# SEMESTER -3

| ECT201 | SOLID STATE DEVICES | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PCC | 3 | 1 | 0 | 4 |

**Preamble:** This course aims to understand the physics and working of solid state devices.

**Prerequisite**: EST130 Basics of Electrical and Electronics Engineering

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Apply Fermi-Dirac Distribution function and Compute carrier concentration at equilibrium and the parameters associated with generation, recombination and transport mechanism |
| **CO 2** | Explain drift and diffusion currents in extrinsic semiconductors and Compute current density due to these effects. |
| **CO 3** | Define the current components and derive the current equation in a pn junction diode and bipolar junction transistor. |
| **CO 4** | Explain the basic MOS physics and derive the expressions for drain current in linear and saturation regions. |
| **CO 5** | Discuss scaling of MOSFETs and short channel effects. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | |
| **CO 2** | 3 | 3 | | | | | | | | | | |
| **CO 3** | 3 | 3 | | | | | | | | | | |
| **CO 4** | 3 | 3 | | | | | | | | | | |
| **CO 5** | 3 | | | | | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 10 | 10 | 20 |
| Understand | 25 | 25 | 50 |
| Apply | 15 | 15 | 30 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

## Course Level Assessment Questions

**Course Outcome 1 (CO1): Compute carrier concentration at equilibrium and the parameters associated with generation, recombination and transport mechanism**

1. Derive the expression for equilibrium electron and hole concentration.

2. Explain the different recombination mechanisms

3. Solve numerical problems related to carrier concentrations at equilibrium, energy band diagrams and excess carrier concentrations in semiconductors.

**Course Outcome 2 (CO2) : Compute current density in extrinsic semiconductors in specified electric field and due to concentration gradient.**

1. Derive the expression for the current density in a semiconductor in response to the applied electric field.

2. Derive the expression for diffusion current in semiconductors.

3. Show that diffusion length is the average distance a carrier can diffuse before recombining.

**Course Outcome 3 (CO3): Define the current components and derive the current equation in a pn junction diode and bipolar junction transistor.**

1. Derive ideal diode equation.

2. Derive the expression for minority carrier distribution and terminal currents in a BJT.

3. Solve numerical problems related to PN junction diode and BJT.

**Course Outcome 4 (CO4): Explain the basic MOS physics with specific reference on MOSFET characteristics and current derivation.**

1. Illustrate the working of a MOS capacitor in the three different regions of operation.

2. Explain the working of MOSFET and derive the expression for drain current.

3. Solve numerical problems related to currents and parameters associated with MOSFETs.

**Course Outcome 5 (CO5): Discuss the concepts of scaling and short channel effects of MOSFET.**

1. Explain the different MOSFET scaling techniques.

2. Explain the short channel effects associated with reduction in size of MOSFET.

## SYLLABUS

**MODULE I**

Elemental and compound semiconductors, Intrinsic and Extrinsic semiconductors, concept of effective mass, Fermions-Fermi Dirac distribution, Fermi level, Doping & Energy band diagram, Equilibrium and steady state conditions, Density of states & Effective density of states, Equilibrium concentration of electrons and holes.

Excess carriers in semiconductors: Generation and recombination mechanisms of excess carriers, quasi Fermi levels.

**MODULE II**

Carrier transport in semiconductors, drift, conductivity and mobility, variation of mobility with temperature and doping, Hall Effect.
Diffusion, Einstein relations, Poisson equations, Continuity equations, Current flow equations, Diffusion length, Gradient of quasi Fermi level

**MODULE III**

PN junctions : Contact potential, Electrical Field, Potential and Charge distribution at the junction, Biasing and Energy band diagrams, Ideal diode equation.
Metal Semiconductor contacts, Electron affinity and work function, Ohmic and Rectifying Contacts, current voltage characteristics.
Bipolar junction transistor, current components, Transistor action, Base width modulation.

**MODULE IV**

Ideal MOS capacitor, band diagrams at equilibrium, accumulation, depletion and inversion, threshold voltage, body effect, MOSFET-structure, types, Drain current equation (derive)- linear and saturation region, Drain characteristics, transfer characteristics.

**MODULE V**

MOSFET scaling – need for scaling, constant voltage scaling and constant field scaling.

Sub threshold conduction in MOS.
Short channel effects- Channel length modulation, Drain Induced Barrier Lowering, Velocity Saturation, Threshold Voltage Variations and Hot Carrier Effects.
Non-Planar MOSFETs: Fin FET –Structure, operation and advantages

**Text Books**

1. Ben G. Streetman and Sanjay Kumar Banerjee, Solid State Electronic Devices, Pearson 6/e, 2010 (Modules I, II and III)

2. Sung Mo Kang, CMOS Digital Integrated Circuits: Analysis and Design, McGraw-Hill, Third Ed., 2002 (Modules IV and V)

**Reference Books**

1. Neamen, Semiconductor Physics and Devices, McGraw Hill, 4/e, 2012
2. Sze S.M., Semiconductor Devices: Physics and Technology, John Wiley, 3/e, 2005
3. Pierret, Semiconductor Devices Fundamentals, Pearson, 2006
4. Sze S.M., Physics of Semiconductor Devices, John Wiley, 3/e, 2005
5. Achuthan, K N Bhat, Fundamentals of Semiconductor Devices, 1e, McGraw Hill,2015
6. Yannis Tsividis, Operation and Modelling of the MOS Transistor, Oxford University Press.
7. Jan M.Rabaey, Anantha Chandrakasan, Borivoje Nikolic, Digital Integrated Circuits - A Design Perspective, PHI.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **MODULE 1** | |
| 1.1 | Elemental and compound semiconductors, Intrinsic and Extrinsic semiconductors, Effective mass | 2 |
| 1.2 | Fermions-Fermi Dirac distribution, Fermi level, Doping & Energy band diagram, | 2 |
| 1.3 | Equilibrium and steady state conditions, Density of states & Effective density of states | 1 |
| 1.4 | Equilibrium concentration of electrons and holes. | 1 |
| 1.5 | Excess carriers in semiconductors: Generation and recombination mechanisms of excess carriers, quasi Fermi levels. | 2 |
| 1.6 | TUTORIAL | 2 |
| **2** | **MODULE 2** | |
| 2.1 | Carrier transport in semiconductors, drift, conductivity and mobility, | 2 |

| | | |
|---|---|---|
| | variation of mobility with temperature and doping. | |
| 2.2 | Diffusion equation | 1 |
| 2.3 | Einstein relations, Poisson equations | 1 |
| 2.4 | Poisson equations, Continuity equations, Current flow equations | 1 |
| 2.5 | Diffusion length, Gradient of quasi Fermi level | 1 |
| 2.6 | TUTORIAL | 2 |
| | | |
| **3** | **MODULE 3** | |
| 3.1 | PN junctions : Contact potential, Electrical Field, Potential and Charge distribution at the junction, Biasing and Energy band diagrams, | 2 |
| 3.2 | Ideal diode equation | 1 |
| 3.3 | Metal Semiconductor contacts, Electron affinity and work function, Ohmic and Rectifying Contacts, current voltage characteristics. | 3 |
| 3.4 | Bipolar junction transistor – working,, current components, Transistor action, Base width modulation. | 2 |
| 3.5 | Derivation of terminal currents in BJT | 2 |
| 3.6 | TUTORIAL | 1 |
| | | |
| **4** | **MODULE 4** | |
| 4.1 | Ideal MOS capacitor, band diagrams at equilibrium, accumulation, depletion and inversion | 2 |
| 4.2 | Threshold voltage, body effect | 1 |
| 4.3 | MOSFET-structure, working, types, | 2 |
| 4.4 | Drain current equation (derive)- linear and saturation region, Drain characteristics, transfer characteristics. | 2 |
| 4.5 | TUTORIAL | 1 |
| | | |
| **5** | **MODULE 5** | |
| 5.1 | MOSFET scaling – need for scaling, constant voltage scaling and constant field scaling. | 2 |
| 5.2 | Sub threshold conduction in MOS. | 1 |
| 5.3 | Short channel effects- Channel length modulation, Drain Induced Barrier Lowering, Velocity Saturation, Threshold Voltage Variations and Hot Carrier Effects. | 3 |
| 5.4 | Non-Planar MOSFETs: Fin FET –Structure, operation and advantages | 1 |
| | | |

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**MODEL QUESTION PAPER**

**ECT 201 SOLID STATE DEVICES**

**Time: 3 hours** **Max. Marks:100**

**PART A**

Answer ***all*** questions. Each question carries ***3 marks***.

1. Draw the energy band diagram of P type and N type semiconductor materials, clearly indicating the different energy levels.
2. Indirect recombination is a slow process. Justify
3. Explain how mobility of carriers vary with temperature.
4. Show that diffusion length is the average length a carrier moves before recombination.
5. Derive the expression for contact potential in a PN junction diode.
6. Explain Early effect? Mention its effect on terminal currents of a BJT.
7. Derive the expression for threshold voltage of a MOSFET.
8. Explain the transfer characteristics of a MOSFET in linear and saturation regions.
9. Explain Subthreshold conduction in a MOSFET. Write the expression for Subthreshold current.
10. Differentiate between constant voltage scaling and constant field scaling

**PART B**

Answer ***any one*** question from each module. Each question carries 14 marks.

**MODULE I**

**11.** (a) Derive law of mass action. (8 marks)

(b) An n-type Si sample with $N_d = 10^5$ $cm^{-3}$ is steadily illuminated such that $g_{op} = 10^{21}$ EHP/$cm^3$ s. If $\tau_n = \tau_p = 1\mu s$ for this excitation. Calculate the separation in the Quasi-Fermi levels ($F_n$-$F_p$). Draw the Energy band diagram.. (6 marks)

**12.** (a) Draw and explain Fermi Dirac Distribution function and position of Fermi level in intrinsic and extrinsic semiconductors. (8 marks)

(b) The Fermi level in a Silicon sample at 300 K is located at 0.3 eV below the bottom of the conduction band. The effective densities of states $N_C$= 3.22 X $10^{19}$ $cm^{-3}$ and $N_V$=1.83 x $10^{19}$ $cm^{-3}$. Determine (a) the electron and hole concentrations at 300K (b) the intrinsic carrier concentration at 400 K. (6 marks)

## MODULE II

**13.** (a) Derive the expression for mobility, conductivity and Drift current density in a semiconductor. (8 marks)

(b) A Si bar 0.1 μm long and 100 $\mu m^2$ in cross-sectional area is doped with $10^{17}$ $cm^{-3}$ phosphorus. Find the current at 300 K with 10 V applied. (b). How long will it take an average electron to drift 1 μm in pure Si at an electric field of 100 V/cm? (6 marks)

**14.** (a) A GaAs sample is doped so that the electron and hole drift current densities are equal in an applied electric field. Calculate the equilibrium concentration of electron and hole, the net doping and the sample resistivity at 300 K. Given $\mu_n = 8500\ cm^2/Vs$, $\mu_p = 400\ cm^2/Vs$, $n_i = 1.79 \times 10^6\ cm^{-3}$. (7 marks)

(b) Derive the steady-state diffusion equations in semiconductors. (6 marks)

## MODULE III

**15.** (a) Derive the expression for ideal diode equation. State the assumptions used. (9 marks)

(b) Boron is implanted into an n-type Si sample ($N_d = 10^{16} cm^{-3}$), forming an abrupt junction of square cross section with area = $2 \times 10^{-3}\ cm^2$. Assume that the acceptor concentration in the p-type region is $N_a = 4 \times 10^{18}\ cm^{-3}$. Calculate $V_0$, W, Q+, and $E_0$ for this junction at equilibrium (300 K). (5 marks)

**16.** With the aid of energy band diagrams, explain how a metal – N type Schottky contact function as rectifying and ohmic contacts. (14 marks)

## MODULE IV

**17.** (a) Starting from the fundamentals, derive the expression for drain current of a MOSFET in the two regions of operation. (8 Marks)

(b) Find the maximum depletion width, minimum capacitance $C_i$, and threshold voltage for an ideal MOS capacitor with a 10-nm gate oxide ($SiO_2$) on p-type Si with $N_a = 10^{16}$ $cm^{-3}$. (b) Include the effects of flat band voltage, assuming an n + polysilicon gate and fixed oxide charge of $5 \times 10^{10}$ q ($C/cm^2$). (6 marks)

**18.** (a) Explain the CV characteristics of an ideal MOS capacitor (8 Marks)

(b) For a long channel n-MOSFET with W = 1V, calculate the $V_G$ required for an $I_{D(sat.)}$ of 0.1 mA and $V_{D(sat.)}$ of 5V. Calculate the small-signal output conductance g and V the transconductance $g_{m(sat.)}$ at $V_D$ = 10V. Recalculate the new $I_D$ for ($V_G - V_T$) = 3 and $V_D$ = 4V. (6 marks)

## MODULE V

**19.** Explain Drain induced barrier lowering, Velocity Saturation, Threshold Voltage Variations and Hot Carrier Effects associated with scaling down of MOSFETs (14 marks)

**20.** With the aid of suitable diagrams explain the structure and working of a FINFET. List its advantages (14 marks)

| ECT 203 | LOGIC CIRCUIT DESIGN | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PCC | 3 | 1 | 0 | 4 |

**Preamble:** This course aims to impart the basic knowledge of logic circuits and enable students to apply it to design a digital system.

**Prerequisite:** EST130 Basics of Electrical and Electronics Engineering

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Explain the elements of digital system abstractions such as digital representations of information, digital logic and Boolean algebra |
| **CO 2** | Create an implementation of a combinational logic function described by a truth table using and/or/inv gates/ muxes |
| **CO 3** | Compare different types of logic families with respect to performance and efficiency |
| **CO 4** | Design a sequential logic circuit using the basic building blocks like flip-flops |
| **CO 5** | Design and analyze combinational and sequential logic circuits through gate level Verilog models. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | |
| **CO 2** | 3 | 3 | 3 | | | | | | | | | |
| **CO 3** | 3 | 3 | | | | | | | | | | |
| **CO 4** | 3 | 3 | 3 | | | | | | | | | |
| **CO 5** | 3 | 3 | 3 | | 3 | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 10 | 10 | 10 |
| Understand | 20 | 20 | 20 |
| Apply | 20 | 20 | 70 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

| | |
|---|---|
| Attendance | : 10 marks |
| Continuous Assessment Test (2 numbers) | : 25 marks |
| Course project | : 15 marks |

It is mandatory that a *course project* shall be undertaken by a student for this subject. The course project can be performed either as a hardware realization/simulation of a typical digital system using combinational or sequential logic. Instead of two assignments, two evaluations may be performed on the course project along with series tests, each carrying 5 marks. Upon successful completion of the project, a brief report shall be submitted by the student which shall be evaluated for 5 marks. The report has to be submitted for academic auditing. A few samples projects are given below:

**Sample course projects:**

**1. M-Sequence Generator** Psuedo random sequences are popularly used in wireless communication. A sequence generator is used to produce pseudo random codes that are useful in spread spectrum applications. Their generation relies on irreducible polynomials.A maximal length sequence generator that relies on the polynomial $P(D) = D^7 + D^3 + 1$, with each D represent delay of one clock cycle.

- An 8-bit shift register that is configured as a ring counter may be used realize the above equation.
- This circuit can be developed in verilog, simulated, synthesized and programmed into a tiny FPGA and tested in real time.
- Observe the M-sequnce from parallel outputs of shift register for one period . Count the number of 1s and zeros in one cycle.
- Count the number of runs of 1s in singles, pairs, quads etc. in the pattern.

**2. BCD Subtractor**

- Make 4 -bit parallel adder circuit in verilog.
- Make a one digit BCD subtracter in Verilog, synthesize and write into a tiny FPGA.
- Test the circuit with BCD inputs.

