① Frequencies above 9500Hz are considered disturbingly high pitched. Increasing the alarm frequency beyond this limit could lead to discomfort, unpleasent or even potential harm to individual's hearing.

② At higer frequency, problem can be occur with the 555 Timer IC.