MOSFET — SOLUTION KEY

Total Points: 40 | Questions: 4 | Date: February 19, 2026

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AI-generated graduate-level electrical assignment. Contains 4 questions covering key concepts.

Question 1

10.0 points

Explain how the threshold voltage affects the drain current in a MOSFET, and how it is influenced by substrate bias in the diagram below.

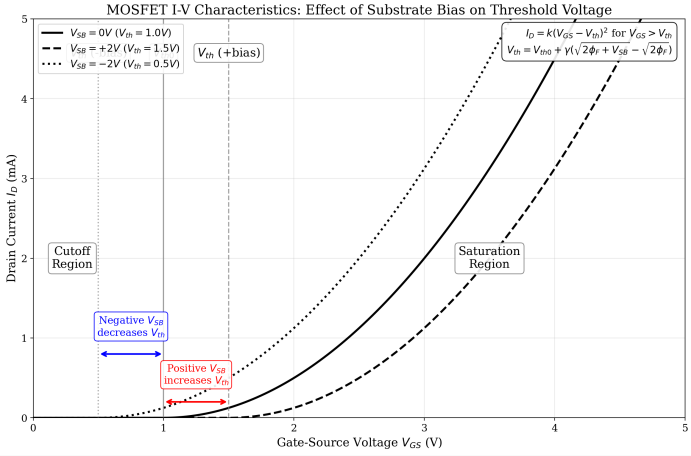

Fig. 1. Circuit diagram for Question 1

ANSWER

The threshold voltage (V_t) is the minimum gate voltage required to create a conducting path between the source and drain. When the gate voltage is below V_t, the MOSFET is off, and the drain current (I_d) is approximately zero. Above V_t, the device enters saturation or triode mode, allowing current to flow. Substrate bias can alter V_t due to the body effect, where an increased voltage between the body and source reduces the channel's effective threshold voltage, modifying current flow.

GRADING RUBRIC

Award full marks if the student accurately describes the role of threshold voltage in switching the MOSFET and its effect on the drain current, including the impact of substrate bias. Partial credit can be given for understanding of threshold voltage without substrate bias effect.

Question 2 10.0 points

For the MOSFET circuit shown below, calculate the drain current if the MOSFET operates with a gate-to-source voltage of 3V, a threshold voltage of 1V, and a drain-to-source voltage of 4V, assuming it is in saturation with a transconductance parameter of 300 µA/V².

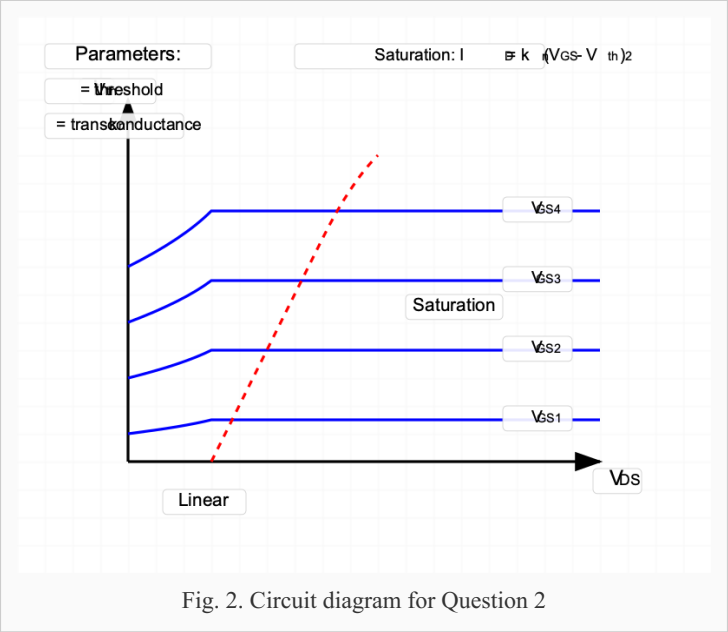

Fig. 2. Circuit diagram for Question 2

ANSWER

$I_d = k_n * (V_{gs} - V_t)^2 / 2 = 300$ bcA/Vb2 * (3V - 1V)^2 / 2 = 300 bcA/Vb2 * $4V^2$ / 2 = 600 bcA

GRADING RUBRIC

Award full marks for correct calculation and reasoning. Deduct points for calculation errors or incorrect understanding of the saturation equation. Ensure the student calculates the effective V_{gs}-V_t and applies the saturation equation accurately.