**3. Digital Thermometer**

- Develop a circuit with a temperature sensor and discrete components to measure and dispaly temperature.
- Solder the circuit on PCB and test it.

**4. Electronic Display**

- This display should receive the input from an alphanumeric keyboard and display it on an LCD diplay.
- The decoder and digital circuitry is to developed in Verilog and programmed into a tiny FPGA.

**5. Electronic Roulette Wheel**

- 32 LEDs are placed in a circle and numbered that resembles a roulette wheel.
- A 32-bit shift register generates a random bit pattern with a single 1 in it.
- When a push button is pressed the single 1 lights one LED randomly.
- Develop the shift register random pattern generator in verilog and implement on a tiny FPGA and test the circuit.

**6. Three Bit Carry Look Ahead Adder**

- Design the circuit of a three bit carry look ahead adder.
- Develop the verilog code for it and implement and test it on a tiny FPGA. item Compare the performance with a parallel adder.

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks. The questions on verlog modelling should not have a credit more than 25% of the whole mark.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1) : Number Systems and Codes**

1. Consider the signed binary numbers A = 01000110 and B = 11010011 where B is in 2's complement form. Find the value of the following mathematical expression (i) A + B (ii) A – B
2. Perform the following operations (i)$D9CE_{16}$-$CFDA_{16}$ (ii) $6575_8$-$5732_8$
3. Convert decimal 6,514 to both BCD and ASCII codes. For ASCII, an even parity bit is to be appended at the left.

**Course Outcome 2 (CO2) : Boolean Postulates and combinational circuits**

1. Design a magnitude comparator to compare two 2-bit numbers $A = A_1A_0$ and $B = B_1B_0B$
2. Simplify using K-map F(a,b,c,d) = Σ m (4,5,7,8,9,11,12,13,15)
3. Explain the operation of a 8x1 multiplexer and implement the following using an 8x1 multiplexer F(A, B, C, D) = Σ m (0, 1, 3, 5, 6, 7, 8, 9, 11, 13, 14)

**Course Outcome 3 (CO3) : Logic families and its characteristics**

1. Define the terms noise margin, propagation delay and power dissipation of logic families. Compare TTL and CMOS logic families showing the values of above mentioned terms.
2. Draw the circuit and explain the operation of a TTL NAND gate
3. Compare TTL, CMOS logic families in terms of fan-in, fan-out and supply voltage

**Course Outcome 4 (CO4) : Sequential Logic Circuits**

1. Realize a T flip-flop using NAND gates and explain the operation with truth table, excitation table and characteristic equation
2. Explain a MOD 6 asynchronous counter using JK Flip Flop
3. Draw the logic diagram of 3 bit PIPO shift register with LOAD/SHIFT control and explain its working

**Course Outcome 5 (CO5) : Logic Circuit Design using HDL**

1. Design a 4-to-1 mux using gate level Verilog model.
2. Design a verilog model for a hald adder circuit. Make a one bit full adder by connecting two half adder models.
3. Compare concurrent signal assignment versus sequential signal assignment.

**Syllabus**

**Module 1: Number Systems and Codes**:

Binary and hexadecimal number systems; Methods of base conversions; Binary and hexadecimal arithmetic; Representation of signed numbers; Fixed and floating point numbers; Binary coded decimal codes; Gray codes; Excess 3 code. Alphanumeric codes: ASCII. Basics of verilog -- basic language elements: identifiers, data objects, scalar data types, operators.

**Module 2: Boolean Postulates and Fundamental Gates**

Boolean postulates and laws – Logic Functions and Gates De-Morgan's Theorems, Principle of Duality, Minimization of Boolean expressions, Sum of Products (SOP), Product of Sums (POS), Canonical forms, Karnaugh map Minimization. Modeling in verilog, Implementation of gates with simple verilog codes.

**Module 3: Combinatorial and Arithmetic Circuits**

Combinatorial Logic Systems - Comparators, Multiplexers, Demultiplexers, Encoder, Decoder. Half and Full Adders, Subtractors, Serial and Parallel Adders, BCD Adder. Modeling and simulation of combinatorial circuits with verilog codes at the gate level.

**Module 4: Sequential Logic Circuits:**

Building blocks like S-R, JK and Master-Slave JK FF, Edge triggered FF, Conversion of Flipflops, Excitation table and characteristic equation. Implementation with verilog codes. Ripple and Synchronous counters and implementation in verilog, Shift registers-SIPO, SISO, PISO, PIPO. Shift Registers with parallel Load/Shift, Ring counter and Johnsons counter. Asynchronous and Synchronous counter design, Mod N counter. Modeling and simulation of flipflops and counters in verilog.

**Module 5: Logic families and its characteristics**:

TTL, ECL, CMOS - Electrical characteristics of logic gates – logic levels and noise margins, fan-out, propagation delay, transition time, power consumption and power-delay product. TTL inverter - circuit description and operation; CMOS inverter - circuit description and operation; Structure and operations of TTL and CMOS gates; NAND in TTL and CMOS, NAND and NOR in CMOS.

**Text Books**

1. Mano M.M., Ciletti M.D., "Digital Design", Pearson India, 4th Edition. 2006
2. D.V. Hall, "Digital Circuits and Systems", Tata McGraw Hill, 1989

3. S. Brown, Z. Vranesic, "Fundamentals of Digital Logic with Verilog Design", McGraw Hill

4. Samir Palnikar"Verilog HDL: A Guide to Digital Design and Syntheis", Sunsoft Press

5. R.P. Jain, "Modern digital Electronics", Tata McGraw Hill, 4th edition, 2009

**Reference Books**

1. W.H. Gothmann, "Digital Electronics – An introduction to theory and practice", PHI, 2nd edition ,2006
2. Wakerly J.F., "Digital Design: Principles and Practices," Pearson India, 4th 2008

.

3. A. Ananthakumar ,"Fundamentals of Digital Circuits", Prentice Hall, 2nd edition, 2016
4. Fletcher, William I., An Engineering Approach to Digital Design, 1st Edition, Prentice Hall India, 1980

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Number Systems and Codes**: | |
| 1.1 | Binary, octal and hexadecimal number systems; Methods of base conversions; | 2 |
| 1.2 | Binary, octal and hexadecimal arithmetic; | 1 |
| 1.3 | Representation of signed numbers; Fixed and floating point numbers; | 3 |
| 1.4 | Binary coded decimal codes; Gray codes; Excess 3 code : | 1 |
| 1.5 | Error detection and correction codes - parity check codes and Hamming code-Alphanumeric codes:ASCII | 3 |
| 1.6 | Verilog basic language elements: identifiers, data objects, scalar data types, operators | 2 |
| | | |
| **2** | **Boolean Postulates and Fundamental Gates:** | |
| 2.1 | Boolean postulates and laws – Logic Functions and Gates, De-Morgan's Theorems, Principle of Duality | 2 |
| 2.2 | Minimization of Boolean expressions, Sum of Products (SOP), Product of Sums (POS) | 2 |
| 2.3 | Canonical forms, Karnaugh map Minimization | 1 |
| 2.4 | Gate level modelling in Verilog: Basic gates, XOR using NAND and NOR | 2 |
| | | |
| **3** | **Combinatorial and Arithmetic Circuits** | |
| 3.1 | Combinatorial Logic Systems - Comparators, Multiplexers, Demultiplexers | 2 |
| 3.2 | Encoder, Decoder, Half and Full Adders, Subtractors, Serial and Parallel Adders, BCD Adder | 3 |

| | | |
|---|---|---|
| 3.3 | Gate level modelling combinational logic circuits in Verilog: half adder, full adder, mux, demux, decoder, encoder | 3 |
| | | |
| **4** | **Sequential Logic Circuits:** | |
| 4.1 | Building blocks like S-R, JK and Master-Slave JK FF, Edge triggered FF | 2 |
| 4.2 | Conversion of Flipflops, Excitation table and characteristic equation. | 1 |
| 4.3 | Ripple and Synchronous counters, Shift registers-SIPO.SISO,PISO,PIPO | 2 |
| 4.4 | Ring counter and Johnsons counter, Asynchronous and Synchronous counter design | 3 |
| 4.5 | Mod N counter, Random Sequence generator | 1 |
| 4.6 | Modelling sequential logic circuits in Verilog: flipflops, counters | 2 |
| | | |
| **5** | **Logic families and its characteristics**: | |
| 5.1 | TTL,ECL,CMOS- Electrical characteristics of logic gates – logic levels and noise margins, fan-out, propagation delay, transition time, power consumption and power-delay product. | 3 |
| 5.2 | TTL inverter - circuit description and operation | 1 |
| 5.3 | CMOS inverter - circuit description and operation | 1 |
| 5.4 | Structure and operations of TTL and CMOS gates; NAND in TTL, NAND and NOR in CMOS. | 2 |
| | | |

# Simulation Assignments (ECT203)



The following simulations can be done in QUCS, KiCad or PSPICE.

**BCD Adder**

- Realize a one bit paraller adder, simulate and test it.
- Cascade four such adders to form a four bit parallel adder.
- Simulate it and make it into a subcircuit.
- Develop a one digit BCD adder, based on the subcircuit, simulate and test it

**BCD Subtractor**

- Use the above 4 -bit adder subcircuit, implement and simulate a one digit BCD subtractor.
- Test it with two BCD inputs

**Logic Implementation with Multiplexer**

- Develop an 8 : 1 multiplexer using gates, simulate, test and make it into a subcircuit.
- Use this subcircuit to implement the logic function $f(A,B,C) = \sum m(1,3,7)$
- Modify the truth table properly and implement the logic function $f(A,B,C,D) = \sum m(1,4,12,14)$ using one 8 : 1 multiplexer.

**BCD to Seven Segment Decoder**

- Develop a BCD to seven segment decoder using gates and make it into a subcircuit.
- simulate this and test it

**Ripple Counters**

- Understand the internal circuit of 7490 IC and develop it in the simulator.
- Make it into a subcircuit and simulate it. Observe the truth table and timing diagrams for mod-5, mod-2 and mod-10 operation.
- Develop a mod-40 (mod-8 and mod-5) counter by cascading two such subcircuits.
- Simulate and observe the timing diagram and truth table.

**Synchronous Counters**

- Design and develop a 4-bit synchronous counter using J-K flip-flops.
- Perform digital simulation and observe the timing diagram and truth table.

**Sequence Generator**

- Connect D flip-flops to realize and 8-bit shift register and make it into a subcircuit.
- sequence generator that relies on the polynomial $P(D) = D_7 + D_3 + 1$, with each D represent delay of one clock cycle
- Simulate and observe this maximal length pseudo random sequence.

**Transfer Characteristics of TTL and CMOS Inverters**

- Develop a standard TTL circuit and perform sweep simulation and observe the transfer characteristics. Compute the threshold voltage and noise margns.
- Develop and simulate standard CMOS inverter circuit and perform sweep simulation and observe the transfer characteristics. Compute the threshold voltage and noise margins.

## Model Question Paper

# A P J Abdul Kalam Technological University

Third Semester B Tech Degree Examination

Branch: Electronics and Communication

**Course: ECT 203 Logic Circuit Design**

**Time: 3 Hrs** | **Max. Marks: 100**

### PART A

*Answer All Questions*

| | | | |
|---|---|---|---|
| 1 | Convert $203.52_{10}$ to binary and hexadecimal. | (3) | $K_1$ |
| 2 | Compare bitwise and logical verilog operators | (3) | $K_1$ |
| 3 | Prove that NAND and NOR are not associative. | (3) | $K_2$ |
| 4 | Convert the expression ABCD+AB$\overline{C}$+ACD to minterms. | (3) | $K_2$ |
| 5 | Define expressions in Verilog with example. | (3) | $K_2$ |
| 6 | Explain the working of a decoder. | (3) | $K_1$ |
| 7 | What is race around condition? | (3) | $K_1$ |
| 8 | Convert a T flip-flop to D flip-flop. | (3) | $K_2$ |
| 9 | Define fan-in and fan-out of logic circuits. | (3) | $K_2$ |
| 10 | Define noise margin and how can you calculate it? | (3) | $K_2$ |

### PART B

*Answer one question from each module. Each question carries 14 mark.*

### Module I

| | | | |
|---|---|---|---|
| 11(A) | Subtract $46_{10}$ from $100_{10}$ using 2's complement arithmetic. | (8) | $K_2$ |
| 11(B) | Give a brief description on keywords and identifiers in Verilog with example. | (6) | $K_2$ |

**OR**

| | | | |
|---|---|---|---|
| 12(A) | Explain the floating and fixed point representation of numbers | (8) | $K_2$ |
| 12(A) | Explain the differences between programming lanuguages and HDLs | (6) | $K_2$ |

**Module II**

| | | | |
|---|---|---|---|
| 13(A) | Simplify using K-map $$f(A,B,C,D) = \sum m(4,5,7,8,9,11,12,13,15)$$ using K-maps | (7) | $K_3$ |
| 13(B) | Write a Verilog code for implementing above function | (7) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 14(A) | Write a Verilog code to implement the basic gates. | (7) | $K_3$ |
| 14(B) | Reduce the following Boolean function using K-Map and implement the simplified function using the logic gates $$f(A,B,C,D) = \sum(0,1,4,5,6,8,9,10,12,13,14)$$ | (7) | $K_3$ |

**Module III**

| | | | |
|---|---|---|---|
| 15(A) | Design a 3-bit magnitude comparator circuit. | (8) | $K_3$ |
| 15(B) | Write a Verilog description for a one bit full adder circuit. | (6) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 16(A) | Write a verilog code to implement 4:1 multiplexer | (6) | $K_3$ |
| 16(B) | Implement the logic function $$f(A,B,C) = \sum m(0,1,4,7)$$ using 8 : 1 and 4 : 1 multiplexers. | (8) | $K_3$ |

**Module IV**

| | | | |
|---|---|---|---|
| 17 | Design MOD 12 asynchronous counter using T flip-flop. | (14) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 18(A) | Explain the operation of Master Slave JK flipflop. | (7) | $K_3$ |
| 18(B) | Derive the ouput $Q_{n+1}$ in Terms of $J_n$, $K_n$ and $Q_n$ | (7) | $K_3$ |

**Module V**

| | | | |
|---|---|---|---|
| 19(A) | Explain in detail about TTL with open collector output configuration. | (8) | $K_2$ |
| 19(B) | Draw an ECL basic gate and explain. | (6) | $K_2$ |

**OR**

| | | | |
|---|---|---|---|
| 20(A) | Demonstrate the CMOS logic circuit configuration and characteristics in detail. | (8) | $K_2$ |
| 20(B) | Compare the characteristics features of TTL and ECL digital logic families | (6) | $K_2$ |

| ECT205 | NETWORK THEORY | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PCC | 3 | 1 | 0 | 4 |

**Preamble:** This course aims to analyze the linear time invariant electronic circuits.

**Prerequisite:** EST130 Basics of Electrical and Electronics Engineering

MAT102 Vector Calculus, Differential Equations and Transforms (Laplace Transform)

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1 K3** | Apply Mesh / Node analysis or Network Theorems to obtain steady state response of the linear time invariant networks. |
| **CO 2 K3** | Apply Laplace Transforms to determine the transient behaviour of RLC networks. |
| **CO 3 K3** | Apply Network functions and Network Parameters to analyse the single port and two port networks. |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 2 |
| **CO 2** | 3 | 3 | | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | | | | | | | | | | 2 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember K1 | 10 | 10 | 10 |
| Understand K2 | 20 | 20 | 20 |
| Apply K3 | 20 | 20 | 70 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1): Obtain steady state response of the network using Mesh / Node analysis. (K3)**

1. Enumerate different types of sources in electronic networks.

2. Solve networks containing independent and dependent sources using Mesh / Node analysis.

3. Evolve the steady-state AC analysis of a given network using Mesh or Node analysis.

**Course Outcome 1 (CO1) : Obtain steady state response of the network using Network Theorems. (K3)**

1. Determine the branch current of the given network with dependent source using superposition theorem.

2. State and prove Maximum Power Transfer theorem.

3. Find the Thevenin's / Norton's equivalent circuit across the port of a given network having dependent source.

**Course Outcome 2 (CO2): Determine the transient behaviour of network using Laplace Transforms (K3)**

1. The switch is opened at t = 0 after steady state is achieved in given network. Find the expression for the transient output current.

