2017-18
M.TECH. (AUTUMN SEMESTER) EXAMINATION
ELECTRONIC CIRCUITS & SYSTEM DESIGN
ACTIVE MONOLITHIC FILTERS
EL-612

Maximum Marks: 60 Credits: 04 Duration: Two Hours

Answer all the questions. Assume suitable data if missing. Notations used have their usual meaning.

Q.No. Question M.M.
1(a) What are the advantages of $g_m$-C filters over opamp –RC filters? [CO1] [05]
1(b) Realize a Tow –Thomas $g_m$-C biquad and compare it with opamp –RC counterpart. [CO2] [10]

OR

1(b') In which order should the biquads be cascaded? Does the cascading sequence make a difference? [CO1] [10]

2(a) What are the effects of nonidealities of the current conveyors (CCII) on the frequency performance of the circuits? [CO1] [05]
2(b) Analyze the circuit of Fig.1 for its output voltage, how it can be used for the realization of universal filter. Give the expressions for filter parameters. [CO2] [10]

Fig.1

Contd....2.
3(a) Give the translinear-C realization of an current mode ideal grounded integrator and differentiator. Also give attractive features. [CO2]

3(b) Give the realization of universal cascadable current mode biquadratic filter using two CCCII and two grounded capacitors. Give various filter responses and filter parameters. [CO2]

4(a) How can we generate voltage controlled bias current of OTA and CCCII? [CO1] OR

4(a') What are the advantages and limitations of switched capacitor filters? [CO1]

4(b) Design the realized Universal biquadratic filter of Q.3(b) for a pole frequency of 10 MHz and a pole Q = 5. [CO3] OR

4(b') Realize a first order low pass filter using switched capacitor filters. Design the realized filter for a dc gain of 20dB and cutoff frequency 4Khz, assuming clock frequency 100Khz. Assuming capacitors of not more than 50 pF. [CO2 and CO3]
Maximum Marks: 60

Credits: 04

Duration: Two Hours

Answer all the questions.
Assume suitable data, if necessary.
Supplement your answers with neat circuit/block diagrams/derivations, wherever necessary.

Q.No.  Question  M.M.
1(a)  The measured parameters of a CCII are listed below. Design a voltage and a current amplifier using this CCII, and comment on the design guidelines, if gain in each case is to be 40 dBs. What is the bandwidth of the two amplifiers?

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_x$ (Ω)</td>
<td>250</td>
<td>$\alpha$</td>
<td>0.9</td>
</tr>
<tr>
<td>$R_y$ (KΩ)</td>
<td>30</td>
<td>$\beta$</td>
<td>0.9</td>
</tr>
<tr>
<td>$R_z$ (KΩ)</td>
<td>50</td>
<td>$f_{\alpha,3db}$</td>
<td>10 MHz</td>
</tr>
<tr>
<td>$C_y=C_z$ (pF)</td>
<td>10</td>
<td>$f_{\beta,3db}$</td>
<td>8 MHz</td>
</tr>
</tbody>
</table>

1(b) Compare the Translinear Loops realized using (i) BJT, (ii) CMOS transistors, on the basis of analysis of their transistors' current relationships.

2(a) Design an instrumentation amplifier using two CFOAs for CMRR=100 dB, assuming $A_v=\text{40 dB}$.

2(b) “The AD-844 ICs can be used for realizing current-mode logarithmic and antilogarithmic amplifiers”. Justify the statement with suitable circuits and derivations.

2(b') With the help of suitable circuit(s) and derivation(s), prove that a CFOA based amplifier’s gain-bandwidth product is not constant.

![Diagram of current-mode amplifier](Image)

Figure 1

contd...
3(a) Justify the utility of the topology of Figure 1 as a configurable analog cell for FPAA application.

3(b) Realize (i) electronically tunable floating resistor; (ii) differential voltage follower; (iii) differential current follower using suitable current-mode building blocks in each case.

OR

3' Analyze the DDCC/DVCC based circuit of Figure 2 and identify the function performed. Also obtain relationship between the marked voltages.

4(a) Implement the system of Figure 3 using current-mode approach.

4b Write a brief technical note on Current-mode circuits.
Maximum Marks: 60  
Duration: Two Hours

**Notes:** Answer all questions. Use the following values of NMOS and PMOS transistors and the supply voltage of 3V unless otherwise specified.

