

Q1 Rizzoni Problem 11.2

The 3 terminals of an n-channel MOSFET with $V_T = 1\text{V}$, are at potentials of 4V, 5V, and 10V with respect to ground. Draw the circuit symbol, with appropriate voltages at each terminal, if the device is operating in the:

- Ohmic region
- Saturation region

Q2 Rizzoni Problem 11.3

An n-channel MOSFET with $V_T = 2\text{V}$ has its source grounded and 3V DC source connected to its gate. Determine the state of the device if:

- $v_D = 0.5\text{V}$
- $v_D = 1\text{V}$
- $v_D = 5\text{V}$

Q3

The operating regions of a MOSFET are cut off, ohmic and saturation.

- Which mode would you use to implement an amplifier?
- Which mode would you not use to implement a logic gate?

Q4

For the circuit in Fig 1, given that r_o is infinitely large,

- Draw the small signal equivalent circuit
- Find the input resistance
- Derive the gain (V_{out}/V_{in}) in terms of g_m , R_S and R_D
- If a capacitor is added in parallel to R_S to bypass it, derive the gain expression.

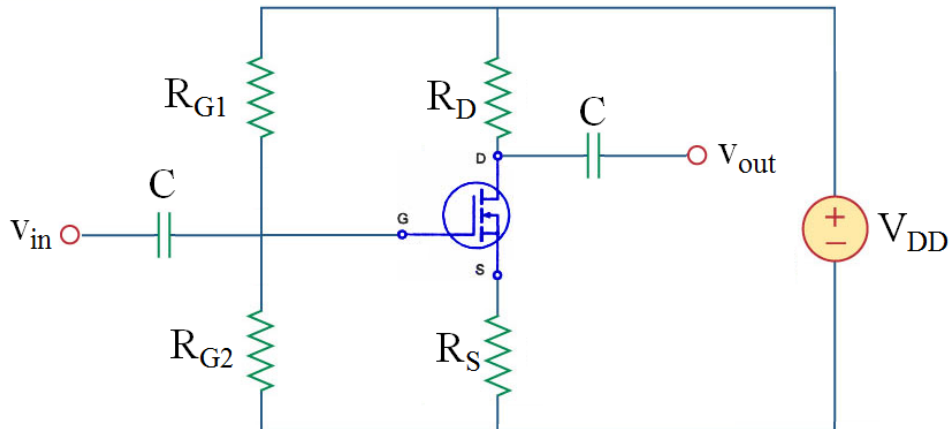


Fig 1

Q5

For the circuit in Fig 2,

- Draw the small signal equivalent circuit
- Find the input resistance
- Derive the gain (V_{out}/V_{in}) in terms of g_m , r_o and R_S

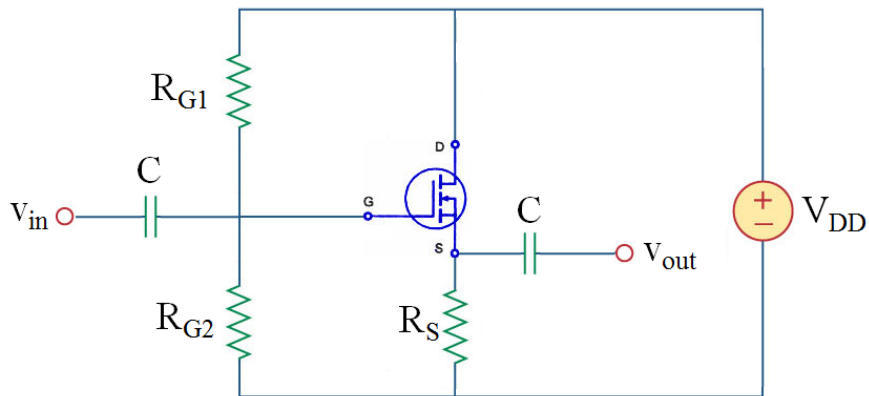


Fig 2

Answers

Q1

- a) $v_G = 10V$, $v_D = 5V$, $v_S = 4V$
 b) $v_G = 5V$, $v_D = 10V$, $v_S = 4V$

Q2

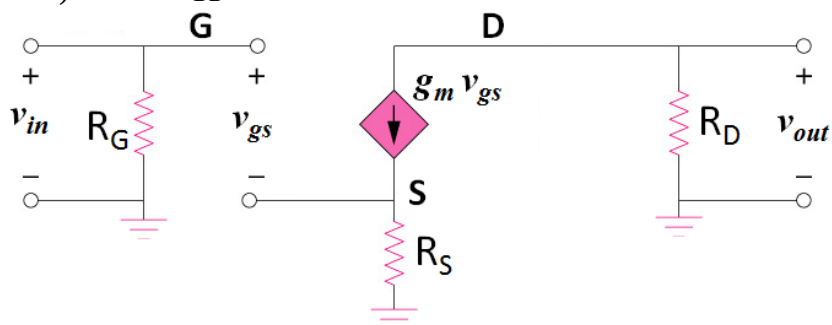
- a) Triode, b) Pinch-off (Between Triode and Saturation when $v_{GD} = V_T$), c) Saturation

Q3

- a) We only use saturation mode for amplifiers
 b) We never use saturation mode for switches, only cutoff and triode

Q4

- a) Short V_{DD} and redraw the circuit:



Remember that only AC signals are reflected in the small signal equivalent circuit and the capacitors are treated as short circuits at the working frequency.

- b) Input resistance = $R_G = R_{G1} \parallel R_{G2}$

- c) Gain expression:

Current through R_S is $g_m v_{gs}$ (from S to ground)

Current through R_D is also $g_m v_{gs}$ (from ground to D)

$$\text{At the input: } v_{in} = v_{gs} + g_m v_{gs} R_S = v_{gs} (1 + g_m R_S) \quad (1)$$

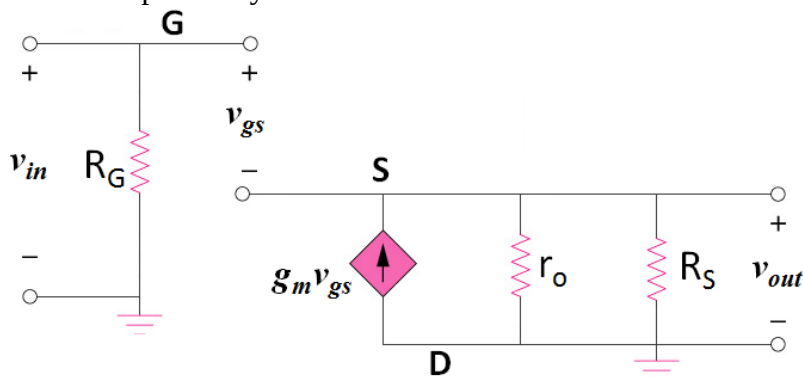
$$\text{At the output: } v_{out} = -g_m v_{gs} R_D \quad (2)$$

$$\text{Combine (2) and (1) to eliminate } v_{gs}: \frac{v_{out}}{v_{in}} = -\frac{g_m R_D}{1 + g_m R_S}$$

- d) With R_S bypassed, the gain expression becomes: $v_{out}/v_{in} = -g_m (r_o \parallel R_D)$

Q5

- a) Short V_{DD} and redraw the circuit. Note that D is now connected directly to ground after V_{DD} is replaced by a short circuit.



Remember that only AC signals are reflected in the small signal equivalent circuit and the capacitors are treated as short circuits at the working frequency.

- b) Input resistance = $R_G = R_{G1} \parallel R_{G2}$

- c) Gain expression:

At the input: $v_{in} = v_{gs} + v_{out}$ (1)

At the output: $v_{out} = g_m v_{gs} (r_o \parallel R_S)$ (2)

Combining (1) and (2) to eliminate v_{gs} :

$$\frac{v_{out}}{v_{in}} = \frac{g_m R'}{1 + g_m R'}, \text{ where } R' = r_o \parallel R_D$$