

**MODELLING OF VLSI DEVICE
(VLSI 5142)**

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 4 (four) from Group B to E, taking one from each group.*

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) The Fermi level throughout a pn junction in thermal equilibrium is
(a) Constant (b) Different (c) Broadened (d) Narrowed.
- (ii) The collector voltage at which the linearly extrapolated collector current of a BJT reaches zero is known as the
(a) early voltage (b) threshold voltage
(c) cut-in voltage (d) cut-off voltage
- (iii) The contact potential of a pn-junction is dependent on
(a) intrinsic carrier concentration (b) doping concentration
(c) absolute temperature (d) all of the above
- (iv) Flat band voltage is determined by
(a) intrinsic Fermi level difference
(b) quasi Fermi level difference
(c) electron affinity
(d) metal-semiconductor work function difference, oxide and interface charge densities
- (v) For a MOS capacitor fabricated on a p-type substrate, strong inversion occurs when the
(a) surface potential is equal to the Fermi potential
(b) surface potential is zero
(c) surface potential is negative and equal to the Fermi potential in magnitude
(d) surface potential is positive and equal to twice the Fermi potential
- (vi) For logic circuits, the feature size of a MOS transistor refers its
(a) junction depth (b) gate length
(c) doping concentration (d) gate-oxide thickness.

- (vii) DIBL in short channel MOSFETs causes its threshold voltage to
 - (a) increase (b) decrease
 - (c) remain unchanged (d) go to zero
- (viii) Power dissipation in constant voltage scaling compared to constant field scaling is
 - (a) more (b) less (c) same (d) indeterminate
- (ix) EKV drain current model describes the device operation for
 - (a) Weak inversion (b) Strong inversion
 - (c) Moderate inversion (d) all the three regions of inversion
- (x) Gradual channel approximation is valid in the _____ region of MOSFET operation.
 - (a) Linear (b) Saturation
 - (c) Both linear and saturation (d) Cut off

Fill in the blanks with the correct word

- (xi) In constant field scaling, the electric field remains_____.
- (xii) The potential difference developed across a pn junction at equilibrium is known as the _____.
- (xiii) Channel length modulation is the dependence of the _____ on V_{ds} in the saturation region of operation of the MOSFET.
- (xiv) In the charge sharing model of a MOSFET, the _____(depletion/inversion) charge is shared.
- (xv) An example of a SP- based compact model is _____.

Group - B

- 2. (a) What is the built-in potential of a pn-junction? [[CO1](Remember/LOCQ)]
 (b) Explain why there is no net current flow through a pn-junction at equilibrium. [[CO1] (Understand/LOCQ)]
 (c) Explain the dependence of the width of the depletion region of a pn-junction with applied bias and doping concentration. [[CO1](Apply/IOCQ)]

4 + 2 + 6 = 12
- 3. (a) Discuss the effect of the emitter and base series resistances on the collector current. [[CO1](Understand/LOCQ)]
 (b) Derive the necessary relation to prove that the Fermi level difference is the driving force for the flow of current in a semiconductor. [[CO1](Evaluate/HOCQ)]

6 + 6 = 12

Group - C

- 4. (a) Show with the help of an energy band diagram that the surface potential of a MOSFET under strong inversion is twice that of the Fermi potential. [[CO2](Apply/IOCQ)]

- (b) Define the threshold voltage of a MOSFET. Why is the channel called 'inverted'? [[CO2](Remember/LOCQ)]
- (c) Derive an expression to show the dependence of the threshold voltage of a MOSFET on the substrate bias. [[CO2](Evaluate/HOCQ)]
- 5 + 2 + 5 = 12**
5. (a) Draw the output characteristics of a practical NMOS. [[CO2](Understand/LOCQ)]
- (b) How are the characteristics different from those of an ideal MOSFET? [[CO2](Understand/LOCQ)]
- (c) Obtain an expression for the output resistance of the MOSFET in saturation. What is the ideal value of the resistance? [[CO2](Evaluate/HOCQ)]
- 6 + 2 + 4 = 12**

Group - D

6. (a) State the assumptions of constant field scaling theory. [[CO5](Remember/LOCQ)]
- (b) Show the effect of full scaling on the following MOSFET parameters: gate oxide capacitance per unit area and the packing density. [[CO5](Apply/IOCQ)]
- (c) Justify the use of constant voltage scaling in the industry. [[CO5](Analyze/HOCQ)]
- 3 + 4 + 5 = 12**
7. (a) Explain the dependence of threshold voltage on the length of a MOSFET. How can the threshold voltage roll-off in short channel MOSFETs be taken care of? [[CO4](Understand/LOCQ)]
- (b) How are 'hot' electrons created in short channel devices? Discuss the vertical and lateral hot electron effects. [[CO4](Understand/LOCQ)]
- 6 + 6 = 12**

Group - E

8. (a) How can compact models be classified? [[CO6](Remember/LOCQ)]
- (b) What is GCA in MOSFETs? Discuss the conditions under which it is valid. [[CO6](Apply/IOCQ)]
- (c) Discuss the accuracy of Level 1 MOSFET model. [[CO6](Analyse/IOCQ)]
- 6 + 3 + 3 = 12**
9. (a) What are compact MOSFET models? Why is the development of compact models necessary for general circuit simulation? [[CO5](Understand/LOCQ)]
- (b) Differentiate between the physical, empirical and look-up table based compact models. [[CO5](Understand/LOCQ)]
- 6 + 6 = 12**

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	57.29	21.88	20.83