2. Find the Laplace Transform of a given waveform.

3. In the given circuit, the switch is closed at $t = 0$, connecting an energy source to the R,C,L circuit. At time $t = 0$, it is observed that capacitor voltage has a initial value. For the element values given, determine expression for output voltage after converting the circuit into transformed domain.

**Course Outcome 3 (CO3): Apply Network functions to analyse the single port and two port network. (K3)**

1. What are the necessary conditions for a network Driving point function and Transfer functions?

2. Evaluate the Driving point function and Transfer function for the given network,

3. Plot the poles and zeros of the given network.

**Course Outcome 3 (CO3): Apply Network Parameters to analyse the two port network. (K3)**

1. Deduce the transmission parameters of two port network in terms of two port network parameters.

2. Define the condition for a two port network to be reciprocal.

3. Two identical sections of the given networks are connected in parallel. Obtain the two port network parameters of the combination.

## SYLLABUS

**Module 1 : Mesh and Node Analysis**

Mesh and node analysis of network containing independent and dependent sources. Supermesh and Supernode analysis. Steady-state AC analysis using Mesh and Node analysis.

**Module 2 : Network Theorems**

Thevenin's theorem, Norton's theorem, Superposition theorem, Reciprocity theorem, Maximum power transfer theorem. (applied to both dc and ac circuits having dependent source).

**Module 3 : Application of Laplace Transforms**

Review of Laplace Transforms and Inverse Laplace Transforms, Initial value theorem & Final value theorem, Transformation of basic signals and circuits into s-domain.
Transient analysis of RL, RC, and RLC networks with impulse, step and sinusoidal inputs (with and without initial conditions). Analysis of networks with transformed impedance and dependent sources.

**Module 4 : Network functions**

Network functions for the single port and two port network. Properties of driving point and transfer functions. Significance of Poles and Zeros of network functions, Time domain response from pole zero plot. Impulse Function & Response. Network functions in the sinusoidal steady state, Magnitude and Phase response.

**Module 5 : Two port network Parameters**

Impedance, Admittance, Transmission and Hybrid parameters of two port network. Interrelationship among parameter sets. Series and parallel connections of two port networks. Reciprocal and Symmetrical two port network. Characteristic impedance, Image impedance and propagation constant (derivation not required).

**Text Books**

1. Valkenburg V., “Network Analysis”, Pearson, 3/e, 2019.

2. Sudhakar A, Shyammohan S. P., “Circuits and Networks- Analysis and Synthesis”, McGraw Hill, 5/e, 2015.

**Reference Books**

1. Edminister, “Electric Circuits – Schaum’s Outline Series”, McGraw-Hill, 2009.

2. W. Hayt, J. Kemmerly, J. Phillips, S. Durbin, “Engineering Circuit Analysis,” McGraw Hill.

2. K. S. Suresh Kumar, “Electric Circuits and Networks”, Pearson, 2008.

3. William D. Stanley, “Network Analysis with Applications”, 4/e, Pearson, 2006.

4. Ravish R., “Network Analysis and Synthesis”, 2/e, McGraw-Hill, 2015.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Mesh and Node Analysis** | |
| 1.1 | Review of circuit elements and Kirchhoff’s Laws | 2 |
| 1.2 | Independent and dependent Sources, Source transformations | 1 |
| 1.3 | Mesh and node analysis of network containing independent and dependent sources | 3 |
| 1.4 | Supermesh and Supernode analysis | 1 |
| 1.5 | Steady-state AC analysis using Mesh and Node analysis | 3 |
| | | |
| **2** | **Network Theorems (applied to both dc and ac circuits having dependent source)** | |
| 2.1 | Thevenin’s theorem | 1 |
| 2.2 | Norton’s theorem | 1 |
| 2.3 | Superposition theorem | 2 |
| 2.4 | Reciprocity theorem | 1 |
| 2.5 | Maximum power transfer theorem | 2 |
| | | |
| **3** | **Application of Laplace Transforms** | |
| 3.1 | Review of Laplace Transforms | 2 |
| 3.2 | Initial value theorem & Final value theorem (Proof not necessary) | 1 |
| 3.3 | Transformation of basic signals and circuits into s-domain | 2 |
| 3.4 | Transient analysis of RL, RC, and RLC networks with impulse, step, pulse, exponential and sinusoidal inputs | 3 |

| | | |
|---|---|---|
| 3.5 | Analysis of networks with transformed impedance and dependent sources | 3 |
| | | |
| **4** | **Network functions** | |
| 4.1 | Network functions for the single port and two port network | 2 |
| 4.2 | Properties of driving point and transfer functions | 1 |
| 4.3 | Significance of Poles and Zeros of network functions, Time domain response from pole zero plot | 1 |
| 4.4 | Impulse Function & Response | 1 |
| 4.5 | Network functions in the sinusoidal steady state, Magnitude and Phase response | 3 |
| | | |
| **5** | **Two port network Parameters** | |
| 5.1 | Impedance, Admittance, Transmission and Hybrid parameters of two port network | 4 |
| 5.2 | Interrelationship among parameter sets | 1 |
| 5.3 | Series and parallel connections of two port networks | 2 |
| 5.4 | Reciprocal and Symmetrical two port network | 1 |
| 5.5 | Characteristic impedance, Image impedance and propagation constant (derivation not required) | 1 |
| | | |

**Simulation Assignments:**

Atleast one assignment should be simulation of steady state and transient analysis of R, L, C circuits with different types of energy sources on any circuit simulation software. Samples of simulation assignments are listed below. The following simulations can be done in QUCS, KiCad or PSPICE.

1. Make an analytical solution of Problem 4.3 in page 113 of the book *Network Analysis* by M E Van Valkenberg. Realize this circuit in the simulator and observe *i(t)* and $V_2(t)$ using transient simulation.

2. Realize a series RLC circuit with

- R = 200Ω, L = 0.1H, C = 13.33μF
- R = 200Ω, L = 0.1H, C = 10μF and
- R = 200Ω, L = 0.1H, C = 1μF and no source respectively. The initial voltage across the capacitor is 200V Simulate the three circuits, and observe the current *i(t)* through them.

3. Repeat the above assignment for the three set of component values for a parallel RLC circuit.

4. Refer Problem 9.18 in page 208 in the book *Electric Circuits* by Nahvi and Edminister 4th Edition. See Fig. 9.28. Simulate this circuit to verify superposition theorem for the three current with individual sources and combination.

5. Refer Problem 9.22 in page 210 in the book *Electric Circuits* by Nahvi and Edminister 4th Edition. See Fig. 9.32. Implement the circuit on the simulator with V = 30∠ 30°. Verify the duality between the sources V and the current *I2* and *I3* using simulation.

6. See Fig. 12.40 in Chapter 12 (page 298) in the above book. Let R1 = R2 = 2kΩ, L = 10mH and C = 40nF. Implement this circuit in the simulator and perform the ac analysis to plot the frequency response.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

THIRD SEMESTER B.TECH DEGREE EXAMINATION, **(Model Question Paper)**

**Course Code: ECT205**

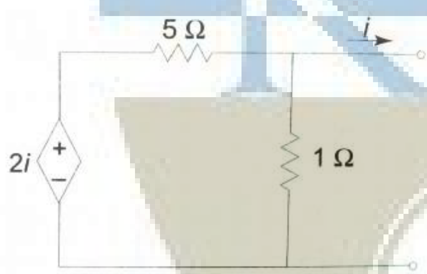
## Course Name: NETWORK THEORY

Max. Marks: 100 Duration: 3 Hours

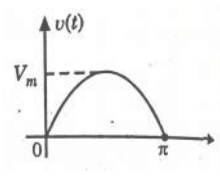
**PART A**

Answer ALL Questions. Each Carries 3 mark.

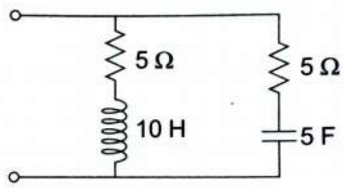
| | | |
|---|---|---|
| 1 | Illustrate the source-transformation techniques. | K2 |
| 2 | Explain the concept of supernode. | K2 |
| 3 | State and prove Maximum Power Transfer theorem | K1 |
| 4 | Evaluate the Norton's equivalent current in the following circuit. | K3 |




| | | |
|---|---|---|
| 5 | Evaluate the Laplace Transform of half-wave rectified sine pulse. | K3 |




| | | |
|---|---|---|
| 6 | Give the two forms of transformed impedance equivalent circuit of a capacitor with initial charge across it. | K2 |
| 7 | Enumerate necessary condition for a Network Functions to be Transfer Functions. | K1 |
| 8 | Obtain the pole zero configuration of the impedance function of the following circuit. | K3 |




9 Define the short-circuit admittance parameter with its equivalent circuit. K2

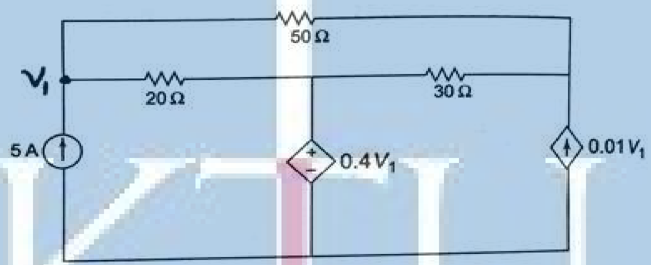
10 Deduce Z-parameter in terms of h-parameter. K2

**PART – B**

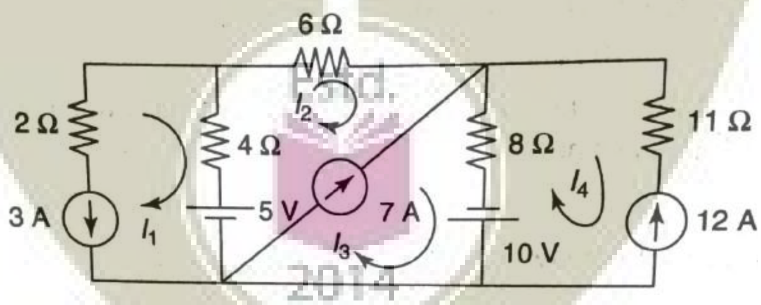
Answer one question from each module; each question carries 14 marks.

**Module - I**

11 a. Find the voltage $V_1$ using nodal analysis. 7 CO1 K3

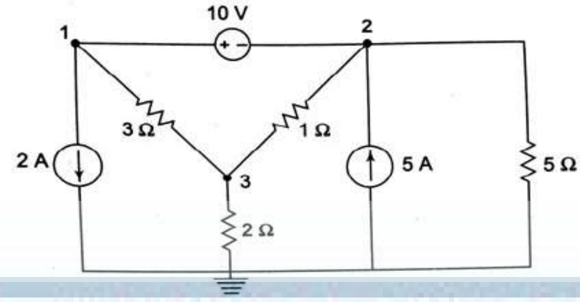



b. Find the current through 8 ohms resistor in the following circuit using mesh analysis. 7 CO1 K3

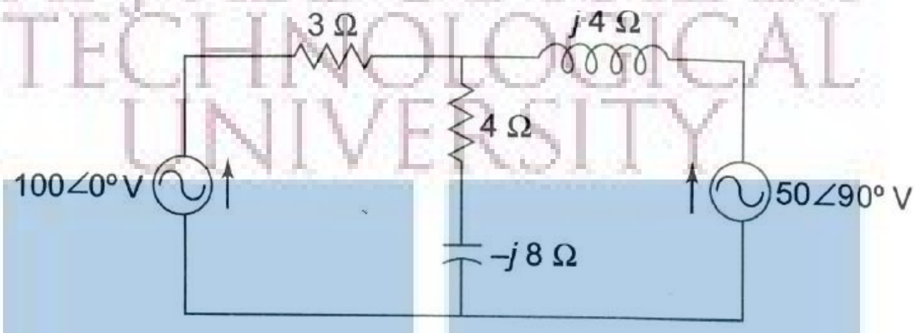



**OR**

12 Find the power delivered by the 5A current source using nodal analysis method. 7 CO1 K3



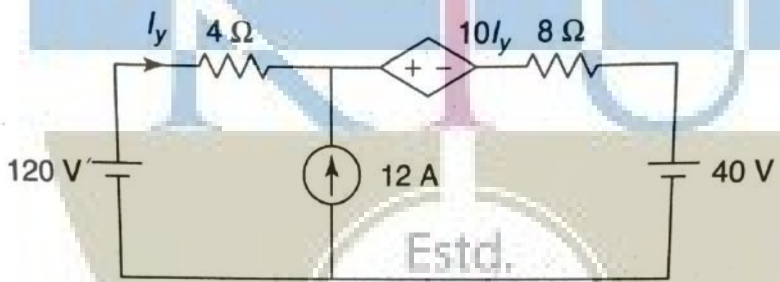

b. Determine the values of source currents using Mesh analysis 7




CO1 K3

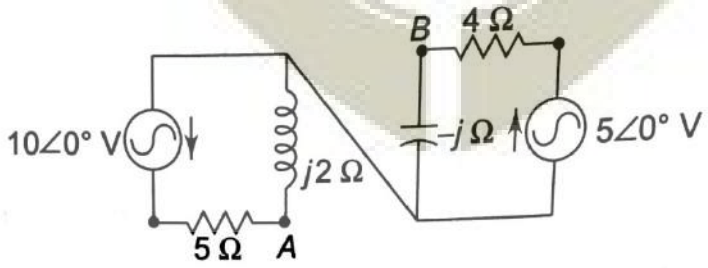
**Module - II**

13 a. Find the current $I_y$ by superposition principle. 7




CO1 K3

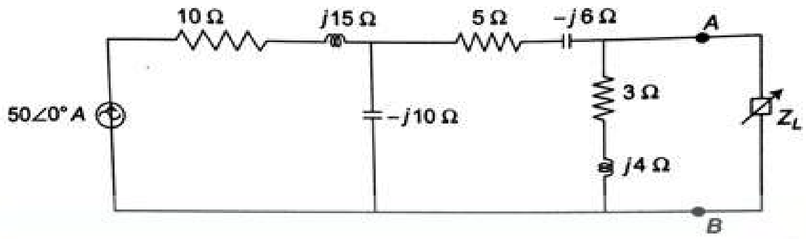
b. Find the Norton's equivalent circuit across the port **AB**. 7




CO1 K3

**OR**

14 Determine the maximum power delivered to the load in the circuit. 14




CO1

K3

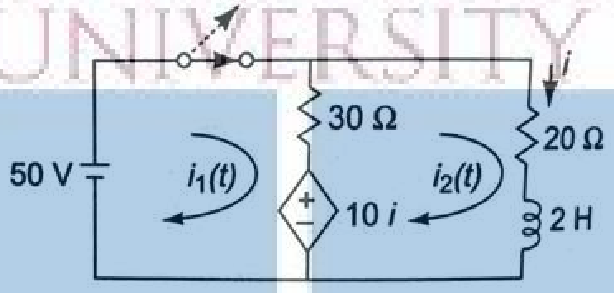


**Module - III**

15 a. The switch is opened at t = 0 after steady state is achieved. Find the expression for the transient current ***i***. 8

CO2

K3




b. A voltage pulse of unit height and width ***' T '*** is applied to a low pass RC circuit at time t=0. Determine the expression for the voltage across the capacitor C as a function of time. 6