NMOS: \( V_{th} = 0.7V, \gamma = 0.45 V^{1/2}, \lambda = 0.1 V^{-1}, \mu_i C_ox = 50 \mu A V^2, 2\Phi_F = 0.7V \)

PMOS: \( V_{th} = -0.8V, \gamma = 0.40 V^{1/2}, \lambda = 0.2 V^{-1}, \mu_p C_ox = 25 \mu A V^2 \)

1. (a) Why is the Analog Circuit Design more challenging than Digital Circuit Design? Justify your answer. Also describe the different parameters that are to be optimized in an Analog circuit. (CO1)  

1. (b) How a good quality current source can be designed using a MOS transistor? What is the importance of a current mirror and a voltage reference? (CO1)  

1. (c) Compute the voltage gain and output swing of the circuit shown in Fig. 1. Assume all transistors are in saturation and body effect is neglected. (CO2)  

![Fig. 1](image)

2. (a) The cascode of Fig. 2 is designed to provide an output swing of 1.8V with a bias current of 0.5mA. If \( \gamma = 0 \), calculate \( V_{b1}, V_{b2} \) and \( W/L \) of all the transistors. What is the voltage gain, if \( L = 0.5 \mu m \)? (CO1, CO2, CO3)  

![Fig. 2](image)
2' (a) Compute the differential voltage gain of the circuit shown in Fig. 3. Also plot Vout as Vin1 and Vin2 vary differentially from 0 to VDD. (CO1, CO2, CO3)

2 (b) Compute the input referred noise power of the cascode circuit shown in Fig. 4 (CO1, CO2)

3 (a) In the circuit shown in Fig. 5, \( (W/L)_{1,2} = 50\mu/0.5\mu, (W/L)_{3,4} = 10\mu/0.5\mu \) with \( I_{SS} = 0.5mA \). Also \( I_{SS} \) is realized using an NMOS with \( (W/L) = 50\mu/0.5\mu \). Compute CMRR if \( M_1 \) and \( M_2 \) have a threshold mismatch of 2mV. (CO2, CO3)

3 (b) How is it possible to increase the slew rate of a CMOS OPAMP? (CO3)

3' (b) How is it possible to reduce the input referred noise in an amplifier? (CO3)

4 (a) Calculate the gain of the circuit shown in Fig. 6 at very low and very high frequencies. Neglect all other capacitances. (CO2)
Design a folded Cascode CMOS OPAMP shown in Fig. 7 for an output voltage swing of 2.5V, voltage gain of 1800 and power consumption =15mW. Assume $V_{DD}=3V$, $\mu_{n}C_{ox}=60\mu A/V^2$, $\mu_{p}C_{ox}=30\mu A/V^2$, $\gamma = 0$, $V_{THN}=V_{THP}=0.7V$, $\lambda n=0.1V^{-1}$, $\lambda p=0.2 V^{-1}$ for a channel length of 0.5\mu m. (CO1, CO3)
2017-18
M.TECH. (WINTER SEMESTER) EXAMINATION
(ELECTRONICS ENGINEERING)
DIGITAL SYSTEM DESIGN USING HDL
(E1-626)

Maximum Marks: 60         Credits: 04         Duration: Two Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No.                  Question                                      M.M.
1(a) Using Boolean expression and schematic of a 2-bit comparator, write its [09]
Structural Verilog description.
   (CO1)

1(b) Write the test bench of a 4 bit Ripple Counter. Set the clock to toggle every 10 [06]
times units and finish the simulation at time 350. Show the output of
simulation results.
   (CO1)

OR

1 (b') Explain a typical design flow of a digital system using design automation tool. [06]
   (CO1)

2(a) Using appropriate example, differentiate between Task and Function. Describe [06]
their significance too.
   (CO2)

2 (b) Using the subprogram task, write a Verilog code for the design of an adder that [09]
adds two 8-bit words and carry bit.
   (CO2)

Contd... 2.
2(b') Using the subprogram *function*, write a Verilog code to design a word aligner that aligns a word of 64 bits to the left until the most significant bit is 1.

(CO3)

3(a) Design a Programmable Logic Device (PLD) to implement a 4-bit Binary-to-Grey code converter.

(CO3)

OR

3(a') Design a Programmable Array Logic Device (PAL) to implement the following functions.

