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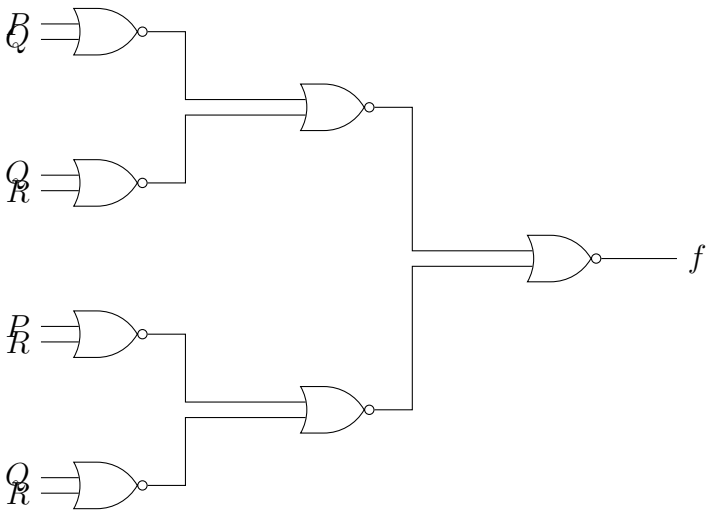
Batch: COMETFWC018
Date: 16 may 2025

GATE QUESTION
CSE 2010 Q31

Question

Q.31 *What is the boolean expression for the output f of the combinational logic circuit of NOR gates given below?*



(A) $\overline{Q+R}$ (B) $\overline{P+\overline{Q}}$ (C) $\overline{P+R}$ (D) $\overline{P+Q+R}$

Solution:

We are given a logic circuit made entirely of NOR gates, and we are to determine the Boolean expression for the output f.

Recall: A NOR gate performs the operation:

$$A \downarrow B = \overline{A+B}$$

Step-by-step Analysis

1. Let the intermediate outputs of the NOR gates be labeled as follows:

$$A = \overline{P+Q}$$
$$B = \overline{Q+R}$$
$$C = \overline{P+R}$$
$$D = \overline{Q+R}$$

2. The next layer of NOR gates takes inputs as follows:

$$E = \overline{A + B} = \overline{\overline{P + Q} + \overline{Q + R}}$$
$$F = \overline{C + D} = \overline{\overline{P + R} + \overline{Q + R}}$$

3. The final output is:

$$f = \overline{E + F} = \overline{\overline{\overline{P + Q} + \overline{Q + R}} + \overline{\overline{P + R} + \overline{Q + R}}}$$

4. On simplifying or testing the expression through truth tables, we find that the output is high only when both $Q = 0$ and $R = 0$. This corresponds to:

$$f = \overline{Q + R}$$

Final Answer:

$$\boxed{f = \overline{Q + R}} \quad \text{(Option A)}$$