CO2

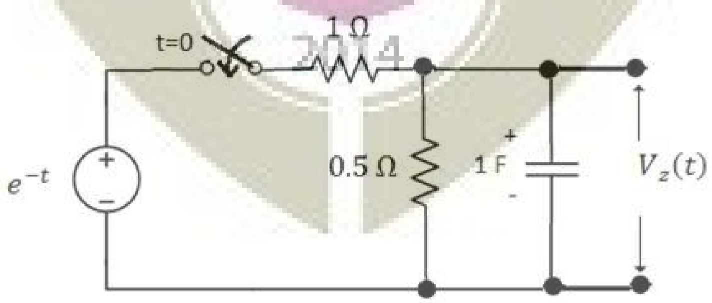
K3

**OR**

16 In the circuit, the switch is closed at $t = 0$, connecting a source $e^{-t}$ to the RC circuit. At time $t = 0$, it is observed that capacitor voltage has the value $V_c(0) = 0.5V$. For the element values given, determine $V_z(t)$ after converting the circuit into transformed domain. 14

CO2

K3

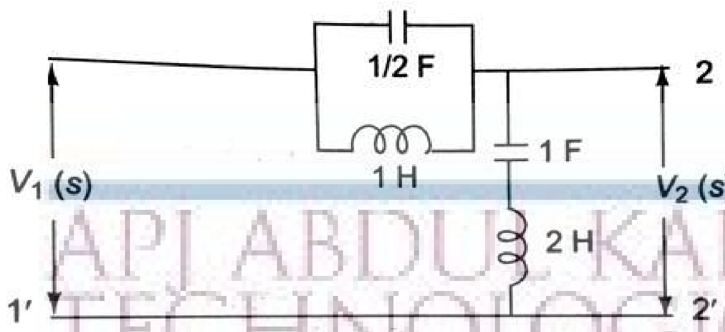





**Module - IV**

17 For the network, determine Driving point impedance ***$Z_{11}$ (s)***, Voltage gain Transfer 14

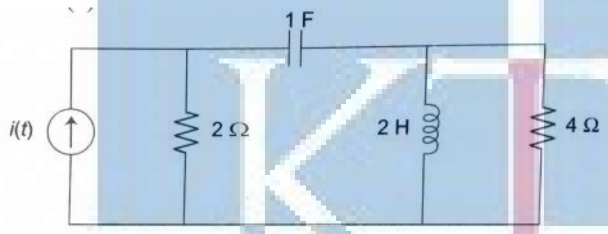
function ***G₂₁ (s)*** and Current gain Transfer function ***α₂₁ (s)***. CO3 K3




**OR**

18 a. Compare and contrast the necessary conditions for a network Driving point function and Transfer functions. 7 CO3 K2

b. For following network, evaluate the admittance function Y(s) as seen by the source i(t). Also pot the poles and zeros of Y(s). 7 CO3 K3




**Module - V**

19 a. Deduce the transmission parameters of two port network in terms of 10

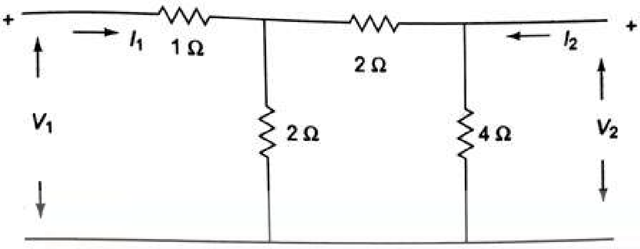
(i) Z-parameters, (ii) Y-parameters and (iii) Hybrid parameters. CO4 K2

b. How to determine the given two port network is Symmetrical 4 K2

**OR**

20 Two identical sections of the following networks are connected in parallel. Obtain the Y-parameters of the combination. 14

K3



+
$I_1$
1 Ω
2 Ω
$I_2$
+
$V_1$
2 Ω
4 Ω
$V_2$

| ECL 201 | SCIENTIFIC COMPUTING LABORATORY | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PCC | 0 | 0 | 3 | 2 |

**Preamble**

- The following experiments are designed to translate the mathematical concepts into system design.
- The students shall use Python for realization of experiments. Other softwares such as R/MATLAB/SCILAB/LabVIEW can also be used.
- The experiments will lay the foundation for future labs such as DSP lab.
- The first two experiments are mandatory and any six of the rest should be done.

**Prerequisites**

- MAT 101 Linear Algebra and Calculus
- MAT 102 Vector Calculus, Differential Equations and Transforms

**Course Outcomes** The student will be able to

| | |
|---|---|
| CO 1 | Describe the needs and requirements of scientific computing and to familiarize one programming language for scientific computing and data visualization. |
| CO 2 | Approximate an array/matrix with matrix decomposition. |
| CO 3 | Implement numerical integration and differentiation. |
| CO 4 | Solve ordinary differential equations for engineering applications |
| CO 5 | Compute with exported data from instruments |
| CO 6 | Realize how periodic functions are constituted by sinusoids |
| CO 7 | Simulate random processes and understand their statistics. |

**Mapping of Course Outcomes with Program Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 3 | 1 | 0 | 3 |
| CO2 | 3 | 3 | 1 | 2 | 3 | 0 | 0 | 0 | 3 | 0 | 0 | 1 |
| CO3 | 3 | 3 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| CO4 | 3 | 3 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| CO5 | 3 | 3 | 1 | 3 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 0 |
| CO6 | 3 | 3 | 2 | 2 | 3 | 0 | 0 | 0 | 3 | 1 | 0 | 0 |
| CO7 | 3 | 3 | 2 | 2 | 3 | 0 | 0 | 0 | 3 | 1 | 0 | 1 |

## Assessment Pattern

### Mark Distribution

| Total Mark | CIE | ESE |
|---|---|---|
| 150 | 75 | 75 |

### Continuous Internal Evaluation Pattern

| Attribute | Mark |
|---|---|
| Attendance | 15 |
| Continuous assessment | 30 |
| Internal Test (Immediately before the second series test) | 30 |

**End Semester Examination Pattern** The following guidelines should be followed regarding award of marks.

| Attribute | Mark |
|---|---|
| Preliminary work | 15 |
| Implementing the work/Conducting the experiment | 10 |
| Performance, result and inference (usage of equipments and trouble shooting) | 25 |
| Viva voce | 20 |
| Record | 5 |

**General instructions:** End-semester practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the examination only on submitting the duly certified record. The external examiner shall endorse the record.

# Course Level Assessment Questions

**CO1-The needs and requirements of scientific computing and to familiarize one programming language for scientific computing and data visualization**

1. Write a function to compute the first $N$ Fibonacci numbers. Run this code and test it.
2. Write a function to compute the sum of $N$ complex numbers. Run this code and test it.
3. Write a function to compute the factorial of an integer. Run this code and test it.

**CO2-Approximation an array/matrix with matrix decomposition.**

1. Write a function to compute the eigen values of a real valed valued matrix (say $5 \times 5$). Run this code. Plot the eigen values and understand their variation.
2. Write a function to approximate a $5 \times 5$ matrix using its first 3 eigen vales. Run the code and compute the absolute square error in the approximation.

**CO3-Numerical Integration and Differentiation**

1. Write and execute a function to return the first and second derivative of the function $f(t) = 3t^4 + 5$ for the vector $t = [-3, 3]$.
2. Write and execute a function to return the value of

$$\int_{-3}^{3} e^{-|t|}\, dt$$

**CO4-Solution of ODE**

1. Write and execute a function to return the numerical solution of

$$\frac{d^2x}{dt^2} + 4\frac{dx}{dt} + 2x = e^{-t}\cos(t)$$

.

2. Write and execute a function to solve for the current transient through an RL network (with $\frac{r}{L} = 1$) that is driven by the signal $5e^{-t}U(t)$

### CO5-Data Analysis

1. Connect a signal generator toa DSO and display a $1\,V$, $3\,kHz$ signal. Store the trace in a usb device as a spreadsheet. Write and execute a function to load and dispaly signal from the spreadsheet. Compute the rms value of the signal.

2. Write and execute a program to display random data in two dimensions as continuous and discrete plots.

### CO6-Convergence of Fourier Series

1. Write the Fourier series of a traingular signal. Compute this sum for 10 and 50 terms respectively. Plot both signals on the same GUI.

### CO7-Simulation of Random Phenomena

1. Write and execute a function to toss three fair coins simultaneously. Compute the probability of getting exactly two heads for 100 and 1000 number of tosses

## Experiments

### Experiment 1. Familarization of the Computing Tool

1. Needs and requirements in scientific computing

2. Familiarization of a programming language like Python/R/ MATLAB/SCILAB/LabVIEW for scientific computing

3. Familiarization of data types in the language used.

4. Familiarization of the syntax of *while, for, if* statements.

5. Basic syntax and execution of small scripts.

### Experiment 2. Familarization of Scientific Computing

1. Functions with examples

2. Basic arithmetic functions such as *abs*, *sine*, *real*, *imag*, *complex*, *sinc* etc. using bulit in modules.

3. Vectorized computing without loops for fast scientific applications.

**Experiment 3. Realization of Arrays and Matrices**

1. Realize one dimensional array of real and complex numbers
2. stem and continous plots of real arrays using *matplotlib*/GUIs/charts.
3. Realization of two dimensional arrays and matrices and their visualizations with *imshow/matshow/charts*
4. Inverse of a square matrix and the solution of the matrix equation

$$[\mathbf{A}][\mathbf{X}] = [\mathbf{b}]$$

   where $\mathbf{A}$ is an $N \times N$ matrix and $\mathbf{X}$ and $\mathbf{b}$ are $N \times 1$ vectors.

5. Computation of the rank($\rho$) and eigen values ($\lambda_i$) of $\mathbf{A}$
6. Approximate $\mathbf{A}$ for $N = 1000$ with the help of singular value decomposition of $\mathbf{A}$ as

$$\tilde{\mathbf{A}} = \sum_{i=0}^{r} \lambda_i U_i V_i^T$$

   where $U_i$ and $V_i$ are the singular vectors and $\lambda_i$ are the eigen values with $\lambda_i < \lambda_j$ for $i > j$. One may use the built-in functions for singular value decomposition.

7. Plot the absolute error($\zeta$) between $\mathbf{A}$ and $\tilde{\mathbf{A}}$ as $\zeta = \sum_{i=1}^{N} \sum_{j=1}^{N} |a_{i,j} - \tilde{a_{i,j}}|^2$ against $r$ for $r = 10, 50, 75, 100, 250\ , 500, 750$ and appreciate the plot.

**Experiment 4. Numerical Differentiation and Integration**

1. Realize the functions $\sin t$, $\cos t$, $sinht$ and $cosht$ for the vector $t = [0, 10]$ with increment 0.01
2. Compute the first and second derivatives of these functions using built in tools such as *grad*.
3. Plot the derivatives over the respective functions and appreciate.
4. Familiarize the numerical integration tools in the language you use.
5. Realize the function

$$f(t) = 4t^2 + 3$$

   and plot it for the vector $t = [-5, 5]$ with increment 0.01

6. Use general integration tool to compute
$$\int_{-2}^{2} f(t)\,dt$$
7. Repeat the above steps with trapezoidal and Simpson method and compare the results.
8. Compute
$$\frac{1}{\sqrt{2\pi}}\int_{0}^{\infty} e^{-\frac{x^2}{2}}\,dx$$
using the above three methods.

**Experiment 5. Solution of Ordinary Differential Equations**

1. Solve the first order differential equation
$$\frac{dx}{dt} + 2x = 0$$
with the initial condition $x(0) = 1$
2. Solve for the current transient through an RC network (with $RC = 3$) that is driven by
   - $5\,V$ DC
   - the signal $5e^{-t}U(t)$

   and plot the solutions.
3. Solve the second order differential equation
$$\frac{d^2x}{dt^2} + 2\frac{dx}{dt} + 2x = e^{-t}$$
4. Solve the current transient through a series RLC circuit with $R = 1\Omega$, $L = 1\,mH$ and $C = 1\,\mu F$ that is driven by
   - $5\,V$ DC
   - the signal $5e^{-t}U(t)$

**Experiment 6. Simple Data Visualization**

1. Draw stem plots, line plots, box plots, bar plots and scatter plots with random data.
2. plot the histogram of a random data.
3. create legends in plots.
4. Realize a vector $t = [-10, 10]$ with increment 0.01 as an array.
5. Implement and plot the functions
   - $f(t) = \cos t$
   - $f(t) = \cos t \cos 5t + \cos 5t$

**Experiment 7. Simple Data Analysis with Spreadsheets**

1. Display an electrical signal on DSO and export it as a *.csv* file.
2. Read this *.csv* or *.xls* file as an array and plot it.
3. Compute the mean and standard deviation of the signal. Plot its histogram with an appropriate bin size.

**Experiment 8. Convergence of Fourier Series**

1. The experiment aims to understand the lack of convergence of Fourier series
2. Realize the Fourier series
$$f(t) = \frac{4}{\pi}[1 - \frac{1}{3}\cos\frac{2\pi 3t}{T} + \frac{1}{5}\cos\frac{2\pi 5t}{T} - \frac{1}{7}\cos\frac{2\pi 7t}{T} + \cdots]$$
3. Realize the vector $t = [0, 100]$ with an increment of 0.01 and keep $T = 20$.
4. Plot the first 3 or 4 terms on the same graphic window and understand how the smooth sinusoids add up to a discontinous square function.
5. Compute and plot the series for the first 10, 20, 50 and 100 terms of the and understand the lack of convergence at the points of discontinuity.
6. With $t$ made a zero vector, $f(0) = 1$, resulting in the *Madhava* series for $\pi$ as
$$\pi = 4[1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \cdots]$$
7. Use this to compute $\pi$ for the first 10, 20, 50 and 100 terms.

**Experiment 9: Coin Toss and the Level Crossing Problem**

1. Simulate a coin toss that maps a head as 1 and tail as 0.
2. Toss the coin $N = 100$, 500,1000, 5000 and 500000 times and compute the probability ($p$) of head in each case.
3. Compute the absolute error $|0.5 - p|$ in each case and plot against $N$ and understand the law of large numbers.
4. Create a uniform random vector with maximum magnitude 10, plot and observe.
5. Set a threshold ($V_T = 2$) and count how many times the random function has crossed $V_T$.
6. Count how many times the function has gone above and below the threshold.

**Schedule of Experiments** Every experiment should be completed in three hours.

| ECL 203 | LOGIC DESIGN LAB | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PCC | 0 | 0 | 3 | 2 |

**Preamble:** This course aims to (i) familiarize students with the Digital Logic Design through the implementation of Logic Circuits using ICs of basic logic gates (ii) familiarize students with the HDL based Digital Design Flow.

**Prerequisite:** Nil

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Design and demonstrate the functioning of various combinational and sequential circuits using ICs |
| **CO 2** | Apply an industry compatible hardware description language to implement digital circuits |
| **CO 3** | Implement digital circuis on FPGA boards and connect external hardware to the boards |
| **CO 4** | Function effectively as an individual and in a team to accomplish the given task |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | | | | | | 3 | | | 3 |
| **CO 2** | 3 | 1 | 1 | 3 | 3 | | | | 3 | | | 3 |
| **CO 3** | 3 | 1 | 1 | 3 | 3 | | | | 3 | 1 | | 3 |
| **CO 4** | 3 | 3 | 3 | | 3 | | | | 3 | | | 3 |

**Assessment**

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 75 | 75 | 2.5 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 15 marks
Continuous Assessment : 30 marks

Internal Test (Immediately before the second series test) : 30 marks

**End Semester Examination Pattern:** The following guidelines should be followed regarding award of marks

| | |
|---|---|
| (a) Preliminary work | : 15 Marks |
| (b) Implementing the work/Conducting the experiment | : 10 Marks |
| (c) Performance, result and inference (usage of equipments and trouble shooting) | : 25 Marks |
| (d) Viva voce | : 20 marks |
| (e) Record | : 5 Marks |

**General instructions:** End-semester practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the examination only on submitting the duly certified record. The external examiner shall endorse the record.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1): Design and Development of combinational circuits**

1. Design a one bit full adder using gates and implement and test it on board.

2. Implement and test the logic function f(A,B,C)=∑m(0,1,3,6) using an 8:1 Mux IC

3. Convert a D flip-flop to T flip-flop and implement and test on board.

**Course Outcome 2 and 3 (CO2 and CO3): Implementation of logic circuits on tiny FPGA**

1. Design and implement a one bit subtracter in Verilog and implement and test it on a tiny FPGA board.

2. Design and implement a J-K flip-flop in Verilog, implement and test it on a tiny FPGA board.

3. Design a 4:1 Multiplexer in Verilog and implement and test it on tiny FPGA board.

**List of Experiments:**

It is compulsory to conduct a minimum of 5 experiments from Part A and a minimum of 5 experiments from Part B.

