DSM Midsem Solutions

September 30, 2024

Answer 1

Subpart(a)

Simplify below Boolean function and implement using minimum NOR gates. F = $\prod(1,3,6,9,11,12,14)$ **(4)**

Can simplify to one of the below 2 methods:

POS form

To get a POS form in y, obtain the SOP form in y'.

Consider the kmap and truth table for y':

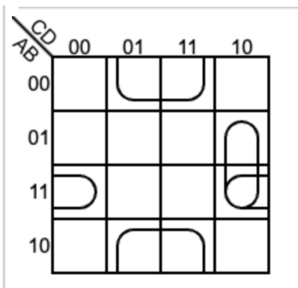


Figure 1: K-Map

Truth Table

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

Figure 2: Truth Table

$$\overline{y} = \overline{B} \cdot D + B \cdot C \cdot \overline{D} + A \cdot B \cdot \overline{D}$$

$$\overline{\overline{y}} = \overline{\overline{B} \cdot D + B \cdot C \cdot \overline{D} + A \cdot B \cdot \overline{D}}$$

$$y = (B + \overline{D}) \cdot (\overline{B} + \overline{C} + D) \cdot (\overline{A} + \overline{B} + D)$$

So simplified y in POS form:

$$y = (B + \overline{D}) \cdot (\overline{B} + \overline{C} + D) \cdot (\overline{A} + \overline{B} + D)$$

To implement circuit using nor gate:

$$\overline{y} = \overline{(B + \overline{D}) \cdot (\overline{B} + \overline{C} + D) \cdot (\overline{A} + \overline{B} + D)}$$

$$\overline{y} = \overline{(B + \overline{D})} + \overline{(\overline{B} + \overline{C} + D)} + \overline{(\overline{A} + \overline{B} + D)}$$

$$y = \overline{\overline{y}} = \overline{(\overline{(B + \overline{D})} + \overline{(\overline{B} + \overline{C} + D)} + \overline{(\overline{A} + \overline{B} + D)})}$$

Circuit Diagram:

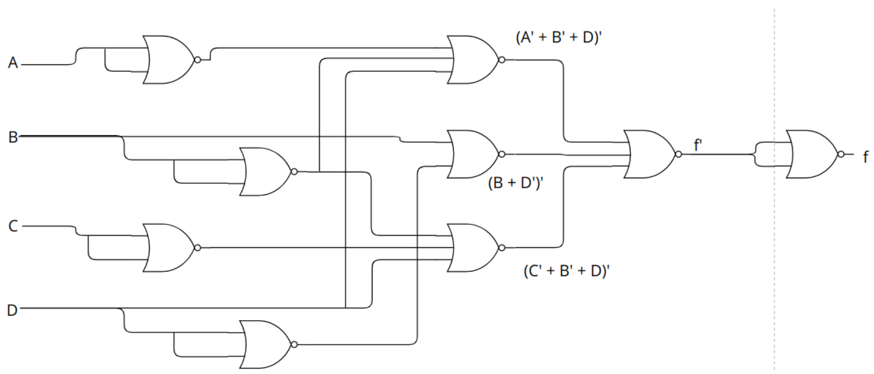


Figure 3: Circuit Diagram

SOP form

Use a K-Map to get f in SOP form:

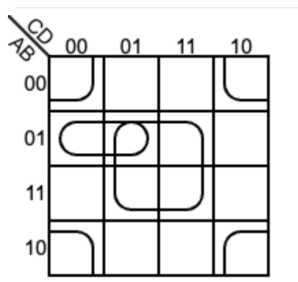


Figure 4: K-Map

Truth Table

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

Figure 5: Truth Table

y in SOP form:

$$y = B \cdot D + \overline{B} \cdot \overline{D} + \overline{A} \cdot B \cdot \overline{C}$$

To use NOR gates:

$$\overline{y} = \overline{(B \cdot D + \overline{B} \cdot \overline{D} + \overline{A} \cdot B \cdot \overline{C})}$$

$$\overline{y} = \overline{(B \cdot D)} \cdot \overline{(\overline{B} \cdot \overline{D})} \cdot \overline{(\overline{A} \cdot B \cdot \overline{C})}$$

$$\overline{y} = (\overline{B} + \overline{D}) \cdot (B + D) \cdot (A + \overline{B} + C)$$

$$y = \overline{\overline{y}} = \overline{((\overline{B} + \overline{D}) \cdot (B + D) \cdot (A + \overline{B} + C))}$$

$$y = \overline{(\overline{B} + \overline{D})} + \overline{(B + D)} + \overline{(A + \overline{B} + C)}$$

$$y = (y')' = \overline{\overline{\overline{(\overline{B} + \overline{D})} + \overline{(B + D)} + \overline{(A + \overline{B} + C)}}}$$

Circuit:

