# KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

B.Sc. Engineering 4th Year 1st Term Examination, 2018
Department of Electronics and Communication Engineering
ECE 4101
(VLSI Design and Nanotechnology)

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

## SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1. a) What are the differences between semi-custom and full-custom design? Briefly describe the top-down design hierarchy for full-custom VLSI design. (12)
   b) State the Moore's law. Does Moore's law still hold true? – Justify your answer. (07)
   c) What is transmission gate? Discuss the importance of it in VLSI design. (06)
   d) State λ-based design rules and hence draw the stick diagram and mask layout of nMOS shift register cell. (10)

2. a) What are the considerations for systems timing in VLSI design? (08)
   b) Explain the PLA based realization of JK flip-flop using necessary diagrams. (09)
   c) What is RAM? Draw the general schematic of a $2^n \times 1$ RAM and explain its operation. (12)
   d) Estimate the power dissipation of a pseudo-static RAM cell considering 2μm technology. (06)

3. a) What is pseudo-nMOS logic? Determine the pull-up to pull-down ratio of pseudo-nMOS inverter and compare its speed-power performance with conventional nMOS logic. (11)
   b) Write down the advantages of $C^2$MOS logic. Realize the following function using $C^2$MOS logic $Z = \overline{A + BC}$. (07)
   c) What are the reasons behind wide acceptance of CMOS based Si technology for IC fabrication? Explain in details. (08)
   d) How can you generate $2^4$ different functions of two variables (A,B) using 4-way MUX? Explain in brief. (09)

4. a) Explain the pre-charged bus concept used in VLSI design. (08)
   b) What is the significance of Schottkey barrier in GaAs technology? (06)
   c) Compare different features of CMOS, Bipolar and GaAs technology. (12)
   d) Discuss on the promising materials for nanoelectronics and future electronics. (09)

## SECTION B

(Answer **ANY THREE** questions from this section in Script B)

5. a) What are the goals of VLSI design? (08)
   b) What are the different scales of integration in microelectronics evolution? Compare different technologies used in the IC fabrication. (10)
   c) Write short note on: (i) Etching process; (ii) Lithographic process; (iii) Noise Margin; (iv) Film formation. (10)
   d) Draw the equivalent RC model of MOS transistor and briefly explain the procedure of its delay estimation. (07)

6. a) What is the significance of gate capacitance in MOSFET? Briefly explain the behavior of gate capacitance model in cutoff, linear and saturation region of MOSFET. (12)
   b) Define photolithography. Explain different steps of photolithography process using necessary diagrams. (13)
   c) Describe the operations of pseudo nMOS inverter. (10)

7. a) Find the impulse response of CMOS inverter driving load capacitor. (10)
   b) Estimate rising and falling propagation delays of 2-input NAND driving h identical gates using Elmore delay formula. (10)
   c) Design a PLA, PAL and ROM at a gate level to realize the sum of product (SOP) functions: (15)

$$X(A,B,C) = AB + ABC + ABC$$
$$Y(A,B,C) = AB + ABC$$
$$Z(A,B,C) = A + B.$$

8. a) Draw the flow diagram of physical design cycle for chip. (08)
   b) What are the characteristics of cells for standard based cell design? (10)
   c) What is FPGA? Show the flow diagram of FPGA design. (07)
   d) Draw and explain the flow diagram of generalized ASIC. (10)

# KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

B.Sc. Engineering 4th Year 1st Term Examination, 2018

Department of Electronics and Communication Engineering

ECE 4105

(Optical Fiber Communication)

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

## SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1. a) What is an optical fiber? Mention its advantages and limitations in communication. (07)
   b) What is mode of propagation? Explain different types of modes for an optical waveguide. What are the parameters that determine the number of modes supported by an optical fiber? (10)
   c) What is a graded index fiber? Outline the primary consideration that may lead one to choose a graded index fiber over a step-index fiber. (07)
   d) A step-index optical fiber has a numerical aperture of $NA = 0.1$. Its cladding is pure silica and has a refractive index of $n_2 = 1.465$. (11)
      i) What is the largest core diameter for which the fiber remains single moded at an optical wavelength of 1.3 μm.
      ii) If the core diameter is found to be 8 μm, what is the wavelength range in which the fiber remains single moded?
      iii) What is the refractive index $n_1$ of the core?

