Reg. No. | | | | | | | | | | | | |

Question Paper Code : 66322

M.E. DEGREE EXAMINATION, DECEMBER 2015/JANUARY 2016

First Semester

VLSI Design

VL7103 : Solid State Device Modeling and Simulation

(Regulations : 2013)

Time : Three Hours **Maximum : 100 Marks**

Answer ALL questions.

PART – A (10 × 2 = 20 Marks)

1. Thickness of gate oxide in a MOSFET is 20 nm. Mask length of the channel is 100 nm and electrical channel length is 80 nm. If the gate width is 100 nm, estimate the gate oxide capacitance and overlap capacitance when the MOSFET is biased in inversion. Given that dielectric constant of silicon dioxide is $3.9\ \varepsilon_0$.

2. Draw high frequency small signal equivalent circuit of a MOSFET.

3. What is a sparse matrix ? Give an example of a sparse matrix.

4. What are the uses of node analysis and mesh analysis ?

5. What is a stiff system ?

6. Why stability is a concern in circuit simulation ?

7. Explain properties of grid in the depletion region and neutral regions of a diode.

8. How the continuity equation for electrons modifies in the absence of applied electric field ?

9. If n-side and p-side doping concentrations are 10^{14} cm^{-3} and 10^{15} cm^{-3}, find the depletion region width when the applied reverse bias is 2V.

10. What is the value of gate capacitance of a MOS capacitor when applied gate bias is equal to threshold voltage ?

PART – B (5 × 13 = 65 Marks)

11. (a) Derive drain current-drain voltage characteristics of a long channel MOSFET.

OR

(b) (i) For a short channel MOSFET, derive equations for transconductance, drain conductance in linear mode and saturation mode. **(8)**

(ii) An n-channel MOSFET has following parameters : gate oxide thickness 10 nm, threshold voltage 0.4 V, channel length 180 nm, channel width 360 nm, carrier mobility 40 cm^2V^{-1} s^{-1}, Gate supply voltage 1.8 V, oxide dielectric constant 3.9 ε_0, and channel length modulation parameter 0.01V-1. Find the current through MOSFET when applied drain bias is 2 V. **(5)**

12. (a) What are branch equations for the following circuit elements ?

(i) Resistor (1M)

(ii) Capacitor (1M)

(iii) Inductor (1M)

(iv) Voltage source (1M)

(v) Current source (1M)

(vi) Voltage controlled voltage source (2M)

(vii) Voltage controlled current source (2M)

(viii) Current controlled current source (2M)

(ix) Current controlled voltage source (2M)

OR

(b) Explain Newton-Raphson Method (Newton Method). What are its advantages and disadvantages ? Using Newton-Raphson method, estimate atleast two root of the following equation :

$$y(x) = x^3 + 15x^2 + 20$$

13. (a) Explain the procedure to obtain solution to stiff systems.

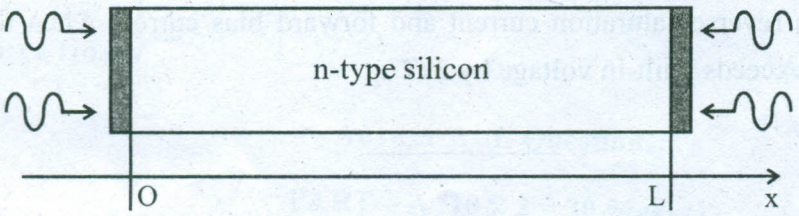
OR

(b) Explain the procedure to obtain solution by using multistep method.

14. (a) Find wave function and energy of an infinite square well potential.

OR

(b) The two ends of a uniformly doped n-type Si bar of length are simultaneously illuminated so as to create γN_D excess holes at both x = 0 and x = L, as shown in figure. The characteristics of incident light are such that no light penetrates into the interior (0 < x < L) of the bar. $\gamma = 10^{-3}$ and steady state conditions prevail. Given T = 300 K and $N_D >> n_i$.



(i) Based on reasoning, sketch the expected general form of the $\Delta p_n(x)$ solution. **(5)**

(ii) Which kind of injection conditions prevail inside the illuminated bar ? Explain. **(4)**

(iii) Write down the differential equation one should solve to determine $\Delta p_n(x)$ inside the bar. **(2)**

(iv) What is the general form of solution and the boundary condition(s) appropriate for this problem ? **(2)**

15. (a) Draw and explain capacitance voltage characteristics of an nMOS capacitor.

OR

(b) How doping concentration of a diode can be estimated ?

PART – C (1 × 15 = 15 Marks)

16. (a) Explain various mobility models that need to be used in simulating a short geometry MOSFET.

OR

(b) Consider a PN junction diode. Cross-section area of the diode is $10^{-4}cm^2$. Various parameters of the diode are listed in the table below.

Name of the parameter	P-region	N-region
Doping concentration (cm^{-3})	10^{15}	10^{16}
Carrier mobility ($cm^2\ V^{-1}\ s^{-1}$)	450	1350
Neutral region length (μm)	15	20
Life time (μs)	1	0.1

Estimate reverse saturation current and forward bias current when the applied voltage exceeds built-in voltage by 3kT/q.

———————