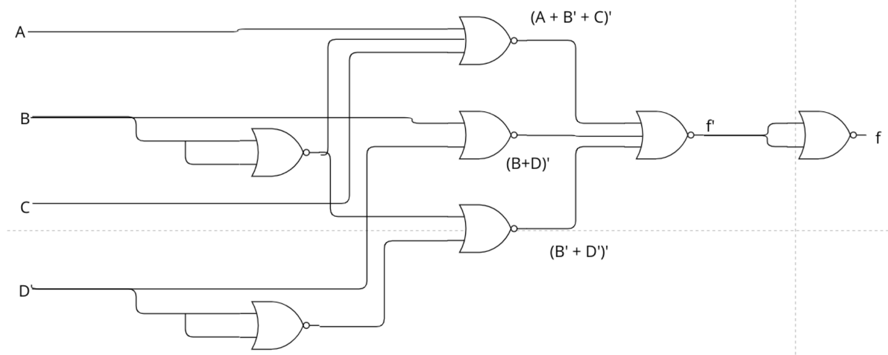


Figure 6: NOR Gate Circuit Diagram

Subpart(b)

Implement above Boolean function using multiplexer. **(3)**

The connections to the select line can be inferred by comparing the values of D and the output Y in the truth table(5).

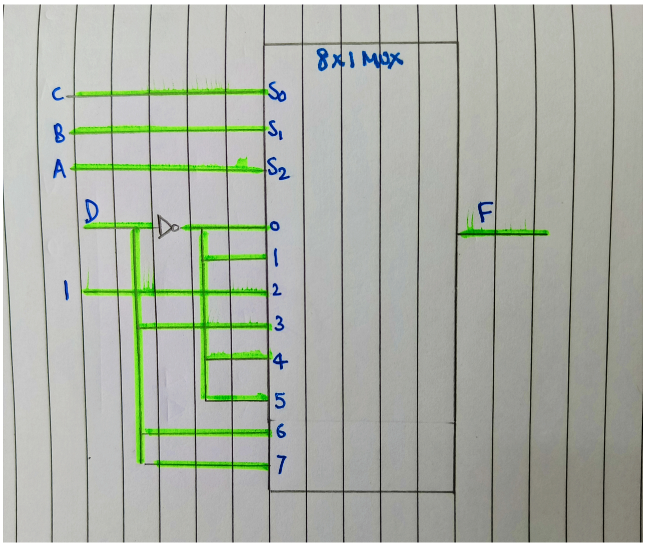
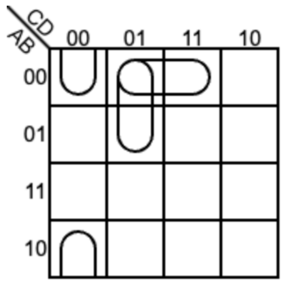
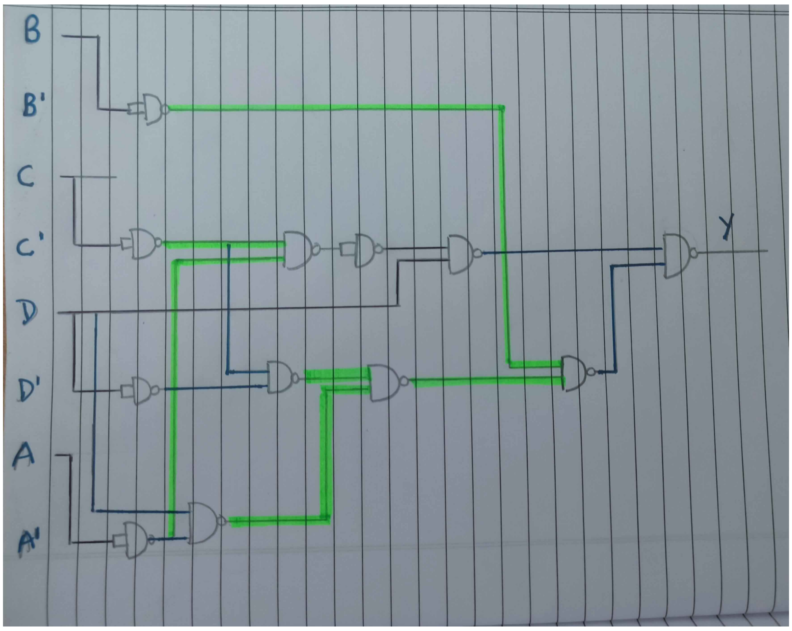


Figure 7: Circuit using MUX

Answer 2

A binary-coded-decimal (BCD) message appears in four input lines of a digital circuit. Design an NAND gate network with minimum possible gates that produces an output value 1 whenever the input combination is 0, 1, 3, 5, or 8.





Answer 3

Subpart(a)

Design one digit octal numbers comparator with minimum possible number of gates. **(3)**

Since it is a one digit octal comparator, we need only 3 bits.