(a) Exclusive OR
(b) Exclusive NOR
(c) Full truth table of a one bit full adder

(CO4)

3(b) Draw the macrocell architecture of Complex Programmable Logic Devices (CPLD) for Altera MAX 7000S Series and explain its operation

(CO4)

4(a) Using the approach to partition the machine into architecture of separate datapath and control units, design a four bit synchronous counter.

(CO3)

4(b) Using the Verilog model, Design the RISC SPM’s Instruction Register and Program Counter.

(CO3)
2017-2018  
M.Tech (Winter Semester) Examination  
Advance Microprocessor System & Design  
EL-641  

Maximum Marks: 60  
Credits: 04  
Time: 2hrs  

Answer All Questions  
Assume suitable data if missing  
Notations used have their usual meaning.

Qno1(a) 

i) Describe the components that are present on board 8048 μC. 
ii) What do you understand by "Turbo Boost"? Discuss it in brief

Qno2(a) 

Discuss in detail the factors affecting the choice of μC for a given application

1(b) 

Give the addressing mode, group and function of the following instructions of 8048 μC

i) ADD A, @Ry  
ii) OUTL Pp, A  
iii) DJNZ Rr, ADDRESS

1(c) 

How much ROM and RAM is available in 8748 μC? Briefly explain how they are organized.

OR

1(c') 

With the help of architectural diagram, explain the function of various units of 8048's

Qno2(a) 

Answer the following in brief

(i) Which pin of 8051 μC is used to select external code memory?  
(ii) What is the function of T0 & T1 pins of 8051 μC?  
(iii) Which of the following Register of 8051 is not bit addressable?
   a) ACC    b) PSW    c) TMOD    d) TCON  
(iv) Which SFR is used for setting the Interrupt Priorities of 8051 μC? Give its format

2(b) 

i) Give the format of TCON register.  
ii) Write a program for generating a time delay of 10 seconds. Use Timer 1 in appropriate mode. Assume the Crystal frequency as 12Mhz.

2(c) 

i) Draw the configuration of Timer 0 in mode 3.  
ii) Write program to generate a square wave of 2 Hz frequency on PIN. Assume the XTAL clock frequency to be 8.0 MHz. Make suitable assumptions wherever necessary

3(a) 

Briefly discuss the salient features of 68000 μP. Compare these features with that of 8086 μP?  

OR

3(a') 

Discuss the role of 'W', 'V', 'D', 'S' and 'Z' bits in the 8086 μP's Instruction.
Answer the following
(i) What is the size of the bit addressable RAM in 8051 μC? [CO1] (1x5)
(ii) What is the function of various bits of SCON Register? [CO2]
(iii) What is the role of SM0, SM1 and SM2 bits of SCON Register? [CO2]
(iv) What specific functions are assigned to Ax, Cx Registers of 8086 Microprocessor? [CO2]
(v) What do you understand by sign extension? Explain it with the help of suitable example. [CO3]

3 (c) Write an 8086 μP’s assembly language program for arranging 10 data values in descending order. Choose appropriate data values and use assembler directives wherever necessary. [CO4] (5)

4(a) The following are the initial contents of Registers and Memory locations of a 68000 based μP system. [CO3] (5)

002000=3456
002002=AA67
002004=BADE
D₀=44556789
D₁=AABBCDDD
A₀=00002006
A₁=00002004

Give the contents of Registers and Memory locations when each of the following instruction is executed:
i) MOVEA.W (A₁), A0
ii) MOVEM.W $2000, D1/D3/A2/A5
iii) MOVE.L D4, -(A₀)
iv) MOVE.B -(A₁), -(A₀)

4(b) Give a brief account of comparison between Intel’s Core i3, Core i5, Core i7 range of Processors. Also discuss as to how you would choose the processor from among these for various applications? [CO1] (5)

4 (c) Give the Status word format of 8087 Mathematical Co-Processor and discuss the role of various bits in it. [CO4] (5)

4(c') Mathematical Co-Processor 8087 is to be interfaced with 8086 μP. Draw the schematic diagram showing the connections between the two. Also explain how these processors interact with each other. [CO4] (5)
2017-18
M.TECH. (WINTER SEMESTER) EXAMINATION
ELECTRONICS ENGINEERING
DATA TRANSMISSION SYSTEMS
EL-652

Maximum Marks: 60 Credits: 04 Duration: Two Hours

Answer ALL questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No. Question M.M.

