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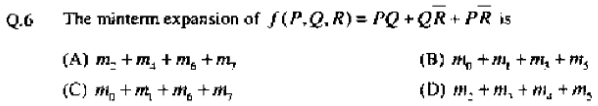
GATE CS 2010 – Question Number 6

Question


Q.6 The minterm expansion of $f(P,Q,R) = PQ + Q\overline{R} + P\overline{R}$ is

(A) $m_2 + m_3 + m_6 + m_7$ (B) $m_0 + m_4 + m_5 + m_7$

(C) $m_0 + m_1 + m_6 + m_7$ (D) $m_2 + m_3 + m_4 + m_5$

Figure: GATE CS Q6 - Minterm Expansion

Given:

$$f(P,Q,R) = PQ + Q\overline{R} + P\overline{R}$$

We need to find the minterm expansion for this function.

Solution

Let us compute output f for all $2^3 = 8$ combinations of P, Q, R:

P	Q	R	$f = PQ + Q\overline{R} + P\overline{R}$
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	1

Truth Table for f(P, Q, R)

From the truth table, $f = 1$ for minterms: m_2, m_3, m_4, m_6, m_7

$$f(P,Q,R) = \sum m(2,3,4,6,7)$$

Correct Option: (D)

Components Required

Component	Quantity
Raspberry Pi Pico2W / Arduino Uno	1
Push Buttons (Inputs for P, Q, R)	3
LED (Output indicator for f)	1
220Ω Resistor	1
10kΩ Resistors	3
Breadboard	1
Jumper Wires	As required
USB Cable (Micro USB / USB-B)	1

Table: Component List

GPIO Connection Table

Raspberry Pi Pico2W

Component	GPIO Pin	Role
Button P	GP14	Input
Button Q	GP15	Input
Button R	GP16	Input
LED f	GP13	Output
GND	GND	Ground
3.3V	3.3V	Pull-up

Pico2W Connections

Arduino Uno

Component	Pin	Role
Button P	D2	Input
Button Q	D3	Input
Button R	D4	Input
LED f	D5	Output
GND	GND	Ground
VCC	5V	Pull-up

Arduino Uno Connections

Theory: Uploading and Executing on Microcontrollers

Microcontrollers such as Raspberry Pi Pico2W and Arduino Uno allow us to implement digital logic circuits using software and hardware integration. The logical expressions can be evaluated in real-time by reading digital input signals from push buttons and generating output through LEDs.

Raspberry Pi Pico2W (MicroPython-based)

- The Raspberry Pi Pico2W can be programmed using MicroPython via the Thonny IDE.
- To upload code:
  1. Connect Pico2W to PC while holding the `BOOTSEL` button.
  2. It mounts as a USB drive named `RPI-RP2`.
  3. Drag and drop the `MicroPython UF2` firmware file.
  4. Open Thonny IDE, set the interpreter to "MicroPython (Raspberry Pi Pico)".
  5. Write the digital logic code using `machine.Pin()` and logic operations.
  6. Click Run to upload and execute the code.
- The program continuously monitors GPIO pins connected to push buttons (representing inputs), evaluates the logic expression, and sets the output LED accordingly.

Arduino Uno (C/C++ based)

- Arduino Uno uses the Arduino IDE and a simplified C++ syntax.
- To upload code:
  1. Connect the Uno board using USB.
  2. Open Arduino IDE, select board as "Arduino Uno" and correct COM port.
  3. Write a sketch using `digitalRead()` for inputs and `digitalWrite()` for output.
  4. Click Upload (→) button to compile and flash the code.
- The Uno reads button states, evaluates the Boolean expression, and sets the LED pin high or low.

Note: Ensure pull-down resistors are used with push buttons to maintain a definite input logic level when the button is not pressed.

This method effectively demonstrates Boolean logic practically, helping students to visualize logic gate behavior and truth table evaluation in real-time.

GitHub Repository

All code, circuit diagrams and images are available at:
`https://github.com/Alekyakuruba/fwc/tree/main/hardware`

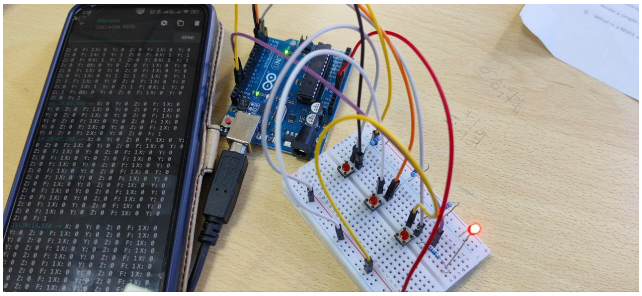


Figure:Minterm Expansion Implementation

Conclusion

This question required evaluating the minterm expansion of a composite Boolean function. We analyzed the function, derived the truth table, identified minterms where output is 1, and verified using hardware with Pico2W and Arduino Uno.

Final Answer: **(D)** $m_2 + m_3 + m_4 + m_6 + m_7$