2. a) With the help of suitable diagram, discuss about the concept of evanescent field and Goos-Haenchen shift in optical fiber transmission. (10)
   b) Explain the zig-zag wave theory of light propagation through an optical fiber. Hence, show that the light of each mode is corresponding to a certain discrete incidence angle. (10)
   c) What should be the limit of propagation constant ($\beta$) for a guided mode? Explain the propagation conditions when $\beta < n_2K$, where $n_2$ is the refractive index of cladding and $K$ is the wavenumber. (06)
   d) A graded index fiber with a parabolic index profile supports the propagation of 742 guided modes. The fiber has a numerical aperture in air of 0.3 and the core diameter of 70 μm. Determine the wavelength of the light propagating in the fiber. Further estimate the maximum diameter of the fiber which gives single-mode operation at the same wavelength. (09)

3. a) What are the sources of dispersion in optical fiber? show that the material dispersion coefficient $D_{mat} = -\frac{\lambda}{c}\frac{d^2n}{d\lambda^2}$, where the symbols have their usual meanings. (12)
   b) What are dispersion compensation fibers (DCF) and dispersion shifter fibers? Explain how to shift dispersion in such fiber during fabrication. (08)
   c) A conventional 1300 nm optical fiber communication system is to be upgraded to operate at 1550 nm. However, the conventional single mode fiber (SMF) has a large total dispersion of –17 ps/nm/km at 1550 nm. To eliminate this large dispersion, it is proposed to employ a length of DCF with appropriate dispersion. (15)
      (i) If the SMF is 70 km long and the DCF is 10 km, calculate the required total dispersion of DCF.
      (ii) If the cut-off wavelength of the DCF is 900 nm and has a step index profile and the Laser diode has a spectral width of 1 nm, calculate the core refractive index and core radius of the DCF. Given that the material dispersion of the fiber at 1550 nm is till –17 ps/nm/km. The cladding index is 1.457 and $W = 1.1428\ V - 0.996$, $b = (W/V)^2$, where the symbols have their usual meanings.

4. a) What is nonlinear effect in optical fiber? Briefly explain the nonlinear phenomena of SRS and SPM in optical fiber communication. (09)

b) Write short notes, with the help of necessary sketch, on (*i*) Polarization mode dispersion and (*ii*) Modal noise. (08)

c) Define acceptance angle. Show that the light collecting power of an optical fiber is independent of the dimension of the fiber. (09)

d) A multimode step index fiber has numerical aperture of 0.2 and core refractive index of 1.48. Estimate the insertion loss at a joint in the fiber caused by a $5^0$ angular misalignment of the fiber core axes. It may be assumed that the medium between the fibers is air. (09)

## SECTION B

(Answer **ANY THREE** questions from this section in Script B)

5. a) Classify optical sources. What are the requirements of an optical source to be used with optical fiber? (08)

b) Show that, the optical power generated internally by the LED is given by $P_{int} = \frac{\eta_{int} i}{e} hf$; where the symbols have their usual meaning. (10)

c) Compare the electrical and optical bandwidths for an optical fiber communication system and develop a relationship between them. (07)

d) Calculate the ratio of the stimulated emission to the spontaneous emission rate for an incandescent lamp operating at a temperature of 1000K. It may be assumed that the average operating wavelength is 0.5 μm. (10)

6. a) Write down the basic criteria to choose an optical detector. Compare the advantages and disadvantages of PIN and APD. (10)

b) Briefly explain the operation of Electro Absorption modulator. Also discuss its advantages and disadvantages compared to the Mach-Zehnder modulator (MZM). (10)

c) Draw the block diagram of the front end of an optical receiver showing the various sources of noise. (06)

d) A planar LED is fabricated from gallium arsenide which has a refractive index of 3.6. (09)

(i) Calculate the optical power emitted into air as a percentage of the internal optical power for the device when the transmission factor at the crystal-air interface is 0.68.

(ii) When the optical power generated internally is 50% of the electric power supplied, determine the external power efficiency.

