IIITB COMET FOUNDATION

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GATE 2009, EC, 60^{th} Question Analysis

Question 60

60) What are the minimum numbers of NOT gates and 2-input OR gates required to design the logic of the driver for this 7-segment display?

(a) 3 NOT and 4 OR

(b) 2 NOT and 4 OR

(c) 1 NOT and 3 OR

(d) 2 NOT and 3 OR

(GATE EC 2009)

Question Analysis:

- Let the 4-bit BCD input be D, C, B, A where A is the LSB.
- Let the output of the required 7-segment driver be F.
- The segment should glow for decimal inputs $0, 2, 3, 5, 6, 7, 8, 9$ and remain OFF for $1, 4$.
- The canonical SOP expression is $F = \sum m(0, 2, 3, 5, 6, 7, 8, 9)$.
- The don't care conditions are $d = \sum m(10, 11, 12, 13, 14, 15)$.
- After Karnaugh map simplification, the minimized expression is $F = A + B + \overline{C} + \overline{D}$.
- For NOT gates, $\overline{C}$ and $\overline{D}$ are required.
- For OR gates, the implementation can be written as $F = (A + B) + (\overline{C} + \overline{D})$.
- Hence, the minimum requirement is 2 NOT gates and 3 two-input OR gates.

The Truth Table

Hardware Implementation

The above problem is implemented and tested in hardware using Arduino UNO board. Here we used a seven segment display, and inputs A B C D to display output F is 1 or 0 as per truth table and verified the expression.

Required Components & Pin Connections

S.No	Component
1	Arduino Uno Board
2	Breadboard
3	Seven segment (1)
4	Resistors: 220Ω (1)
5	Jumper Wires
6	USB Cable

Component	Arduino Pin
Output a (seg a)	Digital 2
Output b (seg b)	Digital 3
Output c (seg c)	Digital 4
Output d (seg d)	Digital 5
Output e (seg e)	Digital 6
Output f (seg f)	Digital 7
Output g (seg g)	Digital 8
GND	GND
VCC	5V

Logic Description

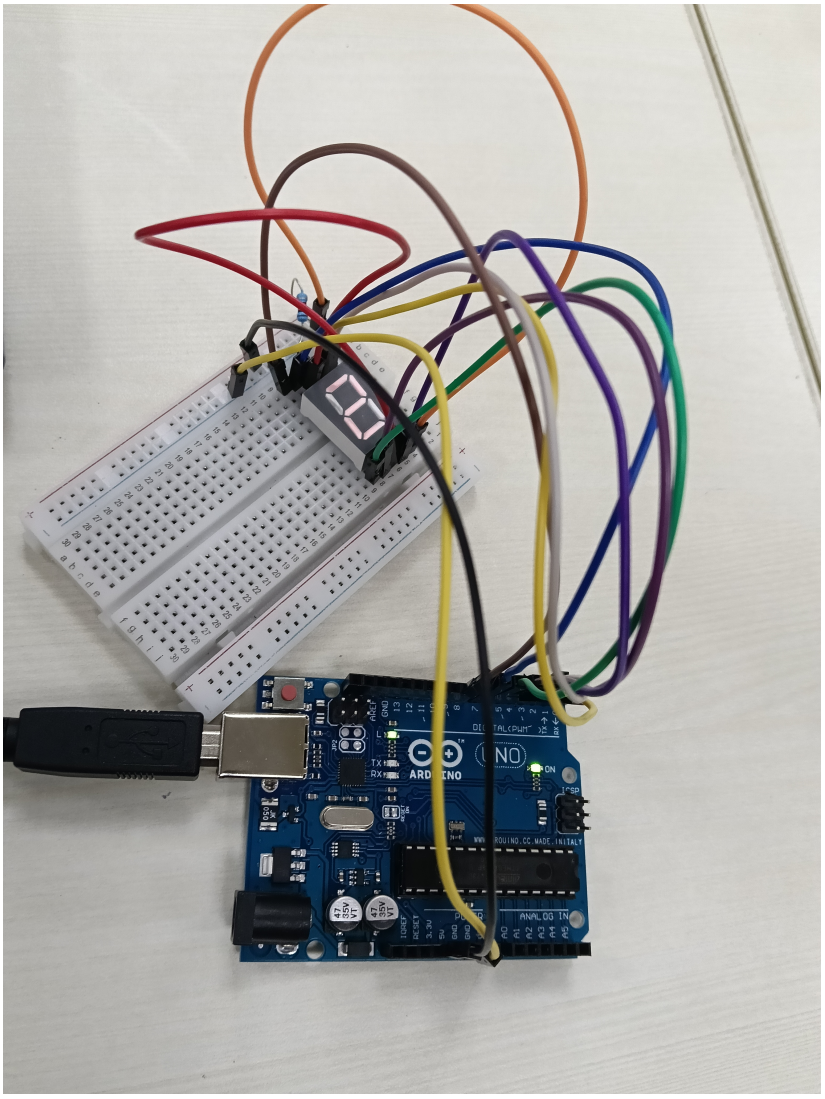
- Let the 4-bit BCD inputs be D, C, B, A.
- Initialize the inputs as $D = 0, C = 0, B = 0, A = 0$.
- Let the output of the required 7-segment driver be F.
- From the experimental truth table, the segment should glow for $0, 2, 3, 5, 6, 7, 8, 9$ and remain OFF for $1, 4$.
- The canonical expression obtained from the truth table is $F = \sum m(0, 2, 3, 5, 6, 7, 8, 9)$.
- The don't care conditions are $d = \sum m(10, 11, 12, 13, 14, 15)$.
- After Karnaugh map simplification, the minimized output expression is $F = A + B + C' + D'$.
- Implement the logic using two NOT operations to generate C' and D'.
- Combine the terms using three two-input OR gates as $F = (A + B) + (C' + D')$.
- Change the inputs as per the truth table and observe the segment display.
- The segment glows when $F = 1$ and remains OFF when $F = 0$.

Code Uploading Steps

1. Create a Platform IO project
2. Write the code in main.cpp in src
3. Run the PIO project with command "pio run". It will compile the code and create .hex file
4. Copy the .hex file to ArduinoDroid folder
5. Connect the Arduino UNO to mobile with OTG cable
6. Upload the hex file using "upload precompiled" option
7. Observe the output and verify the expression

Experimental Truth Table

Decimal	D	C	B	A	F (Output)
0	0	0	0	0	1
1	0	0	0	1	0
2	0	0	1	0	1
3	0	0	1	1	1
4	0	1	0	0	0
5	0	1	0	1	1
6	0	1	1	0	1
7	0	1	1	1	1
8	1	0	0	0	1
9	1	0	0	1	1
10	1	0	1	0	X
11	1	0	1	1	X
12	1	1	0	0	X
13	1	1	0	1	X
14	1	1	1	0	X
15	1	1	1	1	X



Conclusion

- From the experimental truth table, $F = 1$ for decimal inputs $0, 2, 3, 5, 6, 7, 8, 9$ and $F = 0$ for $1, 4$.
- The minimized Boolean expression obtained is $F = A + B + C' + D'$.
- The logic implementation requires 2 NOT gates and 3 two-input OR gates.
- This matches option (D) from the original GATE question.
- The hardware experiment confirms the theoretical logic of the 7-segment driver.