**Part A (Any 5)**

The following experiements can be conducted on breadboard or trainer kits.

1. Realization of functions using basic and universal gates (SOP and POS forms).
2. Design and Realization of half /full adder and subtractor using basic gates and universal gates.
3. 4 bit adder/subtractor and BCD adder using 7483.
4. Study of Flip Flops: S-R, D, T, JK and Master Slave JK FF using NAND gates.
5. Asynchronous Counter:3 bit up/down counter

6. Asynchronous Counter:Realization of Mod N counter
7. Synchronous Counter: Realization of 4-bit up/down counter.
8. Synchronous Counter: Realization of Mod-N counters.
9. Ring counter and Johnson Counter. (using FF & 7495).
10. Realization of counters using IC's (7490, 7492, 7493).
11. Multiplexers and De-multiplexers using gates and ICs. (74150, 74154)
12. Realization of combinational circuits using MUX & DEMUX.
13. Random Sequence generator using LFSR.

**PART B (Any 5)**

The following experiments aim at training the students in digital circuit design with verilog and implementation in small FPGAs. Small, low cost FPGAs, that can be driven by open tools for simulation, synthesis and place and route, such as *TinyFPGA* or *Lattice iCEstick* can be used. Open software tools such as *yosis* (for simulation and synthesis) and *arachne* (for place and route) may be used. The experiments will lay the foundation for digital design with FPGA with the objective of increased employability.

Experiment 1. Realization of Logic Gates and Familiarization of FPGAs

(a) Familiarization of a small FPGA bboard and its ports and interface.
(b) Create the .pcf files for your FPGA board.
(c) Familiarization of the basic syntax of verilog
(d) Development of verilog modules for basic gates, synthesis and implementation in the above FPGA to verify the truth tables.
(e) Verify the universality and non associativity of NAND and NOR gates by uploading the corresponding verilog files to the FPGA boards.

Experiement 2: Adders in Verilog

(a) Development of verilog modules for half adder in 3 modeling styles (dataflow/structural/ behavioural).
(b) Development of verilog modules for full adder in structural modeling using half adder.

Experiement 3: Mux and Demux in Verilog

(a) Development of verilog modules for a 4x1 MUX.
(b) Development of verilog modules for a 1x4 DEMUX.

Experiement 4: Flipflops and coutners

(a) Development of verilog modules for SR, JK and D flipflops.
(b) Development of verilog modules for a binary decade/Johnson/Ring counters

Experiment 5. Multiplexer and Logic Implementation in FPGA

(a) Make a gate level design of an 8 : 1 multiplexer, write to FPGA and test its functionality.
(b) Use the above module to realize the logic function f (A, B, C) = ∑m(0, 1, 3, 7) and test it.
(c) Use the same 8 : 1 multiplexer to realize the logic function f (A, B, C, D) = ∑m(0, 1, 3, 7, 10, 12) by partitioning the truth table properly and test it.

Experiment 6. Flip-Flops and their Conversion in FPGA

(a) Make gate level designs of J-K, J-K master-slave, T and D flip-flops, implement and test them on the FPGA board.
(b) Implement and test the conversions such as T to D, D to T, J-K to T and J-K to D

Experiment 7: Asynchronous and Synchronous Counters in FPGA

(a) Make a design of a 4-bit up down ripple counter using T-flip-lops in the previous experiment, implement and test them on the FPGA board.
(b) Make a design of a 4-bit up down synchronous counter using T-flip-lops in the previous experiment, implement and test them on the FPGAboard.

Experiment 8: Universal Shift Register in FPGA

(a) Make a design of a 4-bit universal shift register using D-flip-flops in the previous experiment, implement and test them on the FPGA board.
(b) Implement ring and Johnson counters with it.

Experiment 9. BCD to Seven Segment Decoder in FPGA

(a) Make a gate level design of a seven segment decoder, write to FPGA and test its functionality.
(b) Test it with switches and seven segment display. Use ouput ports for connection to the display.

# SEMESTER -3
# MINOR

| ECT281 | ELECTRONIC CIRCUITS | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | Minor | 3 | 1 | 0 | 4 |

**Preamble:** This course aims to develop the skill of the design of various analog circuits.

**Prerequisite**: EST130 Basics of Electrical and Electronics Engineering

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Realize simple circuits using diodes, resistors and capacitors |
| **CO 2** | Design amplifier and oscillator circuits |
| **CO 3** | Design Power supplies, D/A and A/D convertors for various applications |
| **CO4** | Design and analyze circuits using operational amplifiers |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 2 |
| **CO 2** | 3 | 3 | | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | | | | | | | | | | 2 |
| **CO 4** | 3 | 3 | | | | | | | | | | 2 |

Assessment Pattern

| **Bloom's Category** | | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|---|
| | | **1** | **2** | |
| Remember | K1 | 10 | 10 | 10 |
| Understand | K2 | 20 | 20 | 20 |
| Apply | K3 | 20 | 20 | 70 |
| Analyse | K4 | | | |
| Evaluate | | | | |
| Create | | | | |

**Mark distribution**

| **Total Marks** | **CIE** | **ESE** | **ESE Duration** |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

## Course Level Assessment Questions

**Course Outcome 1 (CO1): Realize simple circuits using diodes, resistors and capacitors.**

1. For the given specification design a differentiator and integrator circuit.
2. For the given input waveform and circuit, draw the output waveform and transfer characteristics.
3. Explain the working of RC differentiator and integrator circuits and sketch the output waveform for different time periods.

**Course Outcome 2 (CO2): Design amplifier and oscillator circuits.**

1. For the given transistor biasing circuit, determine the resistor values, biasing currents and voltages.
2. Explain the construction, principle of operation, and characteristics of MOSFETs.
3. Design a RC coupled amplifier for a given gain.
4. Design a Hartley oscillator to generate a given frequency.

**Course Outcome 3 (CO3): Design Power supplies, D/A and A/D convertors for various applications.**

1. Design a series voltage regulator.
2. For the regulator circuit, find the output voltage and current through the zener diode.
3. In a 10 bit DAC, for a given reference voltage, find the analog output for the given digital input.

**Course Outcome 4 (CO4): Design circuits using operational amplifiers for various applications**

1. For the given difference amplifier, find the output voltage.
2. Derive the expression for frequency of oscillation of Wien bridge oscillator using op-amp.
3. Realize a summing amplifier to obtain a given output voltage.

# SYLLABUS

**Module 1:**

**Wave shaping circuits:** Sinusoidal and non-sinusoidal wave shapes, Principle and working of RC differentiating and integrating circuits, Clipping circuits - Positive, negative and biased clipper. Clamping circuits - Positive, negative and biased clamper.

**Transistor biasing:** Introduction, operating point, concept of load line, thermal stability (derivation not required), fixed bias, self bias, voltage divider bias.

**Module 2:**

MOSFET- Structure, Enhancement and Depletion types, principle of operation and characteristics.

**Amplifiers:** Classification of amplifiers, RC coupled amplifier – design and working, voltage gain and frequency response. Multistage amplifiers - effect of cascading on gain and bandwidth.

Feedback in amplifiers - Effect of negative feedback on amplifiers.

MOSFET Amplifier- Circuit diagram, design and working of common source MOSFET amplifier.

**Module 3:**

**Oscillators:** Classification, criterion for oscillation, Wien bridge oscillator, Hartley and Crystal oscillator. (design equations and working of the circuits; analysis not required).

**Regulated power supplies:** Review of simple zener voltage regulator, series voltage regulator, 3 pin regulators-78XX and 79XX, DC to DC conversion, Circuit/block diagram and working of SMPS.

**Module 4 : Operational amplifiers:** Characteristics of op-amps(gain, bandwidth, slew rate, CMRR, offset voltage, offset current), comparison of ideal and practical op-amp(IC741), applications of op-amps- scale changer, sign changer, adder/summing amplifier, subtractor, integrator, differentiator, Comparator, Instrumentation amplifier.

**Module 5:**

**Integrated circuits:** D/A and A/D convertors – important specifications, Sample and hold circuit, R-2R ladder type D/A convertors.

Flash and sigma-delta type A/D convertors.

**Text Books**

1. Robert Boylestad and L Nashelsky, Electronic Devices and Circuit Theory, Pearson, 2015.
2. Salivahanan S. and V. S. K. Bhaaskaran, Linear Integrated Circuits, Tata McGraw Hill, 2008.

**Reference Books**

1. David A Bell, Electronic Devices and Circuits, Oxford University Press, 2008.

2. Neamen D., Electronic Circuits, Analysis and Design, 3/e, TMH, 2007.

3. Millman J. and C. Halkias, Integrated Electronics, 2/e, McGraw-Hill, 2010.

4. Op-Amps and Linear Integrated Circuits, Ramakant A Gayakwad, PHI, 2000.

5. K.Gopakumar, Design and Analysis of Electronic Circuits, Phasor Books, Kollam, 2013

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Wave shaping circuits** | |
| 1.1 | Sinusoidal and non-sinusoidal wave shapes | 1 |
| 1.2 | Principle and working of RC differentiating and integrating circuits | 2 |
| 1.3 | Clipping circuits - Positive, negative and biased clipper | 1 |
| 1.4 | Clamping circuits - Positive, negative and biased clamper | 1 |
| | **Transistor biasing** | |
| 1.5 | Introduction, operating point, concept of load line | 1 |
| | Thermal stability, fixed bias, self bias, voltage divider bias. | 3 |
| **2** | **Field effect transistors** | |
| 2.2 | MOSFET- Structure, Enhancement and Depletion types, principle of operation and characteristics | 2 |
| | **Amplifiers** | |
| 2.3 | Classification of amplifiers, RC coupled amplifier - design and working voltage gain and frequency response | 3 |
| 2.4 | Multistage amplifiers - effect of cascading on gain and bandwidth | 1 |
| 2.5 | Feedback in amplifiers - Effect of negative feedback on amplifiers | 1 |
| | MOSFET Amplifier- Circuit diagram, design and working of common source MOSFET amplifier | 2 |
| | | |
| **3** | **Oscillators** | |
| 3.1 | Classification, criterion for oscillation | 1 |
| 3.2 | Wien bridge oscillator, Hartley and Crystal oscillator | 3 |
| | **Regulated power supplies** | |
| 3.3 | simple zener voltage regulator, series voltage regulator line and load regulation | 3 |
| 3.4 | 3 pin regulators-78XX and 79XX | 1 |
| 3.5 | DC to DC conversion, Circuit/block diagram and working of SMPS | 1 |
| | | |
| **4** | **Operational amplifiers** | |
| 4.1 | Differential amplifier | 2 |
| 4.2 | characteristics of op-amps(gain, bandwidth, slew rate, CMRR, offset voltage, offset current), comparison of ideal and practical op-amp(IC741) | 2 |
| 4.3 | applications of op-amps- scale changer, sign changer, adder/summing amplifier, subtractor, integrator, differentiator | 3 |

| | | |
|---|---|---|
| 4.4 | Comparator, Schmitt trigger, Linear sweep generator | 3 |
| | | |
| **5** | **Integrated circuits** | |
| 5.1 | D/A and A/D convertors – important specifications, Sample and hold circuit | 1 |
| 5.2 | R-2R ladder type D/A convertors | 2 |
| 5.3 | Flash and successive approximation type A/D convertors | 2 |
| 5.4 | Circuit diagram and working of Timer IC555, astable and monostable multivibrators using 555 | 3 |

**Assignment:**

Atleast one assignment should be simulation of transistor amplifiers and op-amps on any circuit simulation software.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

THIRD SEMESTER B.TECH DEGREE EXAMINATION, (**Model Question Paper)**

**Course Code: ECT281**

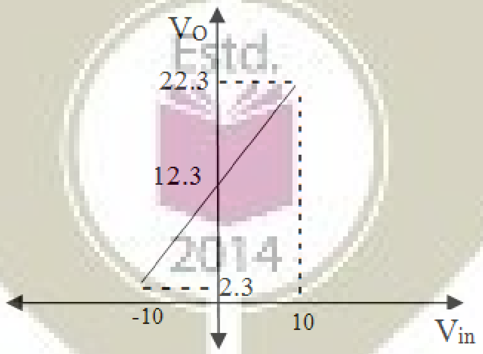
## Course Name: ELECTRONIC CIRCUITS

Max. Marks: 100 Duration: 3 Hours

**PART A**

Answer ALL Questions. Each Carries 3 mark.

1 Design a clamper circuit to get the following transfer characteristics, assuming voltage drop across the diode s 0.7V. K3




2 Give the importance of biasing in transistors? Mention significance of operating point. K2

3 What is line regulation and load regulation in the context of a voltage regulator? Explain with equation for percentage of regulation:- K2

4 Compare the features of FET with BJT:- K1

5 What is the effect of cascading in gain and bandwidth of amplifier? K1

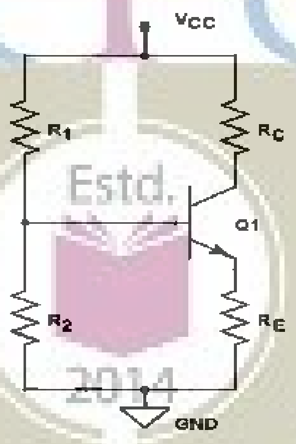
| | | |
|---|---|---|
| 6 | Discuss about simple zener shunt voltage regulator:- | K1 |
| 7 | Realize a circuit to obtain Vo= $-2V_1+3V_2+4V_3$ using operational amplifier. Use minimum value of resistance as 10KΩ. | K3 |
| 8 | Design a monostable multivibrator using IC 555 timer for a pulse period of 1 ms. | K3 |
| 9 | Describe the working of a Flash type A/D Converter, with example. | K2 |
| 10 | Define: (1) Slew rate, (2) CMRR, (3) offset voltage and current:- | K2 |

**PART – B**

Answer one question from each module; each question carries 14 marks.