1(a) It is often said that bipolar NRZ signaling for baseband data transmission has an inherent but small amount of error detection capability. Why? (CO1) [5]

OR

1(a') Draw the frequency spectra of the commonly used baseband signaling formats, and give your comments on the same. (CO1) [5]

1(b) By considering suitable examples of waveforms and input data sequences, give your comments on the synchronization capability of (i) duobinary waveform, and (ii) modified duobinary waveform. (CO1) [10]

2(a) What are undershoot and overshoot errors? Why do they occur in data transmission systems? (CO2) [5]

OR

2(a') Show that raised cosine spectrum is a special case of sinusoidal roll-off spectrum. (CO2) [5]

2(b) What is meant by partial response signalling? (CO2) [5]

3(a) The sample at time instant t = iT of a digital baseband received signal is given by: 
\[ r_i = s_i + 2.5 s_{i-1} + s_{i-2} + w_i \] , where the symbols have their usual meanings. 
Determine the tap gains of the 11-tap linear feedforward transversal equalizer for the given channel. Find the impulse response of the channel and the equalizer taken together. (CO3) [10]

contd...
3(b) Assume that a wireless communication system is such that the various multi-path components (corresponding to an instantaneous value of the transmitted signal) always reach the receiver terminal at the same time instant. (i) How much will be the time delay spread in this case? (ii) Explain whether equalization would be required in this case or not? (CO3)

3(c) How can catastrophic failure occur in the receiver of a data transmission system which employs a combined detector and estimator? How can a receiver avoid such a failure or recover from it quickly? (CO3)

OR

3(c′) How is the performance of a channel estimator measured? Distinguish between steady state channel estimator and fast start-up channel estimator. (CO3)

4(a) What is meant by “intelligent operations” of a modem? How does it work? (CO4)

4(b) Why does Bluetooth employ half-duplex transmission (using time division duplexing) rather than full-duplex transmission (using frequency division duplexing)? (CO4)

OR

4(b′) Consider a Bluetooth piconet consisting of one Master and one Slave. If the level of noise suddenly increases in the wireless channel, what effect will this have: (i) if speech is being transmitted between Master and Slave, (ii) if data is being transmitted between master and Slave. (CO4)

4(e) What is the main reason for the huge increase in data rates obtained through broadband modems as compared to voice-band modems? (CO4)
Question 1 (Based on CO1)

(a) Suppose that a binary additive stream cipher has been used to encrypt an electronic funds transfer. Assuming that no other cryptographic processing is used, show that an attacker can change the amount of the funds transfer without knowing anything about the key used. (You may assume that the attacker knows the format of the plaintext message used for the funds transfer.)

(b) Let $X$ be an elliptic curve defined over $\mathbb{F}_7$:

\[ y^2 = x^3 + 3x + 2 \]

(i) Compute all points on $X$ over $\mathbb{F}_7$.

(ii) What is the order of the group under point addition operation?

(iii) Given the element $P = (0, 3)$ determine the order of $P$. Is $P$ a primitive element?

OR

(a') Let $p=101$, so 2 is a primitive root. It can be shown that $\log_2 3 = 69$ and $\log_2 5 = 24$.

(i) Using the fact that $24 = 2 \cdot 3$, evaluate $\log_2 24$.

(ii) Using the fact that $5^3 = 24 \mod 101$, evaluate $\log_2 24$.

Question 2 (Based on CO2)

Answer any three parts

(a) Describe how a man-in-the-middle attack may be performed on a Wi-Fi network and the consequences of such an attack. Explain how a man-in-the-middle attack on a Wi-Fi network can be defeated.
(b) Consider an encryption system in which the entropy of the plain text is 32 bits per 128 bit block and in which the AES algorithm is used with a single 128 bit key. Assuming that all keys are equally likely, calculate the unicity distance of this cipher system.

(c) Suppose that there are two users on a network. Let their RSA moduli be $n_1$ and $n_2$, with $n_1 \neq n_2$. If you are told that $n_1$ and $n_2$ are not relatively prime, how would you break their systems?

(d) Describe how the OFB mode can be attacked if the initializing vector is not different for each execution of encryption operation.

