Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

ME – SEMESTER I (NEW) – • EXAMINATION – SUMMER 2016

Subject Code: 2712605 **Date:18/05/2016**

Subject Name: Physics of MOS Transistor

Time:02:30 pm to 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)**	Show that the transit time due to drift mechanism is inversely proportional to the applied voltage whereas it is inversely proportional to the thermal voltage in case of diffusion mechanism.	**07**
	(b)	Draw I_D-V_{GS} characteristics on p-channel MOSFET on a log and linear I_D axis for three different values of V_{DS} (e.g. $V_{DS1} > V_{DS2} > V_{DS3}$). Take absolute of I_D.	**07**
Q.2	**(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-type substrate three-terminal MOS structure.	**07**
	(b)	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**
		OR	
	(b)	Define "pinch-off" voltage in three-terminal MOSFET device and derive its expression. Obtain expression for inversion charge in strong inversion region as a function of pinch-off voltage.	**07**
Q.3	**(a)**	Derive and obtain small-signal equivalent capacitive circuit for the two-terminal MOS structure with necessary mathematical analysis.	**07**
	(b)	Derive approximate expressions for inversion charge and surface potential for MOS capacitor operating in weak inversion region. Define parameter *n*.	**07**
		OR	
Q.3	**(a)**	Derive expression for Q'_B and C'_b in MOS capacitor without assuming depletion approximation.	**07**
	(b)	Compare source-referenced versus body-referenced MOSFET modeling.	**07**
Q.4	**(a)**	Show with necessary mathematical steps that $V_{DS,sat} = 3\phi_t$ for MOSFET device operating in weak inversion region.	**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 strong inversion drain current model which is the basis of "level 3" model implemented in Berkely Spice simulator.	**07**
	(b)	Explain constant field downscaling technique. Show that the voltage drop across metal line does not change with downscaling.	**07**
Q.5	**(a)**	What do you understand by quasi-static operation of MOSFET device? Derive various charge expressions as a function of terminal voltages for strong inversion region under the assumption of quasi-static operation. No need to carry out integration.	**07**
	(b)	List out properties of good MOSFET models.	**07**
		OR	

Q.5	**(a)**	What do you understand by non-quasi-static effect? Explain non-quasi-static effect with a simple circuit of NMOS applied with a fixed drain voltage and a pulse excitation at the gate terminal.	**07**
	(b)	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**

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