Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

ME Semester –I Examination Feb. - 2012

Subject code: 712605N **Date: 21/02/2012**
Subject Name: Physics of MOS Transistor
Time: 10.30 am – 01.00 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)**	Briefly explain/define following: 1. Poisson's equation for one dimension, 2. Drift current 3. Diffusion current, 4. Velocity saturation effect, 5. Sheet resistance, 6. Contact potential, 7. Depletion approximation	**07**
	(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 in p-substrate MOS capacitor.	**07**
Q.2	**(a)**	Derive expression for Q'_B and C'_b in MOS capacitor without assuming depletion approximation.	**07**
	(b)	Obtain small-signal equivalent capacitive circuit for MOS capacitor. Plot various capacitance components of small-signal equivalent capacitive circuit for MOS capacitor as a function of V_{GB}. Explain effect of frequency on C_{gb}-V_{GB} plot.	**07**
		OR	
	(b)	Derive approximate expressions for inversion charge and surface potential for MOS capacitor operating in weak inversion region. Define parameter *n*.	**07**
Q.3	**(a)**	Explain how the Fermi level split occurs in three-terminal p-substrate MOS structure when V_{CB} is increased from a level of 0. Draw necessary energy band diagram. Obtain expression for electron concentration at the surface for p-substrate three-terminal MOS structure.	**07**
	(b)	Discuss charge sheet approximation. Derive complete charge sheet drain current model for MOSFET device.	**07**
		OR	
Q.3	**(a)**	Plot surface potential as a function of V_{CB} for different values of V_{GB}. Obtain expressions for following important V_{CB} values: V_Q, V_W, and V_U.	**07**
	(b)	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**
Q.4	**(a)**	Discuss following for MOSFET device: 1. Various scattering phenomena and their effect on mobility, and 2. Effect of increasing temperature on mobility and leakage current.	**07**

	(b)	Discuss the effect of using shallow-trench isolation technique on narrow channel effect along with mathematical analysis. Briefly compare the above effect with that in case of using LOCOS technique.	**07**

OR

Q.4	**(a)**	Derive the relationship between drain current expression with and without considering velocity saturation effect.	**07**
	(b)	Explain constant field downscaling technique. Show that the voltage drop across metal line does not change with downscaling.	**07**
Q.5	**(a)**	List out properties of good MOSFET models.	**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**

OR

Q.5	**(a)**	What are the different benchmark tests to evaluate MOSFET models? What should be the behavior of I_D, Q, and capacitances model equations at $V_{DS} = 0$ V? Draw the test setup to verify the same.	**07**
	(b)	Derive expressions for various charges for the MOSFET device operating in weak inversion region.	**07**

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