**Question 3 (Based on CO3)**

(a) An affine cipher with modulus 26 encrypts 4 as 2 and 7 as 17. Determine the key.

OR

(a') Alice wants to send a message $M$ with a digital signature $\text{sign}(M)$ to Bob. Alice and Bob have an authentic copy of each other's public keys, and have agreed on using a specific hash function $h$. Outline the steps that Alice must follow when signing $M$, and the steps that recipient Bob must follow for validating the signature $\text{sign}(M)$.

(b) Consider the following DES-like encryption method. Start with a message of $2n$ bits. Divide it into two blocks of length $n$ (a left and a right half): $M_0M_1$. The key $K$ consists of $k$ bits. There is a function $f(K, M)$ that takes an input of $k$ bits and $n$ bits and gives an output of $n$ bits. One round of encryption starts with a pair $M_{i-1}M_{i+1}$. The output is a pair $M_{i+1}M_{i+2}$, where $M_{i+2} = M_i \oplus f(K, M_{i+1})$. This is done for $m$ rounds, so the ciphertext is $M_mM_{m+1}$.

(i) If you have a machine that does the $m$ round encryption as described above, how would you use the same machine to decrypt the ciphertext $M_mM_{m+1}$ (using the same key $K$).

(ii) Suppose $K$ has $n$ bits and $f(K, M) = K \oplus M$, and suppose that the encryption process consists of $m=2$ rounds. If you know only a ciphertext, can you deduce the plaintext and the key? If you know a ciphertext and the corresponding plaintext, can you deduce the key?

**Question 4 (Based on CO4)**

(a) Hash functions are commonly used for checking message integrity. List six basic requirements of hash functions

OR

(a') Explain why message authentication alone is insufficient as proof of message origin in general, and to settle disputes about whether messages have been sent. What security
service is provided by digital signatures, and explain how this service relates to message authentication.

(b) Compare the key distribution facilities provided by two local area network vendors illustrated in Figure 1 and in Figure 2.
M.TECH. (WINTER SEMESTER) EXAMINATION
ELECTRONICS ENGINEERING
WIRELESS COMMUNICATION
EL-658

Maximum Marks: 60 Credits: 04 Duration: Two Hours

Answer all the questions. Assume suitable data if missing. Notations used have their usual meaning.

Q. No. Question

1(a). For a Rayleigh faded envelope, find the percentage of time that a signal is 10 dB or more below the rms value. [CO1] [03]

1(b). In a mobile system, channel estimation is performed every 4.615 ms. If the carrier frequency is 1 GHz, determine the maximum mobile velocity for which the system will work satisfactorily. [CO1] [03]

1(c). Consider the following channel model $h(t) = \sum_{n=1}^{N} \alpha_n \delta(t - \tau_n)$, where $\alpha_n$ are zero mean unit variance complex Gaussian and are uncorrelated with each other, $\tau_n$ are uniform between 0 and $\tau_m$ and are independent of each other. Assume that N is large so that $\sum_{n=1}^{N}|\alpha_n|^2 = N$, i.e., can be considered as a constant instead of random. Determine the rms delay spread of the channel. [CO1] [09]

2(a). Determine the necessary SNR, in order to detect BPSK signal in Rayleigh fading channel with an average BER of $10^{-6}$. [CO2] [03]

2(b). Two coherent receivers with diversity in a Rayleigh fading environment are studied. One receiver uses maximum ratio combining and the other uses selection combining. Explain why the transmission performance difference between the two receivers increases with the order of the diversity. [CO2] [06]

OR

2(b'). Consider a 3-branch selection combiner in which each branch receives an independent Rayleigh fading signal. If the average SNR is 30 dB, determine the probability that the SNR will drop below 10 dB. Compare the result with a case without any diversity. [CO2] [06]

2(c). Consider a 2-path diversity system with channel gains $h_1 = [1/\sqrt{2} + j 1/\sqrt{2}]$ and $h_2 = [1/\sqrt{2} - j 1/\sqrt{2}]$ [06]

Contd...
Find the optimal weight for MRC. Also, find the SNR at the combiner output.

