Seat No.: _____ *Enrolment No._____*

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – I • EXAMINATION – WINTER • 2014

Subject code: 2712605 **Date: 09-01-2015**

Subject Name: Physics of MOS Transistor

Time: 02:30 pm - 05:00 pm **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)**	(a) Draw I_D-V_{DS} characteristics for n-channel MOSFET on a log and linear I_D axis for various values of V_{GS}. Clearly indicate all three regions in your plot; 1. Strong inversion, 2. Moderate inversion and 3. Weak inversion.	**04**
		(b) Explain/define followings terms: 1. Degenerate semiconductors, 2. Transit time, and 3. Velocity saturation.	**03**
	(b)	Define various capacitances in MOS capacitor system and obtain exact expressions for C_{ox} and C_{ox}.	**07**
Q.2	**(a)**	Draw the structure of p-type 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**
	(b)	1. Sketch three-terminal MOS structure (p-type substrate) and its energy band diagram for the following: 1. $V_{CB} = 0$ and 2. $V_{CB} > 0$. Assume $V_{GB} > V_T$.	**04**
		2. Sketch surface potential versus V_{CB} for three-terminal MOS structure for a particular value of V_{GB}. Indicate V_Q, V_W, and V_U in the diagram.	**03**
		OR	
	(b)	Obtain simplified general expressions for inversion and depletion charges for p-type substrate MOS capacitor system operating in inversion region and plot them as a function of surface potential. Assume that the device is not operating in accumulation region.	**07**
Q.3	**(a)**	Define body effect parameter in three-terminal MOS structure. Explain qualitatively the effect of increase in V_{CB} on inversion layer charge and why for a given increase in V_{CB}, V_{GC} is to be increased by a larger value compared to an increase in V_{CB} for higher doping and thicker oxide to maintain the same inversion layer charge.	**07**
	(b)	Derive accurate strong inversion model (basis of level 2 model in Berkeley Spice Simulator) for four-terminal p-type substrate MOS structure.	**07**
		OR	
Q.3	**(a)**	Obtain expression of inversion charge for three-terminal p-type MOS structure operating weak inversion region.	**07**
	(b)	Discuss the effect of Ŭ parameter on the accuracy of simplified strong inversion model.	**07**
Q.4	**(a)**	Discuss the effects of temperature change on óONô current, leakage current, and V_T of MOSFET device with necessary diagrams.	**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)**	Derive Level 3 MOSFET model for the drain current flowing through MOSFET device. Write down level 1 equation for the drain current from level 3.	**07**
	(b)	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**
Q.5	**(a)**	Discuss different components of source/drain resistance and derive expression for I_{DS} taking into account effects of source/drain resistance.	**07**
	(b)	Explain MOSFET parameter extraction. How would you extract V_T, $\bar{u}_0$, V_{FB}, and ɔ.	**07**

OR

Q.5	**(a)**	Define drain-induced barrier lowering (DIBL). Derive the expression for the drop in threshold voltage in short-channel MOSFET device compared to long-channel device for deep source/drain regions due to DIBL.	**07**
	(b)	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**

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