Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

ME SEMESTER – I EXAMINATION – SUMMER 2017

Subject Code: 2712605 **Date:10/05/2017**

Subject Name: Physics of MOS Transistor

Time:02:30 p.m. to 05:00 p.m. **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 (a) Identify the region (ON/OFF and linear/saturation) of operation for MOSFET device for the cases given below: **07**

a. P-channel MOSFET with V_T = -2 V; V_G = 0 V, V_B = 5 V, V_D = 0 V, and V_S = 5 V.

b. P-channel MOSFET with V_T = -2 V; V_G = 0 V, V_B = 5 V, V_D = 3 V, and V_S = 5 V.

Draw cross section of p-channel MOSFET and indicate inversion layer in each of the above two cases.

(b) Draw I_{DS} versus V_{DS} characteristics for p-channel MOSFET for three different values of V_{GS} (i. e. $V_{GS1} < V_{GS2} < V_{GS3} < V_{T,p}$, $V_{T,p}$ is the threshold voltage of p-channel MOSFET) for with and without channel length modulation effect. **07**

Q.2 (a) Explain following terms: 1. Degenerate semiconductor, 2. Transit time, 3. Drift current, 4. Diffusion current, 5. Velocity saturation, 6. Sheet resistance, and 7. Fermi potential. **07**

(b) Draw p-type substrate two terminal MOS structure, and derive the exact expression for channel charge (Q'_C). **07**

OR

(b) Draw structure of p-substrate MOS capacitor, and explain the effect of change in V_{GB} on surface potential. Derive expression for electron concentration at the surface as a function of surface potential. **07**

Q.3 (a) Draw surface potential versus V_{CB} for three-terminal MOS structure for a particular value of V_{GB} and derive expressions for transition points: V_Q, V_W, and V_U. **07**

(b) Derive general complete charge-sheet model for MOSFET device. Show that it is symmetric. **07**

OR

Q.3 (a) Obtain expression for inversion charge for three-terminal p-type MOS structure operating in weak inversion region. **07**

(b) Show with necessary mathematical steps that $V_{DS,sat} = 3\phi_t$ for MOSFET device operating in weak inversion region. **07**

Q.4 (a) Derive simplified charge-sheet model for MOSFET device. Plot $-Q'_B$ along the channel length for both cases: 1. Source-referenced and 2. Drain-referenced simplified charge-sheet MOSFET models. **07**

(b) What do you understand by hot carrier effect? How does it affect drain and bulk current? Draw a plot of I_{DB} as a function of V_{GS} at different values of V_{DS}. How can we reduce hot carrier effect? **07**

OR

Q.4 (a) Define effective mobility and discuss various scattering phenomena. Derive expression for effective mobility in terms of inversion and depletion charges. **07**

	(b)	What do you understand by punchthrough? What is the effect of bulk punchthrough on I_D-V_{GS} characteristics? What are the different types of punchthrough and how can you avoid them?	**07**
Q.5	**(a)**	Show that due to velocity saturation effect, the drain current in short-channel MOSFET does not follow square-law. Also justify that the ratio of (W/L) of PMOS and NMOS devices is less than 2 for equal driving capability in short-channel devices.	**07**
	(b)	Explain MOSFET parameter extraction. How would you extract V_T, Φ_0, V_{FB}, and γ.	**07**

OR

Q.5	**(a)**	The gate of MOSFET is applied with pulse signal having finite rise and fall time. Assume that the rise time is greater than the fall time. Also assume that the frequency of input signal is very low and MOSFET operates in quasi-static region. Plot drain and source currents as a function time. Make important comments.	**07**
	(b)	What are the different types of MOSFET models? Discuss merits and demerits of each type of MOSFET models	**07**

****