[CO3]

3. Consider a flat-fading channel with a bandwidth of 30 KHz and three possible SNRs: \( \gamma_1 = 0.8333 \) with \( p(\gamma_1) = 0.1 \), \( \gamma_2 = 83.33 \) with \( p(\gamma_2) = 0.5 \), and \( \gamma_3 = 333.33 \) with \( p(\gamma_3) = 0.4 \). Assume that only receiver has CSI. Find the capacity versus outage for this channel, and find the average rate correctly received for outage probabilities \( p_{out} < 0.1 \), \( p_{out} = 0.1 \) and \( p_{out} = 0.6 \). [CO3]

OR

3'. Assume a Rayleigh fading channel, where the transmitter and receiver have CSI and the distribution of fading SNR \( p(\gamma) \) is exponential with mean \( \text{SNR} = 10 \) dB. Assume a channel bandwidth of 10 MHz. Find the cutoff value \( \gamma_0 \) and the corresponding power adaptation that achieves Shannon capacity on this channel. Compute the Shannon capacity of this channel and compare it with the channel capacity in AWGN with the same average SNR.

4(a) How does OFDM work? What are the key advantages of OFDM over single carrier systems? [CO4]

4(b) Consider an OFDM system with 128-point FFT where each OFDM symbol is 128 \( \mu \)s long. It operates in a slowly time-variant channel, frequency-selective channel. The power delay profile of the channel is \( P(\tau) = e^{-\tau/16} \mu \)s. Calculate the duration of cyclic prefix for the system. [CO4]

4(b). Consider the 2x2 MIMO system with channel gain matrix \( \mathbf{H} \) given by

\[
\mathbf{H} = \begin{bmatrix}
0.3 & 0.5 \\
0.7 & 0.2
\end{bmatrix}
\]

Assume \( \mathbf{H} \) is known at both the transmitter and receiver, and there is a total transmit power of \( P = 10 \) mW across the two transmit antennas, AWGN with power spectral density \( \text{No} = 10^{-9} \) W/Hz at each receive antenna, and bandwidth \( B = 100 \) KHz. On computing the SVD of channel matrix \( \mathbf{H} \), the diagonal matrix is found to be

\[
\begin{bmatrix}
0.8713 & 0 \\
0 & 0.3328
\end{bmatrix}
\]

Determine the SNR of each of the channel.
Q.No. | Question | M.M.
--- | --- | ---
1. | [CO-1] Design an efficient filter bank to determine the low frequency and high frequency components of a signal $x[n]$. Consider the prototype filter has atleast 50 dB attenuation in the stopband and a transition region $\Delta \omega = 0.1\pi$. Use window method. | [12] |
2(a) | [CO-1] Prove the equivalence of the two interpolator configurations shown in Fig. 1. | [06] |
![Figure 1: problem 2(a)](image)
2(b) | [CO-2] Describe briefly the multi-resolution analysis of discrete wavelet transform using subband coding algorithm. | [06] |
3 | [CO-3] Consider a signal $x(n) = s(n) + w(n)$, where $s(n)$ is an AR(1) process that satisfies the difference equation $s(n) = 0.8 s(n-1) + v(n)$. where $\{v(n)\}$ is a white noise sequence with variance = 0.49 and $\{w(n)\}$ is a white noise sequence with variance = 1. The processes $\{v(n)\}$ and $\{w(n)\}$ are uncorrelated. (a) Determine the autocorrelation sequences for signal $x(n)$ and $s(n)$ (b) Design a Wiener filter of length $M = 2$ to estimate $\{s(n)\}$. (c) Determine the MMSE for $M = 2$. | [12] |

OR

Contd... 2
3. [CO-3] Determine a Levinson-Durbin recursive algorithm for solving for the coefficients of a backward prediction-error filter. Use the result to show that coefficients of the forward and backward predictors can be expressed recursively as

\[
\begin{align*}
a_m &= \begin{bmatrix} a_{m-1} \\ 0 \end{bmatrix} + K_m \begin{bmatrix} b_{m-1} \\ 1 \end{bmatrix} \\

b_m &= \begin{bmatrix} b_{m-1} \\ 0 \end{bmatrix} + K_m^* \begin{bmatrix} a_{m-1} \\ 1 \end{bmatrix}
\end{align*}
\]

4. [CO-4] For design of power density spectral estimator using the Bartlett method, describe the steps involved. Also analyse the mean value and variance of the Bartlett estimate.