**Module - I**

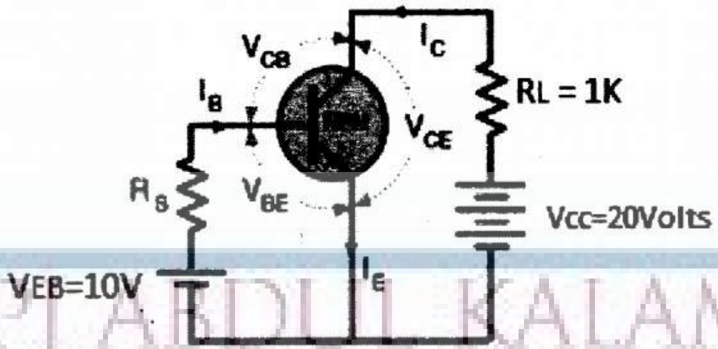
| | | |
|---|---|---|
| 11 a. | Design a differentiator circuit for a square wave signal with Vpp=10 and frequency 10KHz:- | 5 CO1 K3 |
| b. | Consider a self-biasing circuit shown in figure below with Vcc=20V, $R_c$=1.5KΩ, which is operated at Q-point (Vce=8V, Ic=4mA), If $h_{FE}$=100, find $R_1$, $R_2$ and $R_e$. Assume $V_{BE}$=0.7V. | 9 CO2 K3 |



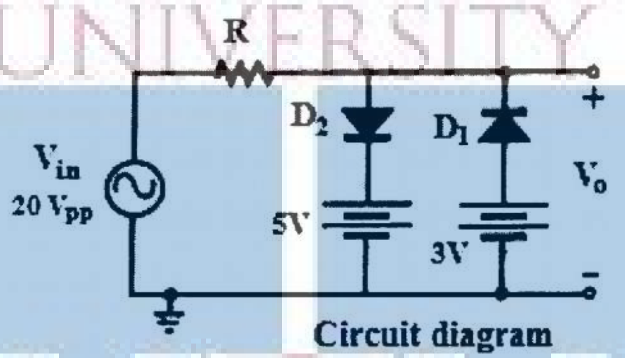

**OR**

| | | |
|---|---|---|
| 12 a. | Explain the working of an RC differentiator circuit for a square wave input with period T.Sketchits output waveform for RC ≫ T ,RC ≪ T and RC = T. | 5 CO1 K3 |
| b. | With reference to the following circuit, draw the load line and mark the Q point of a Silicon transistor operating in CE mode based on the following data (β=80, Rs=47KΩ, $R_L$=1KΩ, neglect $I_{CBO}$) | 5 CO2 |

K3




c. Draw the output waveform and transfer characteristics of the given clipper circuit. 4 CO1 K3




**Module - II**

13 a. With neat sketches, explain the construction, principle of operation and characteristics of an N-channel enhancement MOSFET:- 9 CO2 K2

b. Draw the circuit of an RC coupled amplifier and explain the function of each element:- 5 CO2 K2

**OR**

14 a. Draw the circuit of a common source amplifier using MOSFET. Derive the expressions for voltage gain and input resistance:- 9 CO2 K2

b. Sketch the frequency response of an RC coupled amplifier and write the reasons for gain reduction in both ends. 5 CO2 K2

**Module - III**

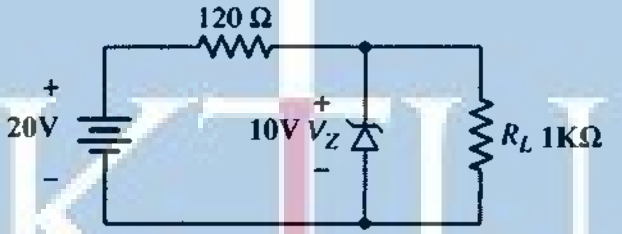
15 a. Design a Hartley oscillator to generate a frequency of 150KHz. 5 CO2

K3

| | | |
|---|---|---|
| b. | Draw the circuit of a series voltage regulator. Explain its working when the input voltage as well as load current varies. Design a circuit to deliver 5V, 100mA maximum load current:- | 9 CO3 K3 |

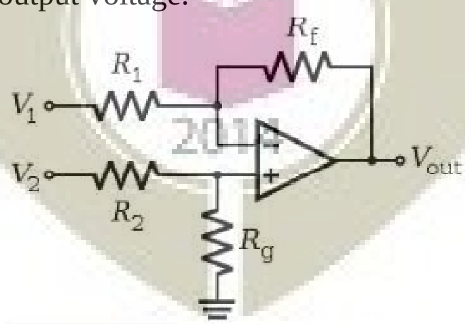
**OR**

| | | |
|---|---|---|
| 16 a. | With neat diagram and relevant equations explain the working of wein bridge oscillator using BJT:- | 7 CO2 K2 |
| b. | Derive the expression for the frequency of oscillation of Wien bridge oscillator using BJT | 4 CO2 K2 |
| c. | For the circuit shown below, find the ouput voltage across RL and current through the zener diode:- | 3 CO3 K3 |




**Module - IV**

| | | |
|---|---|---|
| 17 a. | With circuit, relevant equations and waveforms explain the working of a Schmit trigger using op-amp:- | 10 CO4 K2 |
| b. | The difference amplifier shown in the figure have $R_1$=$R_2$=5KΩ, $R_F$=10KΩ, $R_g$=1KΩ. Calculate the output voltage. | 5 CO4 K3 |




**OR**

| | | |
|---|---|---|
| 18 a. | With circuits and equations show that an op-amp can act as integrator, differentiator, adder and subtractor. | 9 CO4 K2 |

| | | |
|---|---|---|
| b. | What do you mean by differential amplifier? With neat sketches, explain the working of an open loop OP-AMP differential amplifier. | 5 CO4 K2 |

**Module - V**

| | | |
|---|---|---|
| 19 a. | Explain the working of R-2R ladder type DAC. In a 10 bit DAC, reference voltage is given as 15V. Find analog output for digital input of 1011011001. | 10 CO3 K3 |
| b. | With neat diagram explain the working of IC555 timer. | 4 CO4 K3 |

**OR**

| | | |
|---|---|---|
| 20 a. | A 4-bit R-2R ladder type DAC having R= 10 kΩ and $V_R$= 10 V. Find its resolution and output voltage for an input 1101. | 4 CO4 K3 |
| b. | Design an astable multivibrator using IC 555 timer for a frequency of 1KHz and a duty cycle of 70%.Assume c=0.1µF. | 5 CO4 K3 |
| c. | Draw the circuit diagram of a simple sample and hold circuit and explain the necessity of this circuit in A to D conversion. | 5 CO4 K2 |

# Simulation Assignments

The following simulations can be done in QUCS, KiCad or PSPICE.

1. Design and simulate RC coupled amplifer. Observe the input and output signals. Plot the AC frequency response and understand the variation of gain at high frequencies. Observe the effect of negative feedback by changing the capacitor across the emitter resistor.

2. Design and simulate Wien bridge oscillator for a frequency of $10\,kHz$. Run a transient simulation and observe the output waveform.

3. Design and simulate series voltage regulator for output voltage $V_O = 10V$ and output current $I_O = 100mA$ with and without short circuit protection and to test the line and load regulations.

4. Design and implement differential amplifier and measure its CMRR. Plot its transfer characteristics.

5. Design and simulate non-inverting amplifier for gain 5. Observe the input and output signals. Run the ac simulation and observe the frequency response and $3-$ db bandwidth.

6. Design and simulate a 3 bit flash type ADC. Observe the output bit patterns and transfer characteristics

7. Design and simulate $R-2R$ DAC ciruit.

8. Design and implement Schmitt trigger circuit for upper triggering point of $+8\,V$ and a lower triggering point of $-4\,V$ using op-amps.

| ECT 283 | ANALOG COMMUNICATION | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | Minor | 3 | 1 | 0 | 4 |

**Preamble:** The course has two objectives: (1) to study two analog modulation schemes known as amplitude modulation and frequency modulation (2) to understand the implementations of transmitter and reciever systems used in AM and FM.

**Prerequisite:** NIL

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Explain various components of a communication system |
| **CO 2** | Discuss various sources of noise, and its the effect in a communication system |
| **CO 3** | Explain amplitude modulation and its variants for a sinusoidal message |
| **CO 4** | Explain frequency modulation and its variants for a sinusoidal message |
| **CO 5** | List and compare various transmitter and receiver systems of AM and FM |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 3 | | | | | | | | | | |
| CO 2 | 3 | 3 | | | | | | | | | | |
| CO 3 | 3 | 3 | | | | | | | | | | |
| CO 4 | 3 | 3 | | | | | | | | | | |
| CO 5 | 3 | 3 | | | | | | | | | | |
| CO 6 | 3 | 3 | | | | | | | | | | |

Assessment Pattern

| **Bloom's Category** | | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|---|
| | | **1** | **2** | |
| Remember | K1 | 10 | 10 | 10 |
| Understand | K2 | 20 | 20 | 20 |
| Apply | K3 | 20 | 20 | 70 |
| Analyse | | | | |
| Evaluate | | | | |
| Create | | | | |

**Mark distribution**

| **Total Marks** | **CIE** | **ESE** | **ESE Duration** |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):** Explain various components of a communication system.

1. What is the need of a modulator in a radio communcation system?
2. What are the various frequency bands used in radio communication
3. Why base band communication is infeasible for terrestrial air transmission?

**Course Outcome 2 (CO2):** Discuss various sources of noise, and its the effect in a communication system.

1. What is thermal noise?
2. Describe the noise voltage generated across resistor?
3. Why is it that noise voltage can not be used as a source for power?

**Course Outcome 3 (CO3):** Explain amplitude modulation and its variants for a sinusoidal message.

1. Write down the equation for an AM wave for a sinusoidal message
2. What is the significance of modulation index?
3. Describe envelope detector

**Course Outcome 4 (CO4):** Explain frequency modulation and its variants for a sinusoidal message

4. How is practical bandwidth for an FM wave determined?
5. What are the value of frequency devaiation, bandwidth for a typical FM station?
6. What is PLL?

**Course Outcome 5 (CO5):** List and compare various transmitter and receiver systems of AM and FM

1. Draw the block diagram of a super heterodyne receiver.
2. How is adjasecent channel rejection achieved in superhet? How is image rejection achieved in a superhet?
3. Explain the working principle of one FM generator, and one FM demodulator.

## Syllabus

**Module I**

Introduction, Elements of communication systems, Examples of analog communication systems, Frequency bands, Need for modulation.

Noise in communication system, Definitions of Thermal noise (white noise), Various types of noise -- Shot noise, Partition noise, Flicker noise, Burst noise, (No analysis required) Signal to noise ratio, Noise factor, Noise temperature, Narrow band noise.

**Module II**

Brief overview of signals and systems -- Signals, Classification of signals, Energy and power of signals, Basic signal operations, Impulse function, Properties of impulse function, Convolution, LTI system, Fourier Transform, Basic properties, Using Fourier transform to study LTI system.

**Module III**

Amplitude modulation (AM), Double-side band suppressed carrier (DSB-SC) modulation Single sideband modulation (SSB) – spectrum, power, efficiency of all the three variants. (Study of only tone modulation in DSB-SC, AM, and SSB.) Amplitude-modulator implementations – switching modulator, balanced modulator. AM demodulators -- Coherent demodulator. Envelope detector.

**Module IV**

Frequency modulation – modulation index, frequency deviation, average power, spectrum of tone modulated FM. Heuristics for bandwidth of FM. Narrow band FM and wide-band FM. FM generation: Varactor diode modulator, Armstrongs method. FM demodulation – slope detection, PLL demodulator.

**Module V**

Superheterodyne reciever, Principle of Carrier synchronization using PLL, NTSC Television broadcasting.

**Text Books**

1. Kennedy, Davis, "Electronic Communication Systems," 4th Edition, Tata McGraw Hill

2. Wayne Tomasi, "Electronic Communication Systems – Fundamentals through Advanced," 5th edition, Pearson.

3. B. P. Lathi, Zhi Ding, Modern Digital and Analog Communication Systems, 4th edition, Oxford University Press.

**Reference books**

1. Leon W. Couch, Digital and Analog Communication Systems, 8th edition, Prentice Hall.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| | | |
| I | Introduction, Elements of communication systems, Examples of analog communication systems, Frequency bands, Need for modulation | 3 |
| | Noise in communication system, Definitions of Thermal noise (white noise), Shot noise, Partition noise, Flicker noise, Burst noise, (No analysis required) Signal to noise ratio, Noise factor, Noise temperature, Narrow band noise. | 5 |
| II | **Brief Overview of Signals and Systems:** Signals, Classification of signals, Energy and power of signals, Basic signal operations, | 4 |
| | Impulse function, Properties of impulse function, Convolution, | 2 |
| | Definition of Linear time-invariant system. Input-output relation of LTI system | 2 |
| | Definition of Fourier Transforms, Some Properties of Fourier Transform – Linearity, Time-shift, Modulation theorem, Parsevals theorem. Using Fourier Transform to study LTI systems. | 5 |
| III | Amplitude modulation (AM) – modulation index, spectrum, power, efficiency. | 2 |
| | Double-side band suppressed carrier (DSB-SC) modulation – spectrum, power, efficiency. | 1 |
| | Single sideband modulation (SSB) – spectrum, power, efficiency. (Study of only tone modulation in DSB-SC, AM, and SSB.) | 1 |
| | Amplitude-modulator implementations – switching modulator, balanced modulator (at block diagram level). | 2 |
| | AM demodulators -- Coherent demodulator. Envelope detector. | 3 |
| IV | Frequency modulation – modulation index, frequency deviation, average power, spectrum of tone modulated FM | 4 |
| | Heuristics for bandwidth of FM. Narrow band FM and wide-band FM. | 1 |
| | FM generation: Varactor diode modulator, Armstrongs method. FM demodulation – slope detection, PLL demodulator. | 4 |

| | | |
|---|---|---|
| | | |
| V | Receivers for AM/FM: Super heterodyne receiver (block diagram), Adjacent channel selectivity, Image rejection, Double conversion. | 3 |
| | Carrier Synchronization using PLL | 1 |
| | NTSC Television broadcasting using AM, FM radio broadcasting. | 2 |



**Sample Assignments**

1. Using the message signal $m(t)=t/1+t^2$. Determine and sketch the modulated wave for amplitude modulation whose percentage of modulation equal the following values – 50%, 100%, 120%
2. A standard AM transmission sinusoidally modulated to a depth of 30% produces sideband frequencies of 4.98MHz & 4.914 MHz. the amplitude of each sideband frequency is 75V. Determine the amplitude and frequency of the carrier?
3. Write the typical frequency ranges for the following classification of EM spectrum: MF, HF,VHF and UHF.
4. List the basic functions of a radio transmitter and corresponding functions of the receiever?
5. Discuss the types causes and effects of various forms of noise at a receiver.
6. What are the different frequency components in SSB & DSBSC signals?
7. Describe the AM generation using diode as a nonlinear resistor.
8. Define the following terms in the context of FM -- Frequency deviation, frequency sensitivity, instantaneous phase deviation.
9. The equation for FM wave is $s(t)= 10 \cos (2\pi * 10^6 t +5 \sin(200\pi t+10\sin(3000\pi t))$ Calculate frequency deviation, approximate transmission BW and power in the modulated signal.

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

THIRD SEMESTER B.TECH. DEGREE EXAMINATION

**ECT 283: Analog Communication**

Max. Marks: 60 Duration: 3 hours

**PART A**

*Answer all questions. Each question carries 3 marks each.*

1. Explain the need for modulation.
2. A receiver connected to an antenna whose resistance is 50 ohm has an equivalent noise resistance of 30 ohm .calculate receiver noise figure in decibels & its equivalent noise temperature?
3. Plot the signal x(t)=u(t+1)+2u(t)-u(t-3)
4. State Parseval's theorem for DTFT. What is its signifance?
5. Define amplitude modulation? Give the frequency spectrum for AM wave?
6. Derive the expression for total power of AM wave?
7. Explain the following terms a)Modulation index b)Instantaneous frequency deviation
8. Compare AM & FM systems.
9. What are the advantages that the super heterodyne receiver has over the receivers? Are there any disadvantages?
10. Give the limitations of NTSC systems?

