

Block C: Field Effect Transistor

Q1. Problem P11.1

The transistors shown in Figure P11.1 have $|V_T| = 3$ V. Determine the operating region.

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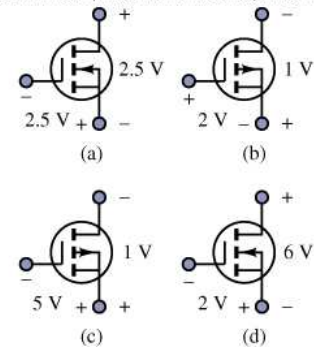


Figure P11.1

Answers:

- (a) Cutoff region
- (b) Cutoff region
- (c) Triode region
- (d) Cutoff region

Q2. Problem P11.3

An enhancement-type NMOS transistor with $V_T = 2$ V has its source grounded and a 3-V DC source connected to the gate. Determine the operating state if

- (a) $v_D = 0.5$ V
- (b) $v_D = 1$ V
- (c) $v_D = 5$ V

Answers:

- (a) triode region
- (b) triode or saturation region
- (c) saturation region

Q3. Problem P11.5

An enhancement-type NMOS transistor has $V_T = 2$ V and $i_D = 1$ mA when $v_{GS} = v_{DS} = 3$ V. Find the value of i_D for $v_{GS} = 4$ V.

Answer: 4mA

Q4. Problem P11.6

An n -channel enhancement-mode MOSFET is operated in the ohmic region, with $v_{DS} = 0.4$ V and $V_T = 3.2$ V. The effective resistance of the channel is given by $R_{DS} = 500/(V_{GS} - 3.2) \Omega$. Find i_D when $V_{GS} = 5$ V, $R_{DS} = 500\Omega$, and $v_{GD} = 4$ V.

Answer: 3.6mA

Q5. Problem P11.9

The NMOS transistor shown in Figure P11.9 has $V_T = 1.5 \text{ V}$ and $K = 0.4 \text{ mA/V}^2$. If v_G is a pulse with 0 to 5 V, find the voltage levels of the pulse signal at the drain output.

Answers:

$$v_D = 5 \text{ V at } v_G = 0 \text{ V}$$

$$v_D = 1.578 \text{ V at } v_G = 5 \text{ V}$$

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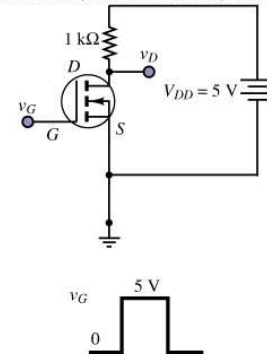


Figure P11.9

Q6. Problem P11.13

The i - v characteristic of an n-channel enhancement MOSFET is shown in Figure P11.13(a); a standard amplifier circuit based on the n-channel MOSFET is shown in Figure P11.13(b). $V_{GG} = 7 \text{ V}$, $V_{DD} = 10 \text{ V}$, $R_D = 5 \Omega$.

Determine the quiescent current i_{DQ} and drain-to-source voltage v_{DSQ}

Answers:

$$i_{DQ} = 0.8 \text{ A}, v_{DSQ} = 6 \text{ V}$$

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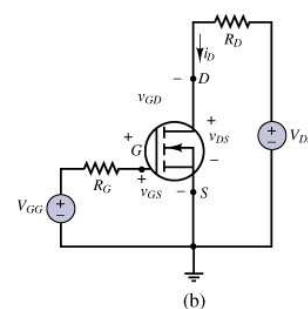
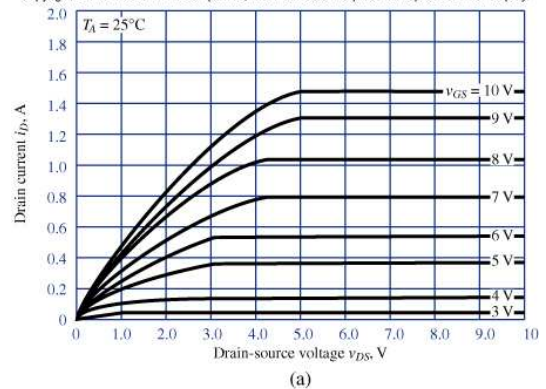


Figure P11.13

Q7. Problem P11.17

The power MOSFET circuit of Figure P11.17 is configured as a voltage-controlled current source. Let $K = 1.5 \text{ A/V}^2$ and $V_T = 3 \text{ V}$.

