Junction Field Effect Transistors (JFETs) Basics - GATE Problems

1. The pinch off voltage for a n – channel JFET is 4 V, when V_{GS} = 1 V, the pinch – off occurs for V_{DS} equal to
   (a) 3 V (c) 4 V
   (b) 5 V (d) 1 V

   [GATE 1987: 2 Marks]

Soln. Pinch – off voltage (V_P) and V_{GS} (off) are defined as:

Pinch off voltage (V_P):- It is the value of V_{DS} at which I_D levels with V_{GS} = 0 V.

V_{GS} (off):- Value of V_{GS} that completely pinches – off the current to zero. Magnitude of the two is same i.e.

$$|V_{GS}\ (off)| = |V_P|$$

When $V_{GS} = 0, I_D\ saturates\ at\ I_{DSS}$ and characteristic shows V_P. When external bias is applied gate channel still requires – V_P to achieve pinch – off. So the relation modifies to

$$|V_{GS}| = |V_P| - |V_{GS}|$$

Where V_{DS} on LHS is the new V_P for the applied bias.

In this problem,

$$V_P = 4V$$

$$\& \ V_{GS} = 1V$$

$$So, \quad |V_{DS}| = |V_P| - |V_{GS}|$$

$$|V_{DS}| = 4 - 1 = 3V$$

Option (a)

2. In an n – channel JFET, V_{GS} is held constant. V_{DS} is less than the breakdown voltage. As V_{DS} is increased
   (a) Conducting cross – sectional area of the channel ‘S’ and the channel current density ‘J’ both increase

(b) 'S' decrease and 'J' decreases
(c) 'S' decrease and 'J' increases
(d) 'S' increases and 'J' decreases

[GATE 1988: 2 Marks]

Soln. Given,

V_{GS} is held constant and V_{DS} is less than breakdown voltage.

Now V_{DS} is increased, so depletion width increases, thus cross sectional area of the channel decreases,

We know,

Current density $(J) = \frac{I}{A} = \frac{I}{S}$

So, as 'S' decreases current density will increase

Option (c)

3. The 'Pinch – off' voltage of a JFET is 5.0 volts. Its 'cut – off' voltage is
(a) $(5.0)^{1/2}$ V
(b) 2.5 V
(c) 5.0 V
(d) $(5.0)^{3/2}$ V

[GATE 1990: 2 Marks]

Soln. Given,

Pinch – off voltage (V_P) = 5 V

We know

$$|V_{GS}\ (off)| = |V_P|$$

So cut – off voltage = 5 V

Option (c)

4. Which of the following effects can be caused by a rise in the temperature?
(a) Increase in MOSFET current (I_{DS})
(b) Increase in BJT current (I_C)
(c) Decrease in MOSFET current (I_{DS})
(d) Decrease in BJT current (I_C)

[GATE 1990: 2 Marks]

Soln. For BJT

Collector current is given by

$$I_C = \beta I_b + (1 + \beta) I_{CO}$$

As temperature increases, I_{CO} increases, so the current I_C increases in BJT with rice in temperature.

Mobility decreases as the temperature is increased.

So, in MOSFET, the current (I_{DS}) decreases with temperature.

As temperature increases I_{DS} decreases

Options (b) and (c)

5. An n – channel JFET has pinch – off voltage $V_p = -5\ V, V_{DS}(max) = 20\ V, and\ g_m = 2\ mA/V$.
The min 'ON' resistance is achieved in the JFET for
(a) $V_{GS} = -7\ V\ and\ V_{DS} = 0\ V$
(b) $V_{GS} = 0\ V\ and\ V_{DS} = 0\ V$
(c) $V_{GS} = 0\ V\ and\ V_{DS} = 20\ V$
(d) $V_{GS} = -7\ V\ and\ V_{DS} = 20\ V$

[GATE 1992: 2 Marks]

Soln. For n – channel JFET, the minimum 'ON' resistance is obtained when V_{GS} is positive and large and V_{DS} is very small, ideally

V_{DS} = 0 V

Since there is no option for V_{GS} positive, so V_{GS} = 0V.Thus

Option (b)

6. The transit time of the current carries through the channel of a JFET decides its _____ characteristic
(a) Source
(b) Drain
(c) GATE
(d) Source and drain

[GATE 1994: 1 Mark]

Soln. The transit time of current carriers through the channel of a JFET will decide its drain characteristics

Option (b)

7. In a JFET

List – I

A. The pinch – off voltage decreases
B. The transconductance increases
C. The transit time of the carriers in the channel is reduced

List – II

1. The channel doping is reduced
2. The channel length is increased
3. The conductivity of the channel is increased
4. The channel length is reduced
5. The GATE area is reduced

(a) A – 1, B – 3, C – 4
(b) A – 2, B – 5, C – 1
(c) A – 2, B – 3, C – 4
(d) A – 4, B – 3, C – 1

[GATE 1995: 2 Marks]

Soln. A. Pinch off voltage (V_P) is given by

$$V_P = \frac{q\,a^2 N_d}{2\epsilon}$$

So, as doping is reduced Pinch off voltage decreases

B. Transconductance (g_m) is given by

$$g_m = \frac{I_D}{V_{GS}}$$

Thus, transconductance increases as drain current increases as conductivity of the channel is increased.

C. If the channel length is reduced then the transit time of the carriers in the channel is reduced

Thus, the option is

A – 1, B – 3, C – 4

Option (a)

8. An n – channel JFET has $I_{DSSS} = 2\ mA\ and\ V_p = -4\ V$. It's transconductance $g_m(in\ mA/V)$. An applied GATE to source voltage V_{GS} of – 2V is

(a) 0.25 (c) 0.75

(b) 0.5 (d) 1.0

[GATE 1999: 2 Marks]

Soln. Given,

n channel JFET

$$\boldsymbol{I_{DS} = 2\ mA}$$

$$\boldsymbol{V_{DS} = -2\ V}$$

The expression for g_m is given as

$$\boldsymbol{g_m = \frac{2\ I_{DSS}}{|V_P|}\left[1 - \frac{V_{GS}}{V_P}\right]}$$

$$\boldsymbol{g_m = \frac{2 \times 2 \times 10^{-3}}{|-4|}\left[1 - \frac{(-2)}{(-4)}\right]}$$

$$\boldsymbol{= 0.5\ mA/V}$$

Option (b)