

Semiconductor Devices

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Assignment for Week 2 (January 1, 2017)

1. Consider an n -channel silicon JFET with $N_d = 1.4 \times 10^{15} \text{ cm}^{-3}$, $a = 2 \mu\text{m}$, $V_{bi} = 0.8 \text{ V}$, $\mu_n = 1000 \text{ cm}^2/\text{V-s}$, $L = 5 \mu\text{m}$, and $Z = 50 \mu\text{m}$. What is the pinch-off voltage V_P ?
(A) -2.40 V (B) -1.65 V (C) -3.52 V (D) -1.80 V
2. For the JFET described in Q-1, what is the device resistance in the low V_{DS} region (e.g., $V_{DS} = 20 \text{ mV}$) for $V_{GS} = -2 \text{ V}$?
(A) $5.7 \text{ k}\Omega$ (B) $2.7 \text{ k}\Omega$ (C) $3.5 \text{ k}\Omega$ (D) $4.8 \text{ k}\Omega$
3. An n -channel silicon JFET is to be designed with the channel thickness in the range $0.4 \mu\text{m} < 2a < 1.6 \mu\text{m}$. The pinch-off voltage is required to be -3.5 V . What should be the minimum value of N_d ? (Assume that $V_{bi} \approx 0.9 \text{ V}$, and $T = 300 \text{ K}$).
(A) $2.3 \times 10^{15} \text{ cm}^{-3}$
(B) $8.9 \times 10^{15} \text{ cm}^{-3}$
(C) $1.5 \times 10^{16} \text{ cm}^{-3}$
(D) $7.0 \times 10^{16} \text{ cm}^{-3}$
4. For the conditions described in Q-3, What should be the maximum value of N_d ?
(A) $1.4 \times 10^{17} \text{ cm}^{-3}$
(B) $5.5 \times 10^{17} \text{ cm}^{-3}$
(C) $8.0 \times 10^{16} \text{ cm}^{-3}$
(D) $5.0 \times 10^{16} \text{ cm}^{-3}$
5. Consider a p -channel silicon JFET with $V_{bi} = 0.9 \text{ V}$, $N_a = 8 \times 10^{16} \text{ cm}^{-3}$, operating at $T = 300 \text{ K}$. With $V_{DS} = V_{GS} = 0 \text{ V}$, half of the channel is depleted of holes. What is the channel thickness ($2a$)?
(A) $0.16 \mu\text{m}$ (B) $0.27 \mu\text{m}$ (C) $0.36 \mu\text{m}$ (D) $0.48 \mu\text{m}$
6. Consider an n -channel silicon JFET at 300 K with $Z = 20 \mu\text{m}$, $L = 4 \mu\text{m}$, $N_a = 5 \times 10^{18} \text{ cm}^{-3}$, $N_d = 6 \times 10^{16} \text{ cm}^{-3}$, $\mu_n = 1200 \text{ cm}^2/\text{V-s}$, and $a = 0.3 \mu\text{m}$. What is V_{bi} ?
($n_i = 1.5 \times 10^{10} \text{ cm}^{-3}$ at 300 K .)
(A) 0.7 V (B) 0.78 V (C) 0.84 V (D) 0.9 V
7. For the JFET described in Q-6, What is the pinch-off voltage V_P ?
(A) -1.50 V (B) -2.38 V (C) -3.27 V (D) -2.73 V
8. For the JFET described in Q-6, what is V_{DS}^{sat} for $V_{GS} = -1 \text{ V}$?
(A) 2.27 V (B) 1.57 V (C) 0.75 V (D) 1.90 V

9. For the conditions described in Q-8, what is the saturation current I_D^{sat} ?
- (A) 0.58 mA (B) 0.92 mA (C) 1.2 mA (D) 1.54 mA
10. For the conditions described in Q-8, what is the transconductance g_m in saturation?
- (A) 5.6 mS (B) 3.48 mS (C) 1.12 mS (D) 2.25 mS
11. For the JFET described in Q-6, what fraction of the channel is undepleted (conducting) for $V_{GS} = -1$ V and $V_{DS} = 0$ V?
- (A) 0.54 (B) 0.17 (C) 0.25 (D) 0.33