IIITB COMET FOUNDATION

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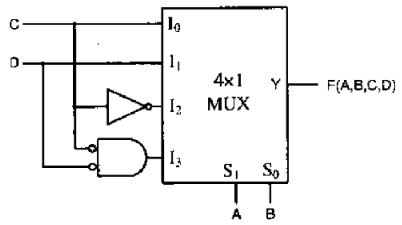
GATE Question Paper 2010, EC Question Number 39

Q.39 The Boolean function realized by the logic circuit shown is



(A) $F = \Sigma m(0, 1, 3, 5, 9, 10, 14)$ (B) $F = \Sigma m(2, 3, 5, 7, 8, 12, 13)$
(C) $F = \Sigma m(1, 2, 4, 5, 11, 14, 15)$ (D) $F = \Sigma m(2, 3, 5, 7, 8, 9, 12)$

Figure: 4x1 MUX Circuit

Question Analysis

Given: A 4x1 MUX circuit is shown with the inputs selected by variables A and B and data inputs driven by combinations of C and D logic. The Boolean function implemented by the circuit must be found.

Solution:

Step 1: Determine the Select Lines and MUX Inputs:
The 4x1 MUX uses A and B as the select lines:

$$S_1 = A, \quad S_0 = B$$

The MUX inputs are:

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

Step 2: Construct Output Expression:

Based on the select lines (A, B), the output F is:

$$F(A,B,C,D) = \begin{cases} I_0 = C & \text{if } A = 0, B = 0 \\ I_1 = D & \text{if } A = 0, B = 1 \\ I_2 = \overline{D} & \text{if } A = 1, B = 0 \\ I_3 = C \cdot \overline{D} & \text{if } A = 1, B = 1 \end{cases}$$

Filling the truth table, the minterms where $F = 1$ are:

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

Correct Option: (A)

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

Truth Table

A	B	Selected Input	Expression	Output (F)
0	0	I0 = C	F = C	1 if C=1
0	1	I1 = D	F = D	1 if D=1
1	0	I2 = $\overline{D}$	F = $\overline{D}$	1 if D=0
1	1	I3 = $C \cdot \overline{D}$	F = $C \cdot \overline{D}$	1 if C=1, D=0

Table: MUX Selection Logic

Hardware Implementation

Logic Expression Inputs: A, B, C, D — all controlled by push buttons.

Output: LED connected to GPIO pin shows value of F.

Hardware Requirements

S.No	Component
1	Pico2W/Arduino
2	Breadboard
3	Push Buttons (4x) for Inputs A, B, C, D
4	LED for Output F
5	Resistors (220Ω for LED, 10kΩ for pull-downs)
6	Jumper Wires
7	Micro USB Cable

Table: Required Components

Component	Pico2W Pin	Description
Button A	GP14	Select line S1
Button B	GP15	Select line S0
Button C	GP16	Input C
Button D	GP17	Input D
LED (Output F)	GP13	Output Logic
GND	GND	Common Ground
3.3V	3.3V	Pull-up Supply

Table: GPIO Pin Mapping

Component	Arduino Pin	Description
Button A	D2	Select line S1
Button B	D3	Select line S0
Button C	D4	Input C
Button D	D5	Input D
LED (Output F)	D6	Output Logic
GND	GND	Common Ground
VCC	5V	Pull-up Supply

Table: Arduino Pin Mapping

Steps to Upload Code using Pico2W

1. Connect Pico 2 W via USB while holding BOOTSEL button.
2. Drag-and-drop MicroPython file (only once).
3. Open Thonny IDE and select MicroPython (Raspberry Pi Pico) as interpreter. If using a phone, use Micro REPL app.
4. Write the MUX logic in Python using input reads and logical mapping.
5. Connect the circuit as per table and test output LED for all input combinations.

Arduino Uno Implementation

Steps to Upload Code to Arduino

1. Connect Arduino Uno to PC using USB cable.
2. Open Arduino IDE and select correct board and COM port.
3. Write code for reading D2-D5 pins and generating logic for output F.
4. Upload code using **Upload** button.
5. Connect circuit as per connection table and validate using LED.

A	B	C	D	Selected Input	Expression	F
0	0	0	0	I0	$F = C$	0
0	0	0	1	I0	$F = C$	0
0	0	1	0	I0	$F = C$	1
0	0	1	1	I0	$F = C$	1
0	1	0	0	I1	$F = D$	0
0	1	0	1	I1	$F = D$	1
0	1	1	0	I1	$F = D$	0
0	1	1	1	I1	$F = D$	1
1	0	0	0	I2	$F = \overline{D}$	1
1	0	0	1	I2	$F = \overline{D}$	0
1	0	1	0	I2	$F = \overline{D}$	1
1	0	1	1	I2	$F = \overline{D}$	0
1	1	0	0	I3	$F = C{\cdot}\overline{D}$	0
1	1	0	1	I3	$F = C{\cdot}\overline{D}$	0
1	1	1	0	I3	$F = C{\cdot}\overline{D}$	1
1	1	1	1	I3	$F = C{\cdot}\overline{D}$	0

Verification Table for MUX Logic

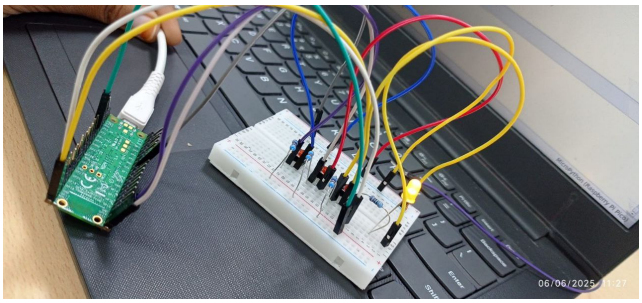


Figure: Experiment using pico2w

GitHub Repository

`https://github.com/Alekyakuruba/fwc/tree/main/hardware`

Conclusion

The logic function implemented using a 4x1 multiplexer was verified both theoretically and through a practical setup using Pico 2 W. Button inputs successfully mapped to select lines and MUX inputs, and the LED output validated the Boolean expression:

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