7. a) Deduce the condition of Bragg diffraction for designing the distributed feedback Laser. (10)

b) Show that, the threshold gain per unit length can be expressed by $g_{th} = \bar{\alpha} + \frac{1}{2L} \ln \frac{1}{r_1 r_2}$, where the symbols have their usual meanings. (08)

c) Prove that the error probability in optical receiver for Gaussian noise can be express by $p_e = Q\left(\frac{S_1 - S_0}{\sigma_1 + \sigma_0}\right)$, where the symbols have their usual meanings. (10)

d) A germanium PIN photodiode with active dimensions of 100 × 50 μm has a quantum efficiency of 55% when operating at a wavelength of 1.3 μm. The measured dark current at this wavelength is 8 nA. Calculate the noise equivalent power and specific detectivity for the device. It may be assumed that dark current is the dominant noise source. (07)

8. a) What are the topologies used in optical networking? Explain FDDI network in brief. (07

b) What is OTDR? Explain the principle of finding fiber fault location using an OTDR. (08

c) Describe briefly on cut-back method and modulation phase shift method for measuring the fiber attenuation and chromatic dispersion, respectively. (1C

d) A digital optical fiber communication system operating at a wavelength of 1 μm requires a maximum bit error rate of $10^{-9}$. Determine: (1C

(i) Theoretical quantum limit at the receiver in terms of the quantum efficiency of the detector and the energy of an incident photon.

(ii) The minimum incident optical power required at the detector in order to achieve the above BER when the system is employing ideal binary signaling at 10 Mbps and assuming ideal detector.

# KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

B.Sc. Engineering 4th Year 1st Term Examination, 2018

Department of Electronics and Communication Engineering

ECE 4103

(Wireless Communications)

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) *Erlang B* traffic table and *Erlang C* chart will be supported if necessary.

## SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1. a) What are the factors associated with different mobile standards? (07)
   b) What are the comparisons between physical and logical channels? (07)
   c) What are the purposes of scrambling and framing in cellular system? (07)
   d) What are the features of 4G and 5G? (07)
   e) What are the set-up channels and voice channels? "Set-up channels are sometimes called access channel and paging channel"- Explain the statement. (07)

2. a) "Transmit power must be reduced in order to fill the original coverage area with microcells"- Justify the statement. (08)
   b) What is paging technique? Draw the simple block diagram of a pager and write down the demerits of a pager. (08)
   c) Compare the spectral efficiency of the digital system with respect to the present analog system using the following data: (10)
      (i) The total number of channels in the US cellular system=416
      (ii) The number of control channels=21
      (iii) The number of voice channels=395
      (iv) The channel bandwidth=30 KHz
      (v) The reuse factor=7
      (vi) The total available bandwidth in each direction=12.5 MHz
      (vii) The total coverage area=10,000 $KM^2$
      (viii) The required S/I ratio for analog system=18dB (63.1)
      (ix) The required S/I ratio for digital system=14dB (25.1)
      (x) The call blocking=2%.
   d) Write down the techniques for improving the coverage and capacity in cellular system. (09)

3. a) What is cell and why is it hexagonal instead of circular or rectangular? (02+05)
   b) What are the problems while you are moving in a car during morning and evening and how is it overcome? (08)
   c) What is co-channel interference and how do you reduce them? Describe three sector case for reducing co-channel interferences. (04+06)
   d) A spectrum of 30 MHz is located to a wireless *FDD* cellular system which uses two 25 KHz simplex channels to provide full duplex voice and control channels, compute the number of channels available per cell if a system uses (i) 13-cell reuse (ii) 17-cell reuse. If 1MHz of the allocated spectrum is dedicated to control channels, determine an equitable distribution of control channels and voice channels in each cell for each of the systems. (10)

4. a) Draw the protocol architecture of IEEE 802.16 and write down its functions. (07+03)
   b) Dr. Mamun wants to call from USA to Khulna, Bangladesh by his mobile, establish the connection using GSM architecture. (07)
   c) Prove that frequency reuse ratio (q) in cellular system is equal to $\sqrt{3N}$, where the symbols have their usual meanings. (09)
   d) Transmit power must be reduced to fill the original coverage area with microcell- Justify the statement. (09)

## SECTION B

(Answer **ANY THREE** questions from this section in Script B)

5. a) Develop an impulse response model of a multipath channel. (10)
   b) Express the advantages of interleaving and antenna diversity. (08)
   c) Deduce the expression for Rayleigh and Rice fading distribution and compare the cumulative distribution of these two types of fading. (12)
   d) Write down the solutions of transmission problems used in cellular system. (05)

6. a) Draw the block diagram of *IS-95* forward link transmission and also show the forward link channel parameters. (13)
   b) What is *PN* sequence? Discuss about *DS-CDMA* and *FH-CDMA* systems with block diagrams. (12)
   c) Distinguish between mobile assisted handoff and intersystem handoff. (10)