Question 3 10.0 points

Describe how a MOSFET is used as a switch in digital circuits, using the circuit shown below to provide an example illustrating its ON and OFF states with voltage levels.

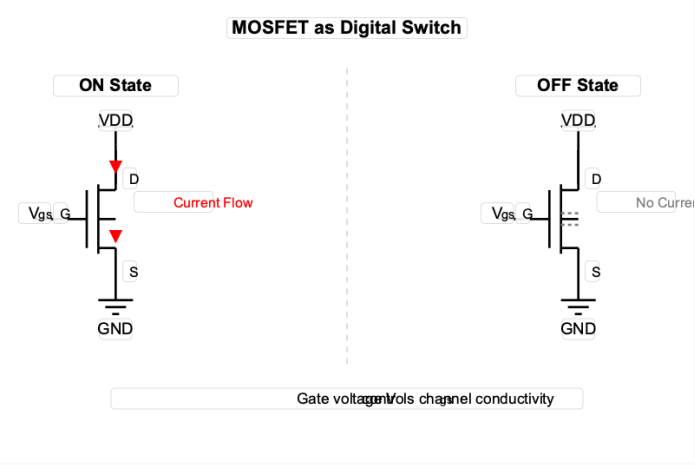

Fig. 3. Circuit diagram for Question 3

ANSWER

A MOSFET can function as a switch by operating in cutoff and saturation regions. In digital circuits, the MOSFET is OFF when V_{gs} is below the threshold voltage (V_t), preventing current flow. It is ON when V_{gs} exceeds V_t, allowing current from drain to source. For example, in an NMOS, V_{gs} can be connected to a high logic level for ON state, and a low level for OFF state. In PMOS, the control is inverted.

GRADING RUBRIC

Award full marks for a detailed explanation that accurately reflects the switching behavior of MOSFETs and provides a practical example. Partial credit can be given for incomplete descriptions or lack of examples.

Question 4 10.0 points

For the NMOS transistor shown in the diagram below, the drain current is measured at different drain-to-source voltages. Calculate the channel length modulation parameter (λ) if the change in drain current is from 10 mA to 10.5 mA when the drain-source voltage changes from 5V to 5.5V, with V_{gs} constant at 3V and V_t at 1V.

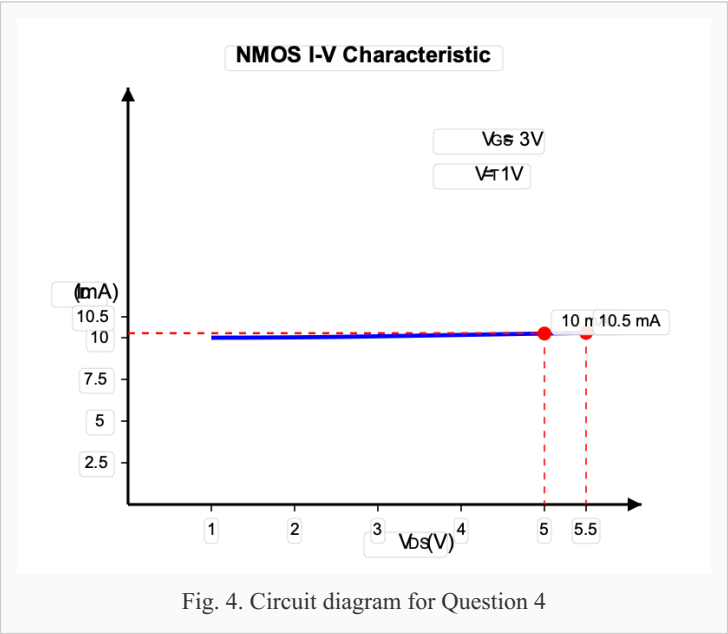

Fig. 4. Circuit diagram for Question 4

ANSWER

$\lambda = \frac{\Delta I_d}{I_d \cdot \Delta V_{ds}} = \frac{10.5 \text{ mA} - 10 \text{ mA}}{10 \text{ mA} \cdot (5.5 \text{ V} - 5 \text{ V})} = \frac{0.5 \text{ mA}}{10 \text{ mA} \cdot 0.5 \text{ V}} = 0.1 \text{ V}^{-1}$

GRADING RUBRIC

Award full marks for correct application of the channel length modulation formula. Deduct points for calculation errors or incorrect application of the concept. Ensure clarity in the differentiation between initial and final voltage/current states.