Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – I • EXAMINATION – WINTER 2012

Subject code: 712605N Date: 16-01-2013

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)** 1. Draw I_D-V_{GS} characteristics for 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**

2. Define following terms: 1. Contact Potential, 2. Fermi Potential, 3. Drift Current, 4. Diffusion Current

(b) 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**

Q.2 **(a)** 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**

(b) Draw p-type substrate two terminal MOS structure and its band diagram for four different region of operation; 1. Flat-band, 2. Accumulation, 3. Depletion and 4. Inversion. **07**

OR

(b) Define and draw surface potential in weak inversion region for MOS capacitor system. Derive approximate expression for inversion charge for the same region of operation. **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 given increase in V_{CB}, V_{GC} is to be increased by a larger value for higher doping and thicker oxide to maintain same inversion layer charge. **07**

(b) Derive simplified source-referenced strong inversion model for four-terminal p-type substrate MOS structure. **07**

OR

Q.3 **(a)** Define and explain briefly following quantities for three terminal MOS structure: V_P, V_Q, V_W, V_L, V_M, V_H and n. **07**

(b) Derive general charge-sheet model for MOSFET device. Show that it is symmetric. How can we obtain inversion charge and surface potential as a function of position along channel length in MOSFET device? **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 **07**

compare the above effect with that in case of using LOCOS technique.

OR

Q.4 **(a)** 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**

(b) Discuss the effects on performance of MOSFET devices with downscaling of MOSFET technology as a function of gate oxide thinning and increase in substrate doping. **07**

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 types of MOSFET models? Discuss merits and demerits of each type of MOSFET models **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) Explain MOSFET parameter extraction. How would you extract V_T, Φ_0, V_{FB}, and γ. **07**

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