7. a) What is radio signal diffraction and when is it occurs? What are the models to describe radio signal diffractions? Write down the comparative statement among them. (15)
   b) What are the practical space diversity considerations? Explain maximal ratio combining and equal gain combining. (10)
   c) What do you mean by spectrum-sensing? What are the factors playing important role to enhance the spectrum utilization efficiency? (10)

8. a) What are the advantages of a delayed handoff? Show the relationship between originating calls and the handoff calls for the following cases: (i) No queuing on either the originating calls or the handoff calls, (ii) queuing the originating calls but not the handoff calls. (15)
   b) Explain two level handoff algorithms with necessary figure. (10)
   c) Define frame and burst. Establish the relationship between burst and frame using block diagram. (10)

# KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

B.Sc. Engineering 4th Year 1st Term Examination, 2018

Department of Electronics and Communication Engineering

ECE 4109

(Computer Networks)

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

## SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1. a) What is meant by internet protocol (IP) address? Write short notes on: (i) Private address, (ii) Link local address, (iii) TEST-NET address. (10)
   b) What are the differences between class full and classless IP addressing? What are the IP classes? (07)
   c) Draw the IPv4 header format and briefly explain its different fields. (08)
   d) For the figure in Fig. 1(d), station A needs to send a payload size of 1400 bytes (including 20 bytes of header) to station B across the network as shown. Data needs to be fragmented as the payload is too big to fit in the smallest MTU size (600 bytes). Find the total data length, identification number, more flag and fragmentation offset values for each fragmented packets only in network 2. (10)

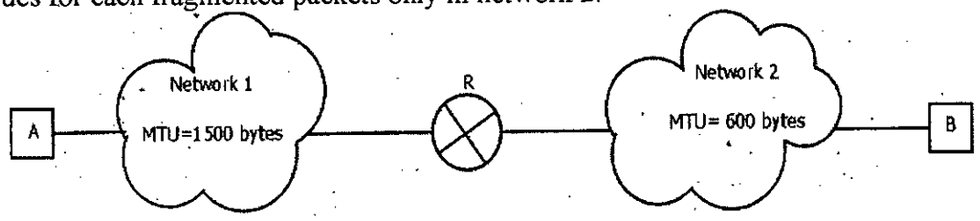


**Fig. 1(d)**

2. a) How a newly arriving client does obtain IP address from a DHCP server? Explain with DHCP client-server interaction message. (08)
   b) What are the error reporting messages of ICMP? Explain redirection message with proper topology. (08)
   c) Briefly explain the Port Address Translation (PAT) technique with the help of network topology. (07)
   d) Let KUET has a registered IP addresses 174.10.0.0/16. It has 6 departments and each department has computer as following. (12)

| Name of the Dept. | Host Number |
|---|---|
| EEE | 105 |
| ECE | 100 |
| CSE | 100 |
| BME | 60 |
| MSE | 150 |
| ESE | 30 |

What will be the appropriate sub network address of each department so that fewest host IP address will be unused?

3. a) What is routing algorithm? Classify routing algorithm. (06)
   b) What is count-to-infinity problem in routing? How it can be solved? (08)
   c) Consider the following network in Fig. 3(c) with the indicated link costs, use Dijkstra's SPF algorithm to compute the shortest path from F to all network nodes. Show how the algorithm works by computing a routing table. (12)

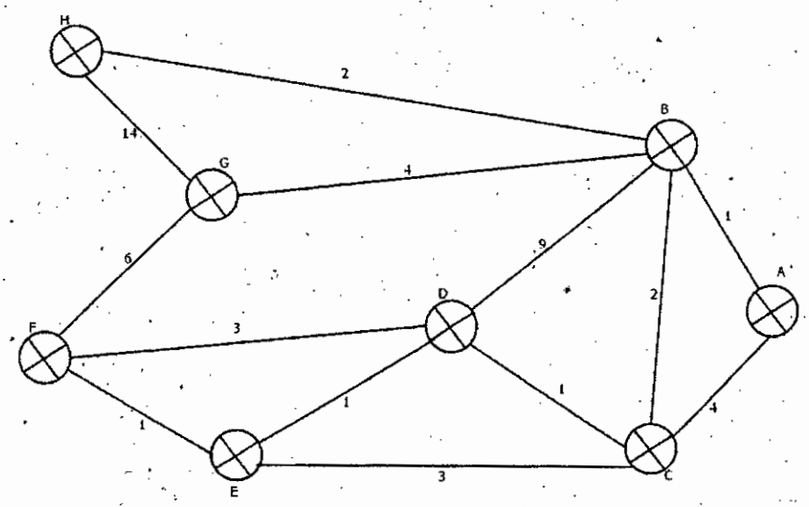


**Fig. 3(c)**

d) "PAT is more economic than NAT" – Justify the statement. (05)

e) Write short note on oscillation problem. (04)

4. a) What are the differences between symmetric and asymmetric key cryptography? Briefly explain DES cryptography technique. (10)

b) Using RSA algorithm encrypt the message '8' and decrypt the cypher text to retrieve the original message. Choose p=7, q=11 to find the public key and private key. (10)

c) How a switch does divide collision domains into smaller regions? What are the media access control techniques? (10)

d) Write short notes on man-in-the-middle attack. (05)

## SECTION B

(Answer **ANY THREE** questions from this section in Script B)

5. a) What do you mean by computer networks? What are the edge and core of computer networks? (07)

b) Describe how web caching can reduce the delay in receiving a requested object? (08)

c) HTTP is called stateless protocol – why? With stateless property how web servers recognize clients? (08)

d) Suppose hosts, A and B are separated by 20,000 KM and are connected by a direct link of 2 Mbps. Suppose the propagation speed over the link is $2.5\times10^8$ m/sec. (12)

i) Calculate the bandwidth-delay product.

ii) What is the width (in meters) of a bit in the link?

iii) Derive a general expression for the width of a bit in terms of propagation speed, the transmission rate and the length of the link.

6. a) "Electronic mail system demands both the push and pull operations" – Justify the statement by mentioning the protocols uses for the operations. (07)

b) Write down the importance of DNS in internet. For DNS address resolution, explain recursive query and iterative query. (10)

c) Draw the UDP segment structure. (06)

d) For the network topology given in Fig. 6(d), a packet size of 200 Mbits transmitted through link with each link speed of 20 Mbps. Calculate the total time required to transmit this file from source to destination for, (12)

i) without segmentation the file

ii) with 10;0000 segmentation of that file.

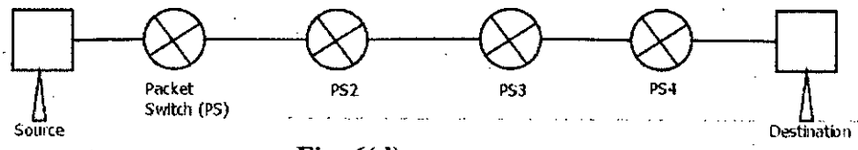


**Fig. 6(d)**

7. a) Briefly explain go-back-N ARQ. Mention the effect of window size on this protocol. (10)
   b) Design the Rdt 2.2 stop and wait protocol to transfer data reliably over a unreadable channel with bit errors. (10)
   c) "FTP sends control information out-of-band"—Justify the statement. (05)
   d) Describe the process of estimating RTT and TCP timeout value. (10)

8. a) Write the process of fast retransmission in TCP. (08)
   b) How does TCP flow control work? (09)
   c) Explain the TCP congestion control process for two senders and a router with finite buffers. (10)
   d) Consider the throughput of TCP connection is 5 Gbps, for 1500 byte segment size and 60ms end-to-end delay, find out the loss rate of TCP. (08)

# KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

B.Sc. Engineering 4th Year 1st Term Examination, 2018

Department of Electronics and Communication Engineering

ECE 4129

(Digital Image Processing)

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

## SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1. a) What is digital image processing? Describe the components of an image processing system. (10)
   b) What are the methods of image sensing and acquisition? Briefly explain the common types of sensor used for image acquisition. (10)
   c) What is meant by adjacency? Briefly explain different types of adjacency. (05)
   d) Consider the image segment shown in figure 1(d). Let $v = \{0, 2\}$ and compute the lengths of the shortest 4, 8 and $m$-path between $p$ and $q$. If a particular path does not exist these paths, explain why? (10)

3 1 2 0 ($q$)
2 2 1 1
1 2 1 1
($p$) 0 1 1 2

Fig. 1(d)

2. a) If function $f(x, y)$ denotes an image, then write the two components by which the function $f(x, y)$ can be characterized? (05)
   b) Write an equation which has a general tendency to spread the histogram of the input image? (03)
   c) Write short notes on – *i*) contrast stretching; *ii*) intensity level slicing; *iii*) Bit-plane slicing. (12)
   d) (*i*) Show the steps of histogram equalization for the following image of size 5×5 given in Fig. 2(c). (15)

| | | | | |
|---|---|---|---|---|
| 1 | 3 | 0 | 1 | 0 |
| 6 | 5 | 2 | 6 | 7 |
| 5 | 7 | 3 | 5 | 6 |
| 7 | 3 | 4 | 4 | 6 |
| 7 | 5 | 6 | 7 | 4 |

Fig. 2 (c)

(*ii*) Also perform the histogram matching operation for the specified histogram given below:

| $Zq$ | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| Specified $P_z(z_q)$ | 0 | 0 | 0 | 0.15 | 0.20 | 0.30 | 0.20 | 0.15 |

3. a) If the continuous intensity values in an image have the PDF: (10)

$$P_r(r) = \begin{cases} \dfrac{2r}{(L-1)^2} & \text{for } 0 \le r \le L-1 \\ 0 & \text{otherwise} \end{cases}$$

where, $r$ is the continuous intensity values of the image. Then show that the transformed/mapped image has a uniform PDF.

   b) For which conditions the alpa-trimmed mean filter is reduced to the arithmetic mean filter and median filter? Explain briefly. (10)
   c) Find the Walsh transform basis for $N = 4$. (10)
   d) Which technique is used for manipulating an image so that the result is more suitable than the original for a specific application? (05)

4. a) What image transform is necessary in digital image processing? (10)

b) What do you mean by digital steganography? Briefly explain the LSB based digital steganography. (07)

c) Perform the 2D DFT of the 4×4 image given in Fig. 4(c). (10)

| | | | |
|---|---|---|---|
| 10 | 11 | 10 | 11 |
| 11 | 10 | 11 | 10 |
| 10 | 11 | 10 | 11 |
| 11 | 10 | 11 | 10 |

Fig. 4(c)

d) Write down the algorithm to generate Haar basis. (08)

## SECTION B

(Answer **ANY THREE** questions from this section in Script B)

5. a) Find the relationship between compression ratio and redundancy for different values of information carrying units. Also find the amount of data required to represent a two-hour standard definition (SD) television moving using 720×480×24 bit pixel arrays, in which video players display the frames sequentially at rates near 30 frames per second. (12)

b) Consider an 8-pixel line of intensity data, {108, 139, 135, 244, 172, 173, 56, 99}. If it is uniformly quantized with 4-bit accuracy. Compute the rms error and rms signal to noise ratios for the quantized data. (11)

c) Consider the simple 4×8, 8-bit image shown in Fig. 5(c). (12)

(i) Compute the entropy of the image.

(ii) Compress the image using Huffman coding.

(iii) Consider Huffman encoding pairs of pixels rather than individual pixels. What is the entropy of the image when looked at as pairs of pixels?

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 80 | 80 | 80 | 90 | 95 | 150 | 150 | 150 |
| 80 | 80 | 80 | 90 | 95 | 150 | 150 | 150 |
| 80 | 80 | 80 | 90 | 95 | 150 | 150 | 150 |
| 80 | 80 | 80 | 90 | 95 | 150 | 150 | 150 |

Fig. 5(c)

6. a) Given a four symbol source $\{a, b, c, d\}$ with source probabilities {0.1, 0.4, 0.3, 0.2} arithmetically encode the sequence "*bbadc*". (08)

b) Can variable-length coding procedures be used to compress a histogram equalized image with $2^n$ intensity levels? Explain. (07)

c) Briefly explain contour tracing and coding method. (07)

d) Write down the steps in JPEG image compression standard. (07)

e) Why Karhunen-Loeve transform (KLT) is seldom used in practice for image compression compared to other transformations? (06)

7. a) What are the advantages of using *B*-frames for motion compensation? (07)

b) Write down the significance of 1st and 2nd derivatives of edge detection. (08)

c) Explain global thresholding algorithm for estimating automatically threshold value of an image. (08)

d) In Hough transform, develop a general procedure for obtaining the normal representation of a line from its slope-intercept form, $y = ax + b$. Also find the normal representation of the line $y = -2x + 1$. (07)

e) Write down the steps of Canny edge detection algorithm. (05)

8. a) Why edge linking is necessary for image segmentation? (07)

b) Briefly explain region based segmentation. (08)

c) Write short notes on Otsu's method for optimum global thresholding. (08)

d) Derive the expression of optical threshold used in image segmentation. (12)