5. [CO-5] An array processor consists of a primary sensor and a reference sensor interconnected with each other. The \( x_1(n) \) and \( x_2(n) \) denote the primary and the reference sensor output respectively, at time \( n \). The output of the reference sensor is weighted by \( a \) and subtracted from the output of the primary sensor. Show that the mean square value of the output of the array processor is minimized when the weight \( a \) attains the optimum value

\[
a_{opt} = \frac{E[x_1(n)x_2^*(n)]}{E[|x_2(n)|^2]}
\]

OR

5'. [CO-5] Consider the random process

\[
x(n) = g v(n) + w(n), \quad n = 0, 1, \ldots, M - 1
\]

where \( v(n) \) is a known sequence, \( g \) is a random variable with \( E[g] = 0 \), and \( E[g^2] = G \). The process \( w(n) \) is a white noise sequence with \( \gamma_{ww}(m) = \sigma_w^2 \delta(m) \). Determine the coefficients of the linear estimator for \( g \), that is,

\[
\hat{g} = \sum_{n=0}^{M-1} h(n)x(n)
\]

that minimizes the mean-square error i.e., \( \varepsilon = E[(g - \hat{g})^2] \).
2017-18
M.TECH. (WINTER SEMESTER) EXAMINATION
ELECTRONICS ENGINEERING
(Communication & Information Systems)
IMAGE AND VIDEO PROCESSING
EL-663

Maximum Marks: 60
Credits: 04
Duration: Two Hours

Note: Answer all questions. Assume suitable data, if missing. Notations used have their usual meaning.

Q.No. Question M.M.
1(a). (CO1) A 3×3 image shown in Fig. 1(a) is filtered using symmetrical 2-D filter shown in Fig. 1(b). Find the output image by performing 2D convolution. [06]

\[
\begin{bmatrix}
2 & 6 & 3 \\
6 & 2 & 1 \\
3 & 1 & 2
\end{bmatrix}
\]

Fig. 1(a)

\[
\begin{bmatrix}
-1 & -2 & -1 \\
0 & 0 & 0 \\
1 & 2 & 1
\end{bmatrix}
\]

Fig. 1(b)

1(b). (CO1) The following two vectors form an orthonormal basis set for 1D vector of dimension 2. [06]

\[
\begin{bmatrix}
1 \\
\frac{1}{\sqrt{2}}
\end{bmatrix}, \quad \begin{bmatrix}
1 \\
\frac{1}{\sqrt{2}}
\end{bmatrix}
\]

(i) Use these 1-D bases to construct a 2D orthonormal transform basis set and find four basis images.

(ii) Apply your 2D transform of part (i) to following 2×2 image, and find all transformed coefficients.

\[
\begin{bmatrix}
8 & 8 \\
4 & 4
\end{bmatrix}
\]

Assume that these coefficients are received without any error, show that the image can be perfectly reconstructed.

OR

1(b'). (CO1) Consider a two dimensional filter \( h(n, m) \) (origin at the centre)
Using 2-D DTFT, obtain the transfer function, \( H(u, v) \) of filter and sketch \( H(u, 0) \) and \( H(0, v) \). By evaluating \( H(0, 0) \), determine the nature of this filter.

2(a). (CO2) What is chromaticity diagram? Explain its properties suitable for colour mixing. Why HSV colour model is preferred in computer vision applications. Clearly differentiate between YIQ and YUV colour models.

2(b). (CO2) Though peak signal to noise ratio (PSNR) is widely used for objective quality measurement of images and videos, it has many limitations. List and explain at least two of its limitations.

2(c). (CO2) Suppose that a flat area with centre at \((x_0, y_0)\) is illuminated by a light source with intensity distribution \( I(x, y) = Ke^{-(x-x_0)^2+(y-y_0)^2} \). Assume for simplicity that the reflectance of the area is constant and equal to 1.0, and let \( K=255 \). If the resulting image is digitized with \( m \) bits of intensity resolution, and the eye can detect an abrupt change of eight shades of intensity between adjacent pixels, what value of \( m \) will cause visible false contouring? (Assume that the false contouring occurs when step-size of quantizer is more than 8 on intensity scale.)

3(a). (CO3) Suppose that a digital image is subjected to histogram equalization. Show that a second pass of histogram equalization will produce exactly the same result as the first pass.

OR

3(a'). (CO3) What effect would be the effect on the histogram of an image if lower-order bit planes are set to zero? What would be the effect on the histogram if we set to zero the higher-order bit planes instead?

3(b). (CO3) In a given application an averaging mask is applied to input images to reduce noise, and then a Laplacian mask is applied to enhance small details. Would the result be the same if the order of these operations were reversed? Give justifications of your answer.

3(c). (CO4) A skilled medical technician is assigned the job of inspecting a certain class of images generated by an electron microscope. In order to simplify the inspection task, the technician decides to use digital image processing techniques, and to this end, examines a set of representative images and finds the following problems:

(i) bright, isolated dots are of no interest and should be removed;

(ii) lack of sharpness;

\( \text{contd...} \)
(iii) not enough contrast in some images;
(iv) shift in the average gray-level value, when this value should be V to perform correctly certain intensity measurements.

The technician wants to correct these problems and then display in white all gray-levels in the band between $I_1$ and $I_2$, while keeping the normal tonality in the remaining gray-levels. Propose a sequence of processing steps that the technician can follow to achieve the desired goal.

4. **(CO3)** Consider a simplified JPEG like image coder, where each 4x4 block is transformed into DCT coefficients and these coefficients are then quantized and coded into binary bits using run-length coding along the zig-zag order. The Fig. 2 shows a 4x4 block of quantized DCT coefficients. To code, these coefficients are scanned in the zig-zag order. Along this scan order, we code each non-zero index with a fixed length coder, and the zero indices using the run-length of zeros. The last run of zeros will be indicated by an EOB (end of block) symbol. Let us assume that there are at most 8 different possible values for the magnitude of the non-zero coefficients (from 1 to 8) so that each can be coded using 3 bits (level k will be coded using binary representation for k-1, i.e. 1 coded as 000, 7 coded as 110). Each non-zero coefficient is coded with 4 bits, with 1 bit for the sign (0 for positive, 1 for negative) and 3 bits for the magnitude. For the run-length, the possible run-length symbols are 0, 1, 2, ..., 14, EOB. We will code the run-length values in the range of 0 to 6, the special symbol EOB, and the special symbol indicating the run-length is larger than 6 using a Huffman codebook, and code the remaining possible run-lengths (7 to 14) using a fixed length code with 3 bits (with run-length l coded using binary representation of l-7).

(i) Write down the sequence of (run-length, non-zero value) pairs that represents this block;

(ii) Table 1 provides the probability distribution of possible run-length symbols to be coded using Huffman coding. Design a Huffman code for all possible symbols;

(iii) Write down the actual coded bitstream for this block using a combination of your Huffman code and fixed length coding as described above. How many bits did you use in total? What is the bit rate (bits/pixel)?

<table>
<thead>
<tr>
<th>Symbol</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>EOB</th>
<th>Flag (&gt;6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability</td>
<td>0.2</td>
<td>0.15</td>
<td>0.1</td>
<td>0.1</td>
<td>0.05</td>
<td>0.03</td>
<td>0.02</td>
<td>0.15</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Table 1: Probability distribution of run-length symbols

Contd... 4.
Fig. 2: Quantized transformed coefficients

4'(a).  (CO3) Draw a block diagram to compute 2-D DWT of an image (for single level of dyadic wavelet decomposition) and explain the function of each block. Which feature of DWT makes it suitable to provide spatial scalability in JPEG2000 image coder? [04]

4'(b).  (CO3) Why DC and AC coefficients of a DCT block are coded separately in a JPEG image coder? What is the blocking artefact? Why and when it occurs in JPEG coded images? [04]

4'(c).  (CO3) What are the main reasons of preferring discrete cosine transform (DCT) over other transform in JPEG image coder? Write the defining equations of forward and inverse DCT. [04]

5(a).  (CO5) Draw the block diagram of typical hybrid video encoder and decoder, used in most of the standard video coders. [04]

5(b).  (CO5) What do you mean by I-, P-, and B- frames in context of video coding? What is the use of these frames in video coding? Why coding order of frames is different than the order in which frames occur? [04]

OR

5(b').  (CO5) Why chroma sub-sampling is done in video frames? Explain the difference between 4:1:1 and 4:2:0 chroma down-sampling. [04]

5(e).  (CO5) Explain the process of full search block motion estimation used in typical video codecs. [04]