PART B

11. (a) Explain the following (i) Thermal noise (ii) Flicker noise (6 marks)
    (b) Explain the elements of communication systems in detail? (8 marks)

OR

12. (a) Define the signal to noise ratio and noise and noise figure of a receiver? How noise temperature related to noise figure? (8 marks)
    (b) List the basic functions of a radio transmitter & the corresponding functions of the receiver? (6 marks)
13. (a) Distinguish between energy & power signals. Give an example for each category? (6 marks)
    (b) State and prove the linearity and time shifting property of Fourier Transform? (8 marks)

OR

14. (a) Check whether the systems are linear & stable. (i) $y(t)=e^{x(t)}$ (ii) y[n]=x[n-1] (6 marks)

    (b) Find convolution of signal x[n] = [1,-1, 1, 1] with itself? (5 marks)
    (c)Distinguish between causal & non causal systems with suitable examples? (3 marks)

OR

15. (a) Derive the expression of total power in SSB wave? (7 marks)

(b) Describe the AM demodulation using envelope detector? (7 marks)

OR

16. (a) Describe the DSB SC wave generation process using balanced modulation (9 marks)

(b) Give the spectrum of SSB & DSB SC waves? Make comparison of bandwidth requirements. (5 marks)

17. (a) Explain the direct method of generating FM signal using varactor diode? (6 marks)

(b) Explain frequency modulation and it average power? (6 marks)

OR

18. (a) Explain with relevant mathematical expressions, the demodulation of FM signal using PLL? (10 marks)

(b) Give the spectrum of tone modulated FM? (4 marks)

19. (a) Explain the super heterodyne receiver with a detailed block diagram? (10 marks)

(b) Explain how the use of RF amplifier & improve the NR of a super heterodyne receiver? (4 marks)

OR

20. (a) Explain the TV broadcasting system using AM? (10 marks)

(b) What is image frequency, how does it arise? (4 marks)

# Simulation Assignments

The following simulations can be done in Python/SCILAB/MTLAB or LabVIEW.

**Amplitude Modulation Schemes**

- Create a sinusoidal carrier($x_c(t)$) and AF signal($x_t$) with the frequency of carrier being 10 times that of the AF signal.
- Compute the AM signal as $mx_c(t)x(t) + x_c(t)$ for various values of the modulation index $m$ ranging from 0 to 1.
- Observe the power spectral density of this AM signal.
- $mx_c(t)x(t)$ is the DSB-SC signal. Observe this signal and its power spectral density.
- Load a speech signal in say in *.wav* format into a vector and use it in place of the AF signal and repeat the above steps for a suitable carrier.

**SSB Signal Generation**

- Simulate an SSB transmitter and receiver using $-\frac{\pi}{2}$ shifters. This can be realized by the Hilbert Transform function in Python, MATLAB etc.
- Test the system with single tone and speech signal.
- Add channel noise to the signal and test for the robustness against noise.
- Slightly offset the receiver carrier phase and observe the effect at the reception.

**FM Signal Generation**

- Create a sinusoidal carrier($x_c(t)$) and a single tone signal ($x(t)$ ) with the frequency of carrier being 50 times that of the message tone.
- Compute the FM signal with a modulation index of 5.
- Observe the power spectral density of this FM signal for spectral width of 10 times that tone frequency.

**AM Radio Receiver**

- Procure a radio kit
- Assemble the kit by soldering all components and enjoy.

**FM Radio Receiver**

- Procure an FM radio kit
- Assemble the kit by soldering all components and enjoy.

**Generation of Discrete Signals**

- Generate the following discrete signals
  - Impulse signal
  - Pulse signal and
  - Triangular signal

| ECT285 | INTRODUCTION TO SIGNALS AND SYSTEMS | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | Minor | 3 | 1 | 0 | 4 |

**Preamble:** This course aims to apply the concepts of electrical signals and systems

**Prerequisite**: None

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Define and classify continuous and discrete signals |
| **CO 2** | Explain and characterize a system and LTI system |
| **CO 3** | Explain the spectrum of a signal |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | 2 | | | | | | | |
| **CO 2** | 3 | 3 | | 3 | 2 | | | | | | | |
| **CO 3** | 3 | 3 | | 3 | 2 | | | | | | | |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 10 | 10 | 20 |
| Understand | 10 | 10 | 20 |
| Apply | 30 | 30 | 60 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1): Definition and classification of signals**

1. Define a signal. Classify them to energy and power signals.
2. Determine whether the signal x(t)=cos(3t)+sin(5t) is periodic. If so what is the period?
3. Compare the frequency range of continuous time and discrete signals.

**Course Outcome 2 (CO2): Explain and characterize a system**

1. Check whether the system y[n]=cos{x[n]}is a. Stable b. Causal c. time invariant d. linear
2. Derive the ouptut of a continuous time LTI system
3. Give the meaning of impulse response of LTI systems

**Course Outcome 2 (CO3): Spectra of Signals**

1. State and prove Parsevals theorem
2. State and prove the modulation property of Fourier transform
3. Find the continuous tiime Fourier transform a pulse of width w and amplitude unity and centred about the origin.

# Syllabus

**Module 1 : Introduction to Continuous Time Signals**

Definition of signal. Basic continous-time signals. Frequency and angular frequency of continous-time signals . Basic operation on signals. Classification of continous-time signals:Periodic and Non-periodic signals.Even and Odd signals, Energy and power signals. Noise and Vibration signals.

**Module 2 : Discrete Time Signals**

Basic discrete-time signals. Frequency and angular frequency of discrete-time signals.Classification of discrete-time signals:Periodic and Non-periodic signals.Even and Odd signals, Energy and power signals.

**Module 3: Systems**

System definition. Continuous-time and discrete-time systems. Properties – Linearity, Time invariance, Causality, Invertibility,Stability. Representation of systems using impulse response.

**Module 4: Linear time invariant systems**

LTI system definition. Response of a continous-time LTI system and the Convolutional Integral. Properties. Response of a discrete-time LTI system and the Convolutional Sum. Properties. Correlation of discrete-time signals

**Module 5 : Frequency analysis of signals**

Concept of frequency in continous-time and discrete-time signals. Fourier transform of continuous-time and discrete-time signals. Parsevals theorem. Interpretation of Spectra. Case study of a vibration signal.The sampling theorem.

**Text Books**


1. Simon Haykin, Barry Van Veen, Signals and systems, John Wiley
2. Hwei P.Hsu, Theory and problems of signals and systems, Schaum Outline Series, MGH.
3. Anders Brandt, Noise and Vibration Analysis,Wiley publication.
4. A Anand Kumar, Signals and systems, PHI learning
5. Sanjay Sharma, Signals and systems


**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Introduction to Continuous Time Signals** | |
| 1.1 | Definition of signal, Basic continous-time signals. | 3 |
| 1.2 | Frequency and angular frequency of continous-time signals | 1 |
| 1.3 | Basic operation on signals | 1 |
| 1.4 | Classification of continous-time signals | 3 |
| 1.5 | Noise and Vibration signals | 1 |
| | | |
| **2** | **Discrete Time Signals** | |
| 2.1 | Basic discrete-time signals and its frequency | 3 |
| 2.2 | Classification of discrete-time signals | 3 |

| | | |
|---|---|---|
| **3** | **Systems** | |
| 3.1 | System definition- CTS & DTS | 1 |
| 3.2 | Properties-Linearity, Time invariance | 3 |
| 3.3 | Causality, Invertibility, Stability | 2 |
| 3.4 | Representation of systems using impulse response | 1 |
| **4** | **Linear time invariant systems** | |
| 4.1 | LTI system definition.Properties. | 1 |
| 4.2 | Response of a continuous-time LTI system and the Convolutional Integral | 3 |
| 4.3 | Response of a discrete-time LTI system and the Convolutional Sum | 3 |
| 4.4 | Correlation of discrete-time signals | 2 |
| **5** | **Frequency analysis of signals** | |
| 5.1 | Concept of frequency in continuous-time and discrete-time signals | 1 |
| 5.2 | CTFT and spectra | 3 |
| 5.3 | DTFT and spectra | 3 |
| 5.4 | DFT | 1 |
| 5.5 | Parsevals theorem | 1 |
| 5.6 | Case study of a vibration signal | 1 |
| 5.7 | The sampling theorem | 2 |

**Model Question Paper**

# A P J Abdul Kalam Technological University



Fourth Semester B Tech Degree Examination

## ECT 285 Introduction to Signals and Systems

**Time: 3 Hrs** **Max. Marks: 100**

**PART A**

*Answer All Questions*

| | | | |
|---|---|---|---|
| 1 | Differentiate between energy and power signal with example. | (3) | $K_2$ |
| 2 | Find the even and odd components of $x(t) = e^{jt}$. | (3) | $K_2$ |
| 3 | Define discrete time signal and comment about its frequency range. | (3) | $K_2$ |
| 4 | Sketch the sequence $x(n) = 2\delta(n-3) - \delta(n-1) + \delta(n) + \delta(n+2)$. | (3) | $K_2$ |
| 5 | State and explain BIBO condition for system. | (3) | $K_1$ |
| 6 | Distinguish between continuous time and discrete time systems. | (3) | $K_2$ |
| 7 | Derive a relationship between input and output for a discrete LTI system | (3) | $K_2$ |
| 8 | Compute the energy of the signal $x(n) = 0.8^n u(n)$ | (3) | $K_2$ |
| 9 | State and explain sampling theorem. | (3) | $K_2$ |
| 10 | Comment about the input output characteristics of continuous time Fourier transform | (3) | $K_2$ |



**PART B**

*Answer one question from each module. Each question carries 14 mark.*

| | | | |
|---|---|---|---|
| 11(A) | Determine whether or not the signal $x(t) = \cos t + \sin \sqrt{2}t$ is periodic. If periodic determine its fundemental period. | (7) | $K_2$ |
| 11(B) | Define, sketch and list the properties of continuous time impulse function | (7) | $K_2$ |

**OR**

| | | | |
|---|---|---|---|
| 12(A) | Determine whether the signal $x(t) = e^{-2t}u(t)$ is energy signal, power signal or neither. | (7) | $K_2$ |
| 12(B) | Define unit step function and plot $u(t+2) - u(t-2)$. | (7) | $K_2$ |
| 13(A) | Given the sequence $x(n) = \{1, 2, 1, 1, 3\}, -1 \leq n \leq 3$. Sketch<br>• $x(-n+2)$<br>• $x(n/2)$ | (8) | $K_3$ |
| 13(B) | Show that any signal $x(n)$ can be represented as the summation of an even and odd signal. | (6) | $K_2$ |

**OR**

| | | | |
|---|---|---|---|
| 14 | Discuss briefly the basic discrete time signals. | (14) | $K_2$ |
| 15(A) | Explain linear and nonlinear systems. | (6) | $K_2$ |
| 15(B) | Apply the properties of system to check whether the following systems are linear or nonlinear<br>• $y(t) = tx(t)$<br>• $y(n) = x^2(n)$ | (8) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 16(A) | A sytem has an input-output relation given by $y(n) = T\{x(n)\} = nx(n)$. Determine whether the system is<br>a)Memoryless<br>b)Causal<br>c) Linear<br>d) Time invariant<br>e)Stable | (14) | $K_3$ |

| | | | |
|---|---|---|---|
| 17 | The impulse response of a linear time invariant system is $h(n) = \{1, 2, 1, -1\}, -1 \leq n \leq 2$<br>Determine the response of the system for the input signal $x(n) = \{1, 2, 3, 1\}$ | (14) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 18 | A system is formed by connecting two systems in cascade. The impulse response of the system is given by $h_1(t)$ and $h_2(t)$ respectively where $h_1(t) = e^{-2t}u(t)$ and $h_2(t) = 2e^{-t}u(t)$<br>a)Find overall impulse response h(t) of the system.<br>b) Determine the stability of the overall system | (14) | $K_3$ |
| 19(A) | Find the Nyquist rate of $x(t) = sin400\pi t + cos500\pi t.$ | (7) | $K_2$ |
| 19(B) | State and prove modulation property of Fourier Transform | (7) | $K_2$ |

**OR**

| | | | |
|---|---|---|---|
| 20(A) | Find the CTFT of the signal $x(t) = te^{-at}u(t)$ | (7) | $K_2$ |
| 20(B) | State and prove Parsevals theorem | (7) | $K_2$ |

# Simulation Assignments

The following simulation assignments can be done with Python/MATLAB/ SCILAB/OCTAVE

1. Generate the following discrete signals
   - Impulse signal
   - Pulse signal and
   - Triangular signal
2. Write a function to compute the DTFT of a discrete energy signal. Test this function on a few signals and plot their magnitude and phase spectra.
3. - Compute the linear convolution between the sequences $x = [1, 3, 5, 3]$ with $h = [2, 3, 5, 6]$. Observe the stem plot of both signals and the convolution.
   - Now let $h = [1, 2, 1]$ and $x = [2, 3, 5, 6, 7]$. Compute the convolution between $h$ and $x$.
   - Flip the signal $x$ by $180^\circ$ so that it becomes $[7, 6, 5, 3, 2]$. Convolve it with $h$. Compare the result with the previous result.
   - Repeat the above two steps with $h = [1, 2, 3, 2, 1]$ and $h = [1, 2, 3, 4, 5, 4, 3, 2, 1]$
   - Give your inference.
4. - Write a function to generate a unit pulse signal as a summation of shifted unit impulse signals
   - Write a function to generate a triangular signal as a convolution between two pulse signals.
5. - Relaize a continuous time LTI system with system response

     $$H(s) = \frac{5(s+1)}{(s+2)(s+3)}$$

     . One may use *scipy.signal.lti* package in Python.
   - Make it into a discrete system (possibly with *scipy.signal.cont2discrete*)
   - Observe the step response in both cases and compare.

# SEMESTER -4

| ECT202 | ANALOG CIRCUITS | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PCC | 3 | 1 | 0 | 4 |

**Preamble:** This course aims to develop the skill of analyse and design of different types of analog circuits using discrete electronic components.

**Prerequisite**: EST130 Basics of Electrical and Electronics Engineering

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Design analog signal processing circuits using diodes and first order RC circuit |
| **CO 2** | Analyse basic amplifiers using BJT and MOSFET |
| **CO 3** | Apply the principle of oscillator and regulated power supply circuits. |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 2 |
| **CO 2** | 3 | 3 | | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | | | | | | | | | | 2 |

Assessment Pattern

| Bloom's Category | | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|---|
| | | 1 | 2 | |
| Remember | K1 | 10 | 10 | 10 |
| Understand | K2 | 20 | 20 | 20 |
| Apply | K3 | 20 | 20 | 70 |
| Analyse | K4 | | | |
| Evaluate | | | | |
| Create | | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

### Course Level Assessment Questions

**Course Outcome 1 (CO1): Design analog signal processing circuits using diodes and first order RC circuit.**

1. For the given specification design a differentiator / integrator circuit.
2. For the given transfer characteristics design clipping / clamping circuit.
3. Design first order RC low-pass / high-pass circuit for the given specification.

**Course Outcome 2 (CO2): Analyse basic amplifiers using BJT.**

1. For the given transistor biasing circuit, determine the resistor values, biasing currents and voltages.
2. Design a RC coupled amplifier for a given gain.
3. Analyse the frequency response of BJT RC coupled amplifier using hybrid π model.

**Course Outcome 2 (CO2): Analyse basic amplifiers using MOSFET.**

1. Perform DC analysis of MOSFET circuits.
2. Design a common source amplifier.
3. Deduce the expression for voltage gain of CS stage with diode-connected load.

**Course Outcome 2 (CO2): Analyse basic feedback amplifiers using BJT and MOSFET**

1. Deduce the expression for voltage gain, input impedance and output impedance of the four feedback amplifier topologies.
2. Design practical discrete amplifiers for the four feedback amplifier topologies.

**Course Outcome 3 (CO3): Apply the principle of oscillator and regulated power supply.**

1. Design oscillator using BJT to generate sine wave for the given frequency.
2. Deduce the expression for maximum efficiency of class B power amplifiers.
3. Illustrate the DC and AC load line in transformer coupled class A power amplifiers.
4. Design voltage regulator for the given specifications.

# SYLLABUS

**Module 1:**

**Wave shaping circuits:** First order RC differentiating and integrating circuits, First order RC low pass and high pass filters.