- If $V_G = 5 \text{ V}$, find the range of R_L for which the VCCS will operate.
- If $R_L = 1 \Omega$, determine the range of V_G for which the VCCS will operate.

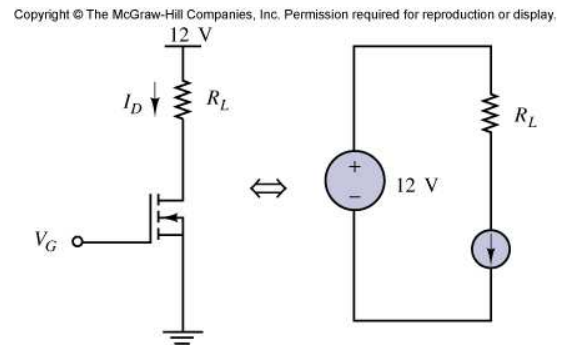


Figure P11.17

Answers:

- $R_L < \frac{10}{6} \Omega$
- $3\text{V} < V_G < 5.51\text{V}$

Q8. Problem P11.19

The circuit of Figure P11.19 is a Class A amplifier.

- Determine the output current for the given biased audio tone input, $V_G = 10 + 0.1 \cos(500t) \text{ V}$. Let $K = 2 \text{ mA/V}^2$ and $V_T = 3 \text{ V}$.
- Determine the output voltage.
- Determine the voltage gain of the $\cos(500t)$ signal.
- Determine the DC power consumption of the resistor and the MOSFET.

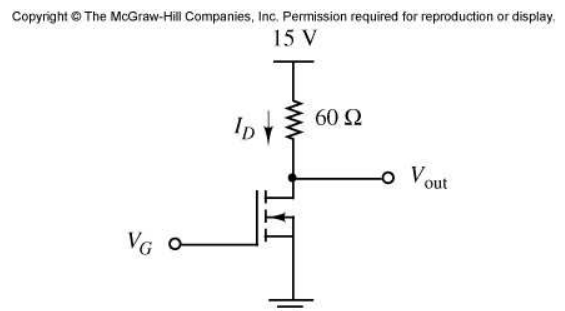


Figure P11.9

Answers:

- $i_D = 0.002(49 + 1.4 \cos(500t) + 0.005 \cos(1000t) + 0.005) \text{ A}$
- $V_{out} = 15 - 60 \times 0.002(49 + 1.4 \cos(500t) + 0.005 \cos(1000t) + 0.005) \text{ V}$
- 1.68
- $P_R = 0.576 \text{ W}$
 $P_{MOSFET} = 0.894 \text{ W}$

Q9. Problem P11.20

The circuit of Figure P11.20 is a source-follower amplifier. Let $K = 30 \text{ mA/V}^2$, $V_T = 4 \text{ V}$, and $V_G = 9 + 0.1 \cos(500t) \text{ V}$.

- Determine the load current I_L .
- Determine the output voltage V_{out} .
- Determine the voltage gain for the $\cos(500t)$ signal.
- Determine the DC power consumption of the MOSFET and R_L .

Answers:

- $I_L = 1.25 + 0.025 \cos(500t)$
- $V_{out} = 5 + 0.1 \cos(500t)$
- 1
- $P_R = 6.25 \text{ W}$
 $P_{MOSFET} = 8.75 \text{ W}$

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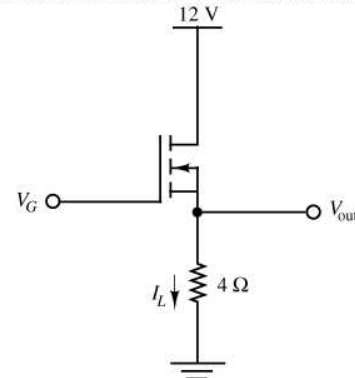


Figure P11.20

Q10. Problem P11.21

Sometimes it is necessary to discharge batteries before recharging. To do this, an electronic load can be used. A high-power electronic load is shown in Figure P11.21, for the battery discharge application. With $K = 4 \text{ A/V}^2$, $V_T = 3 \text{ V}$, and $V_G = 8 \text{ V}$, determine the discharging current I_D and the required MOSFET power rating.

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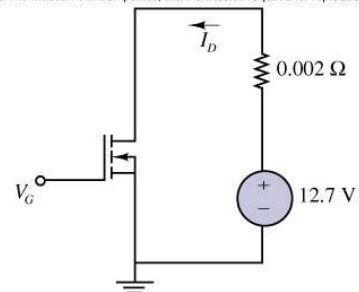


Figure P11.21

Answers:

100A; 1250W