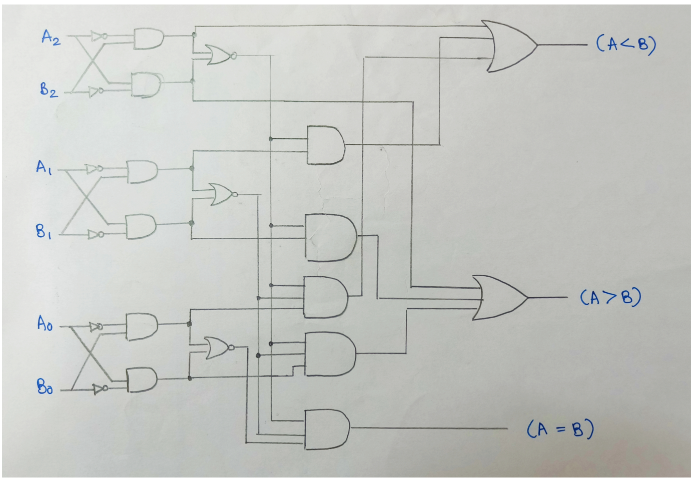


Figure 8: Circuit Diagram

Subpart(b)

What is the need for priority encoder? **(2)**

In a standard encoder, if multiple inputs are equal to 1 at the same time, it can lead to ambiguity since the encoder will not know which input to prioritize. A priority encoder solves this by assigning priority to inputs based on their significance which is decided beforehand, ensuring that only the highest-priority input equal to 1 is encoded.

Subpart(c)

Perform $(546)_8 - (342)_8$ using 8's complement. **(2)**

Since the subtraction is of the form $M - N$ and $M > N$,

Find the 8's complement of $(342)_8 = 436$

Add the 8's complement of N to $M \Rightarrow 546 + 436 = (1204)_8$

Discard the end carry: $(204)_8$

Final answer is $(204)_8$

1 Mark for Answer, 1 Mark for correct steps

Subpart(d)

Compare usage of encoder and multiplexer. **(2)**

Encoders convert 2^n (or fewer) input lines to n output lines.

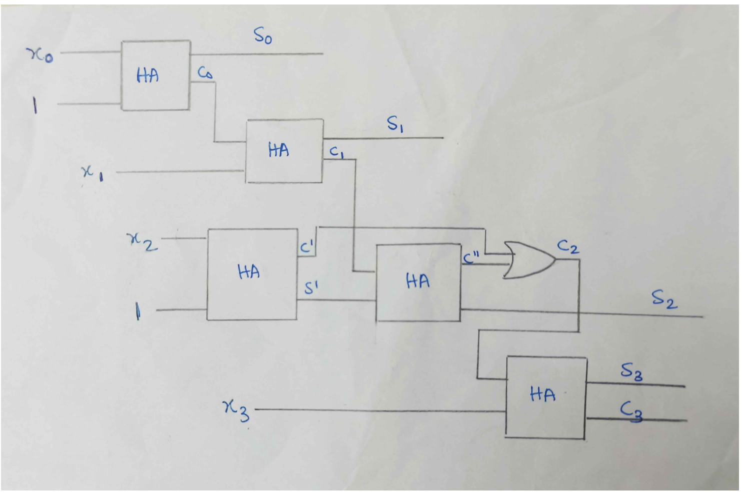
Multiplexers select one of 2^n signals based on n selection lines, whose bit combinations determine which input is selected and routed to the single output.

Answer 4

You are incharge of a spaceship and need to send messages to other ships (buddy-ship) in your team without letting the enemy knowing your plans. Write a simple excess 5 code for numbers if you can only use 4 bits at a time.

Subpart(a)

Implement using half adders. **(4)**



C_3 can be discarded as we are guaranteed that the maximum encoded value cannot be greater than $(2^4 - 1) \Rightarrow 15$

The input is of the form $x_3x_2x_1x_0$.
The encoded output is in the form $S_3S_2S_1S_0$.

Subpart(b)

Draw a parity generator schematic if you plan to use odd parity. **(5)**

If the input is a message of 4 bits: *abcd*, then the parity bit generated is Y.

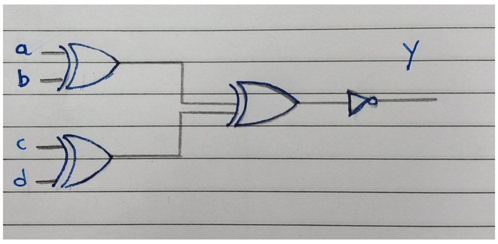


Figure 9: Parity Generator Circuit

Subpart(c)

How can your buddy-ship check if there has been any message interruption/corruption. **(1)**

Given the message, the buddy-ship can use a 5 bit-odd parity checker to detect whether the parity is odd or even. Depending on the output of the parity checker, we can know whether the message has been corrupted.