Diode Clipping circuits - Positive, negative and biased clipper. Diode Clamping circuits - Positive, negative and biased clamper.

**Transistor biasing:** Need, operating point, concept of DC load line, fixed bias, self bias, voltage divider bias, bias stabilization.

**Module 2:**

**BJT Amplifiers:** RC coupled amplifier (CE configuration) – need of various components and design, Concept of AC load lines, voltage gain and frequency response.

Small signal analysis of CE configuration using small signal hybrid-pi model for mid frequency and low frequency. (gain, input and output impedance).

High frequency equivalent circuits of BJT, Miller effect, Analysis of high frequency response of CE amplifier.

**Module 3:**

**MOSFET amplifiers:** MOSFET circuits at DC, MOSFET as an amplifier, Biasing of discrete MOSFET amplifier, small signal equivalent circuit. Small signal voltage and current gain, input and output impedance of CS configuration. CS stage with current source load, CS stage with diode-connected load.

**Multistage amplifiers** - effect of cascading on gain and bandwidth. Cascode amplifier.

**Module 4 :**

**Feedback amplifiers:** Effect of positive and negative feedback on gain, frequency response and distortion. The four basic feedback topologies, Analysis of discrete BJT circuits in voltage-series and voltage-shunt feedback topologies - voltage gain, input and output impedance.

**Oscillators:** Classification, criterion for oscillation, Wien bridge oscillator, Hartley and Crystal oscillator. (working principle and design equations of the circuits; analysis of Wien bridge oscillator only required).

**Module 5:**

**Power amplifiers:** Classification, Transformer coupled class A power amplifier, push pull class B and class AB power amplifiers, complementary-symmetry class B and Class AB power amplifiers, efficiency and distortion (no analysis required)

**Regulated power supplies:** Shunt voltage regulator, series voltage regulator, Short circuit protection and fold back protection, Output current boosting.

**Text Books**


1. Robert Boylestad and L Nashelsky, “Electronic Devices and Circuit Theory”, 11/e Pearson, 2015.
2. Sedra A. S. and K. C. Smith, “Microelectronic Circuits”, 6/e, Oxford University Press, 2013.


**Reference Books**


1. Razavi B., “Fundamentals of Microelectronics”, Wiley, 2015
2. Neamen D., “Electronic Circuits, Analysis and Design”, 3/e, TMH, 2007.
3. David A Bell, “Electronic Devices and Circuits”, Oxford University Press, 2008.
4. Rashid M. H., “Microelectronic Circuits - Analysis and Design”, Cengage Learning, 2/e,2011
5. Millman J. and C. Halkias, “Integrated Electronics”, 2/e, McGraw-Hill, 2010.


**Course Contents and Lecture Schedule**

| No | Topic | No. of lectures |
|---|---|---|
| **1** | **Wave shaping circuits** | |
| 1.1 | Analysis and design of RC differentiating and integrating circuits | 2 |
| 1.2 | Analysis and design of First order RC low pass and high pass filters | 2 |
| 1.3 | Clipping circuits - Positive, negative and biased clipper | 1 |
| 1.4 | Clamping circuits - Positive, negative and biased clamper | 1 |
| | **Transistor biasing** | |
| 1.5 | Need of biasing, operating point, bias stabilization, concept of load line | 1 |
| | Design of fixed bias, self bias, voltage divider bias. | 2 |
| **2** | **BJT Amplifiers** | |
| 2.1 | Classification of amplifiers, RC coupled amplifier (CE configuration) – need of various components and design, Concept of AC load lines. | 2 |
| 2.2 | Small signal analysis of CE configuration using small signal hybrid π model for mid frequency. (gain, input and output impedance). | 3 |
| 2.3 | High frequency equivalent circuits of BJT, Miller effect, Analysis of high frequency response of CE amplifier. voltage gain and frequency response | 4 |
| | | |
| **3** | **MOSFET amplifiers** | |
| 3.1 | MOSFET circuits at DC, MOSFET as an amplifier, Biasing of discrete MOSFET amplifier, | 2 |
| 3.2 | Small signal equivalent circuit. Small signal voltage and current gain, input and output impedances of CS configuration. | 3 |

| | | |
|---|---|---|
| 3.3 | CS stage with current source load, CS stage with diode-connected load. | 2 |
| 3.4 | **Multistage amplifiers** - effect of cascading on gain and bandwidth. Cascode amplifier. | 2 |
| | | |
| **4** | **Feedback amplifiers** | |
| 4.1 | Properties of positive and negative feedback on gain, frequency response and distortion. | 1 |
| 4.2 | Analysis of the four basic feedback topologies | 2 |
| 4.3 | Analysis of discrete circuits in each feedback topologies -voltage gain, input and output impedance | 3 |
| | **Oscillators** | |
| 4.4 | Classification, criterion for oscillation | 1 |
| | Wien bridge oscillator, Hartley and Crystal oscillator. (working principle and design equations of the circuits; analysis not required). | 2 |
| | | |
| **5** | **Power amplifiers** | |
| 5.1 | Classification, Transformer coupled class A power amplifier | 1 |
| 5.2 | push pull class B and class AB power amplifiers, complementary-symmetry class B and Class AB power amplifiers, efficiency and distortion (no analysis required) | 3 |
| | **Linear Regulated power supplies** | |
| 5.3 | Principle of Linear Regulated power supplies, Shunt voltage regulator | 1 |
| 5.4 | Series voltage regulator, Short circuit protection and fold back protection, Output current boosting | 2 |

**Assignment:**

Atleast one assignment should be simulation of different types of transistor amplifiers on any circuit simulation software.

**Model Question paper**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

THIRD SEMESTER B.TECH DEGREE EXAMINATION, (**Model Question Paper)**

**Course Code: ECT202**

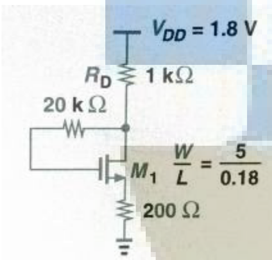
## Course Name: ANALOG CIRCUITS

Max. Marks: 100 Duration: 3 Hours

**PART A**

Answer ALL Questions. Each Carries 3 mark.

| | | | |
|---|---|---|---|
| 1 | Design the first order RC high pass filter with cut off frequency 2Kz. | 3 | K3 |
| 2 | Describe about the double ended clipping. | 3 | K2 |
| 3 | Differentiate between DC and AC load lines. | 3 | K2 |
| 4 | What is the significance of Miller effect on high frequency amplifiers? | 3 | K1 |
| 5 | What are the effects of cascading in gain and bandwidth of an amplifier? | 3 | K1 |
| 6 | Calculate the drain current if $\mu_n C_{ox} = 100\ \mu A/V^2$, $V_{TH} = 0.5V$ and $\lambda = 0$ in the following circuit. | 3 | K3 |



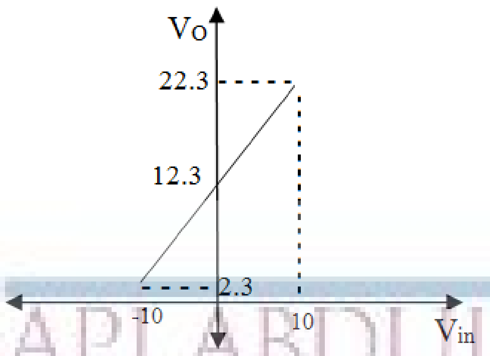

| | | | |
|---|---|---|---|
| 7 | Illustrate the effect of negative feedback on bandwidth and gain of the amplifier. | 3 | K2 |
| 8 | Explain the criteria for an oscillator to oscillate. | 3 | K1 |
| 9 | How to eliminate cross over distortion in class-B power amplifier? | 3 | K2 |
| 10 | What is line regulation and load regulation in the context of a voltage regulator? | 3 | K2 |

**PART – B**

Answer one question from each module; each question carries 14 marks.

**Module - I**

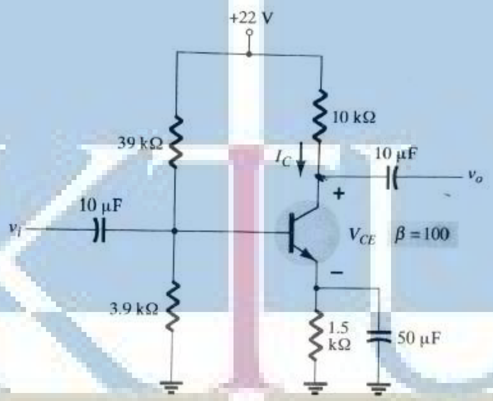
| | | | |
|---|---|---|---|
| 11 a | Design a differentiator circuit for a square wave signal with Vpp=10 and frequency 10KHz. | 6 | CO1 K3 |
| b. | Design a clamper circuit to get the following transfer characteristics, assuming voltage drop across the diodes 0.7V. | 8 | CO1 K3 |




**OR**

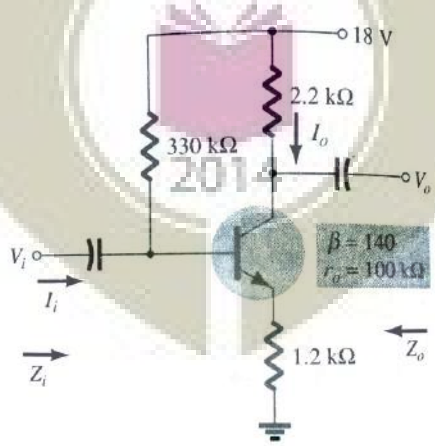
12 a Explain the working of an RC differentiator circuit for a square wave input with period T. Sketch its output waveform for RC ≫ T, RC ≪ T and RC = T. 5 K2 CO1

b. With reference to the following circuit, draw the load line and mark the Q point of the Silicon BJT transistor. 9 K3 CO2




## Module - II

13 For the following RC coupled amplifier determine $r_e$ , $Z_i$ , $Z_o$ and $A_v$ . 14 K3 CO2




**OR**

| | | | |
|---|---|---|---|
| 14 a | Draw the high frequency hybrid π model of BJT in CE configuration and explain the significance of each parameter. | 6 | K2 CO2 |
| b | Analyse BJT RC coupled amplifier in CE configuration at high frequency using hybrid π model. | 8 | K2 CO2 |

**Module - III**

| | | | |
|---|---|---|---|
| 15 a | Draw the circuit of a common source amplifier using MOSFET. Derive the expressions for voltage gain and input resistance from small signal equivalent circuit. | 7 | K2 CO2 |
| b. | How wide bandwidth is obtained in Cascode amplifier ? | 7 | K2 CO2 |

**OR**

| | | | |
|---|---|---|---|
| 16 | Draw the CS stage with current source load and deduce the expression for voltage gain of the amplifier | 14 | K3 CO2 |

**Module - IV**

| | | | |
|---|---|---|---|
| 17 | Give the block schematic of current-series feedback amplifier configuration and deduce the expression for gain, input impedance and output impedance with feedback. Design a practical circuit for this current-series feedback amplifier. | 14 | K3 CO2 |

**OR**

| | | | |
|---|---|---|---|
| 18 a | Design wein-bridge oscillator using BJT to generate 1KHz sine wave. | 8 | K3 CO3 |
| b | Explain the working principle of crystal oscillator | 6 | K2 CO3 |

**Module - V**

| | | | |
|---|---|---|---|
| 19 | Illustrate the working principle of complementary-symmetry class B power amplifiers and deduce the maximum efficiency of the circuit | 14 | K2 CO2 |

**OR**

| | | | |
|---|---|---|---|
| 20 | Design a discrete series voltage regulator with short circuit protection for regulated output voltage 10V and maximum current 100mA. | 14 | K3 CO3 |

# Simulation Assignments (ECT202)

The following simulations can be done in QUCS, KiCad or PSPICE.

1. Design and simulate a voltage series feedback amplifier based on BJT/ MOSFET. Observe the input and output signals. Plot the AC frequency response. Observe the Nyquits plot and understand its stability

2. Design and simulate a voltage shunt feedback amplifier based on BJT/ MOSFET. Observe the input and output signals. Plot the AC frequency response. Observe the Nyquits plot and understand its stability

3. Design and simulate series voltage regulator for output voltage $V_O = 10V$ and output current $I_O = 100mA$ with and without short circuit protection and to test the line and load regulations.

4. Design and simulate Wien bridge oscillator for a frequency of $5\,kHz$. Run a transient simulation and observe the output waveform.

5. Design and simulate Colpitts oscillator for a frequency of $455\,kHz$. Run a transient simulation and observe the output waveform.

6. Design and simulate a current series feedback amplifier based on BJT. Observe the input and output signals. Plot the AC frequency response. Observe the Nyquits plot and understand its stability

7. Design and simulate Hartley oscillator for a frequency of $455\,kHz$. Run a transient simulation and observe the output waveform.

8. Design and simulate clipping circuits that clips the $10\,V$ input sinusoid

   - at $+3.5\,V$ and at $-4.2\,V$
   - at $+2.5\,V$ and at $+4.2\,V$
   - at $-2.5\,V$ and at $-4.2\,V$

   with Si diodes

| ECT 204 | SIGNALS AND SYSTEMS | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PCC | 3 | 1 | 0 | 4 |

**Preamble:** This couse aims to lay the foundational aspects of signals and systems in both continuous time and discrete time, in preparation for more advanced subjects in digital signal processing, image processing, communication theory and control systems.

**Prerequisite:** Nil

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Apply properties of signals and systems to classify them |
| **CO 2** | Represent signals with the help of series and transforms |
| **CO 3** | Describe orthogonality of signals and convolution integral. |
| **CO 4** | Apply transfer function to compute the LTI response to input signals. |
| **CO 5** | Apply sampling theorem to discretize continuous time signals |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | |
| **CO 2** | 3 | 3 | 3 | | | | | | | | | |
| **CO 3** | 3 | 3 | 3 | | | | | | | | | |
| **CO 4** | 3 | 3 | | | | | | | | | | |
| **CO 5** | 3 | 3 | 3 | | | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 10 | 10 | 10 |
| Understand | 20 | 20 | 20 |
| Apply | 20 | 20 | 70 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total | CIE | ESE | ESE Duration |
|---|---|---|---|

| **Marks** | | | |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1) : Apply properties of signals and systems to classify them**

1. Check whether the following systems are stable, causal, linear, and time-invariant (a) y[n] = x[2n] (b) $y(t) = x^2(t) + 3$ (c) y[n] = nx[n]
2. Plot (a) u(t-1) + u(1-t) (b) u(t-1) – u(t+1) (c) sinc(t/T) (d) r(t) – r(t-2) – 2u(t-2)

**Course Outcome 2 (CO2) : Represent signals with the help of series and transforms**

1. Compute the Fourier transform of (a) x(t) = 1, -T/2 < t < T/2, and 0 elsewhere (b) x(t) = 1 - (|t|/T), -T < t < T, and 0 elsewhere
2. Show that a square wave has only odd harmonics.
3. State and prove Parsevals theorem

**Course Outcome 3 (CO3) : Describe orthogonality of signals and convolution integral.**

1. Show that δ(t-a) and δ(t-b), a ≠ b are orthogonal
2. Define convolution of x(t) and h(t)

**Course Outcome 4 (CO4) : Apply transfer function to compute the LTI response to input signals.**

1. Give the frequency response of a first-order low pass filter. What is the 3-dB cut off frequency?
2. What is the signficance of linear phase response?

**Course Outcome 5 (CO5) : Apply sampling theorem to discretize continuous time signals**

1. Derive the interpolation formula for finite-energy band-limited signals from its samples.

**SYLLABUS**

Elementary signals, Continuous time and Discrete time signals and systems, Signal operations, Differential equation representation, Difference equation representation, Continuous time LTI Systems, Discrete time LTI Systems, