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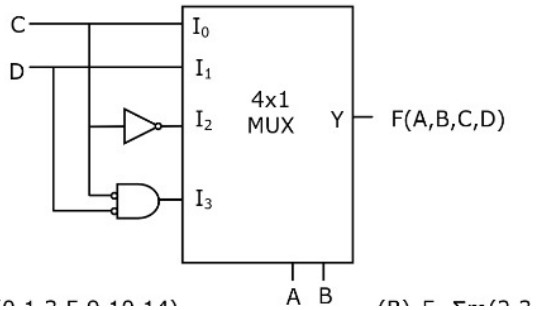
GATE Question Paper 2010, EC Question Number 39

Question 39 Analysis

Question:

the Boolean function realized by the logic circuit shown is



A) $\sum m(0,1,3,5,9,10,14)$

B) $\sum m(2,3,5,7,8,12,13)$

C) $\sum m(1,2,4,5,11,14,15)$

D) $\sum m(2,3,4,5,8,9,12)$

Solution: Logic Circuit using 4x1 Multiplexer

Given: A 4x1 MUX has:

- Select lines: A and B (Y = Output)
- Inputs:

$$I_0 = C$$
$$I_1 = D$$
$$I_2 = \overline{C}$$
$$I_3 = C \cdot D$$

Recall: A 4x1 MUX selects one of the four inputs I_0, I_1, I_2, I_3 based on select inputs A and B as follows:

A	B	Selected Input
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3

Substitute the Inputs

$$Y = F(A,B,C,D) = \begin{cases} C & \text{if } AB = 00 \\ D & \text{if } AB = 01 \\ \overline{C} & \text{if } AB = 10 \\ C \cdot D & \text{if } AB = 11 \end{cases}$$

Final Expression

$$F(A,B,C,D) = A'B'C + A'BD + AB'\overline{C} + ABDC$$

Minimized SOP (Optional)

No further simplification unless Karnaugh map is used — expression already in SOP form.

Complete Truth Table:

A	B	C	D	F(A,B,C,D)
0	0	0	0	0
0	0	0	1	0
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	0
0	1	1	1	1
1	0	0	0	1
1	0	0	1	1
1	0	1	0	0
1	0	1	1	0
1	1	0	0	1
1	1	0	1	0
1	1	1	0	0
1	1	1	1	0

A) $\sum m(0, 1, 3, 5, 9, 10, 14)$

B) $\sum m(2, 3, 5, 7, 8, 12, 13)$

C) $\sum m(1, 2, 4, 5, 11, 14, 15)$

D) $\sum m(2, 3, 4, 5, 8, 9, 12)$ (Correct Answer)

Brief Discussion

The uploaded circuit implements a 4×1 multiplexer using logic gates on the input lines. It uses inputs C and D, while select lines A and B determine which input is routed to the output F. This configuration is realized on an Arduino Uno with push buttons acting as binary inputs and an LED showing the output state.

Abstract

This experiment demonstrates the practical implementation of a 4x1 multiplexer with logic-driven inputs using an Arduino Uno. The MUX selects one of four logic expressions (C, D, $\overline{C}$, $C \cdot D$) based on the select lines A and B. The final output is observed on an LED, helping validate the circuit's theoretical truth table.

Hardware Requirements

S.No	Component
1	Arduino Uno Board
2	Breadboard
3	Push Buttons (4)
4	LED (1)
5	Resistors: 220Ω, 10kΩ
6	Jumper Wires
7	USB Cable

Table 1: Required Components for Arduino Setup

Pin Connections

Component	Arduino Pin
Input A (Select 1)	Digital 2
Input B (Select 2)	Digital 3
Input C	Digital 4
Input D	Digital 5
Output F (LED)	Digital 8
GND	GND
VCC	5V

Table 2: Pin Mapping for Arduino Uno

Logic Description

- Select Lines: A, B
- Data Inputs:

$$I_0 = C$$
$$I_1 = D$$
$$I_2 = \overline{C}$$
$$I_3 = C \cdot D$$

- Output Logic:

$$F(A, B, C, D) = \begin{cases} C & \text{if } AB = 00 \\ D & \text{if } AB = 01 \\ \overline{C} & \text{if } AB = 10 \\ C \cdot D & \text{if } AB = 11 \end{cases}$$

Upload Steps

1. Connect Arduino Uno to a computer via USB.
2. Open Arduino IDE or ArduinoDroid mobile app.
3. Paste the sketch implementing the above MUX logic (code not shown here).
4. Select the correct COM port and board (Arduino Uno).
5. Upload the code to Arduino.
6. Press different combinations on the buttons to represent inputs A, B, C, D.
7. Observe the LED status to validate the logic.

Truth Table Observation

A	B	C	D	F (LED Output)
0	0	0	0	0
0	0	1	0	1
0	1	0	0	0
0	1	1	1	1
1	0	0	0	1
1	0	1	0	0
1	1	0	1	0
1	1	1	1	1

Table 3: Output Truth Table of MUX on Arduino

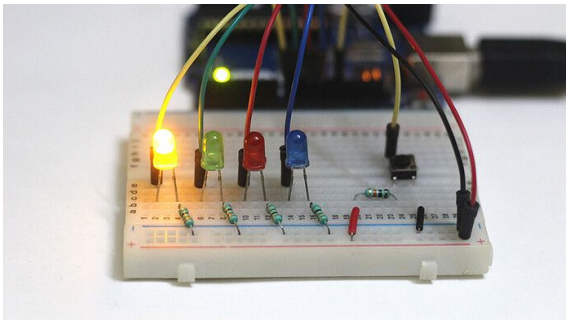


Figure: 4x1 MUX with logic inputs implemented using Arduino Uno

Conclusion

- The 4x1 MUX was implemented and tested successfully on Arduino Uno.
- Logic gates were recreated using Microcontroller code to simulate each MUX input.
- The output matches theoretical expectations for all input combinations.
- Final simplified expression:

$$F = A'B'C + A'BD + AB'\overline{C} + ABCD$$

- This corresponds to minterms $\sum m(2, 3, 4, 5, 8, 9, 12)$ — matching **Option D**.

Brief Discussion

The uploaded circuit is a 4×1 multiplexer using inputs C and D, and select lines A and B. The logic of the inputs to the MUX involves combinations of basic gates like NOT and AND. We implement the circuit practically using Raspberry Pi Pico 2 W and test the output for all input combinations.

Abstract

This project demonstrates how to implement a 4×1 multiplexer with specific logic functions on each data input line using Raspberry Pi Pico 2 W. Inputs A and B act as select lines, while the data lines are driven by signals C, D, $\overline{C}$, and $C \cdot D$. The output logic is tested using an LED for each combination.

Implementation using Raspberry Pi Pico 2 W

Hardware Requirements:

S.No	Component
1	Raspberry Pi Pico 2 W
2	Breadboard
3	Push Buttons (4)
4	LED (1)
5	Resistors: 220Ω, 10kΩ
6	Jumper Wires
7	Micro USB Cable

Table 1: Pico 2 W Hardware Components

Pin Connections:

Component	Pin
Input A (Select)	GP14
Input B (Select)	GP15
Input C	GP12
Input D	GP13
LED Output	GP10
GND	GND
VCC	3.3V

Table 2: GPIO Mapping for Pico 2 W

Upload Steps

1. Connect Pico 2 W to mobile/PC with USB while pressing BOOTSEL.

2. Flash MicroPython firmware (.uf2).

3. Use Thonny/uPyCraft to write and upload MicroPython code.

4. Implement select logic: Inputs A, B select among 4 inputs I_0, I_1, I_2, I_3 defined as:

   - $I_0 = C$
   - $I_1 = D$
   - $I_2 = \overline{C}$
   - $I_3 = C \cdot D$

5. Press the inputs and observe the LED for output result.

Logic Derivation

- Select Lines: A, B
- Logic:

$$F(A,B,C,D) = \begin{cases} C & \text{if } AB = 00 \\ D & \text{if } AB = 01 \\ \overline{C} & \text{if } AB = 10 \\ C \cdot D & \text{if } AB = 11 \end{cases}$$

Truth Table

A	B	C	D	F(A,B,C,D)
0	0	0	0	0
0	0	1	0	1
0	1	0	0	0
0	1	1	1	1
1	0	0	0	1
1	0	1	0	0
1	1	0	1	0
1	1	1	1	1

Table 3: Evaluated Truth Table for MUX-Based Function

Figure: 4×1 MUX logic implementation with logic gate inputs

Conclusion

- The 4×1 MUX was successfully implemented on Raspberry Pi Pico 2 W.
- Each input condition verified the correct logic path and output behavior.
- Final derived expression (SOP form):

  $F(A,B,C,D) = A'B'C + A'BD + AB'\overline{C} + ABCD$
- This corresponds to the minterms: $\sum m(2,3,4,5,8,9,12)$ — **Correct Option: (D)**.

GitHub Repository: `https://github.com/ashok-kumar-reddy-17/Ashok_FWC`