

M.TECH/VLSI/3<sup>RD</sup> SEM /VLSI 6101/2015  
2015

RFIC Design and MEMS Technology  
(VLSI 6101)

Time Allotted : 3 hrs

Full Marks : 70

*Figures out of the right margin indicate full marks.*

*Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.*

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

**Group - A**  
**(Multiple Choice Type Questions)**

1. Choose the correct alternatives for the following: 10 x 1=10
- (i) Dynamic range of a RF circuit can be defined as \_\_\_\_\_ divided by the sensitivity.
- (a) maximum output power that can it tolerate
  - (b) maximum input power that can it tolerate
  - (c) minimum input power that can it tolerate
  - (d) minimum output power that can it tolerate.
- (ii) In an RF circuit Inductive load provides
- (a) narrow band operation with high gain
  - (b) narrow band operation but with low gain
  - (c) wide band operation with high gain
  - (d) wide band operation but with low gain.
- (iii) EDGE is the extension of GSM with respect to
- (a) Data rate
  - (b) Power
  - (c) SNR
  - (d) Modulation scheme.
- (iv) Quadrature downconverter requires \_\_\_\_\_ number of LO.
- (a) 4
  - (b) 2
  - (c) 8
  - (d) 1.
- (v) In RF design Mixers can be characterized by
- (a) Voltage conversion gain
  - (b) Current conversion gain
  - (c) Power conversion gain
  - (d) Frequency conversion gain.
- (vi) SOI stands for
- (a) splitting of ions
  - (b) silicon on insulator
  - (c) substrate on insulator
  - (d) silicon orientation index.
- (vii) The term LIGA refers to
- (a) design
  - (b) material
  - (c) microfabrication process
  - (d) none of these.

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- (viii) Anodic bonding of a silicon/gas substrate takes place under  
(a) high temperature (b) high pressure  
(c) high temperature & pressure (d) high temperature & high electric voltage.
- (ix) MEMS capacitor is used in RF integrated circuits primarily due to  
(a) improved mechanical stability  
(b) low dielectric loss  
(c) low power consumption  
(d) high speed of operation.
- (x) Surface micromachining is preferred over bulk micromachining due to  
(a) its compatibility with IC technology since the processing is carried out on one side of the substrate  
(b) its compatibility with IC technology since it is independent of the doping concentration of the substrate  
(c) the higher mechanical stability of the microstructures formed  
(d) lesser number of fabrication steps.

**Group - B**

- 2.(a) Explain in detail, the effect of non-linearity with respect to gain compression and harmonic distortion.
- (b) What are the various noises present in a MOSFET? Explain their physical origin with proper diagram.
- 6 + 6 = 12**
- 3.(a) A MOS capacitor can be constructed as a single transistor of length L or N transistors in parallel, each of length L/N. Compare the Q's of the two structures.
- (b) Determine the S-parameters of the common gate stage. Neglect the channel length modulation and body effect.
- 4 + 8 = 12**

**Group - C**

- 4.(a) State and explain the Barkhausen criteria. If a symmetric inductor VCO has a value of 4nH & a Q of 5 at 10GHz, what is the minimum value of transconductance required in M1 & M2 to guarantee start up?
- (b) Design a cascade common source LNA for a frequency of 5.5 GHz in 130nm CMOS technology.
- (2+3) + 7 = 12**

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5.(a) Compute the required reference frequency and range of divider ratios for an integer-N frequency synthesizer designed for a Bluetooth receiver considering (i) direct conversion and (ii) sliding IF down conversion with  $f_{LO} = (2/3)f_{RF}$ .

(b) Explain the working principle of a class E power amplifier with necessary circuit diagram.

$$6 + 6 = 12$$

**Group - D**

6.(a) What are the advantages offered by ceramics and polymers for utilization as MEMS materials?

(b) Prove that the Miller indices of 2 equidistant parallel planes in a crystal are same.

(c) Write short notes on i) electrostatic actuation ii) thermal actuation.

$$6 + 2 + (2 \times 2) = 12$$

7.(a) What are the specifications of an etchant in IC technology?

(b) Give example of an isotropic and an anisotropic wet etchant of Silicon. Mention one application for each of the etchants in silicon technology.

(c) Draw the flowchart of realizing cantilever structure by surface micromachining process with proper justification of each step.

$$3 + 4 + 5 = 12$$

**Group - E**

8.(a) What is a pressure sensor?

(b) Describe the working principle and structure of a piezoresistive pressure sensor.  
Explain the working principle of a gas sensor.

(c) Distinguish between electrophoretic flow and electroosmotic flow.

$$2 + (5 + 2) + 3 = 12$$

9.(a) What are micromechanical resonators?

(b) What alterations can be made in the MEMS resonator to increase its resonant frequency?

(c) What is meant by pull-down voltage in MEMS capacitor and explain its significance.

(d) Show the process steps for fabrication of a MEMS inductor.

$$3 + 2 + 4 + 3 = 12$$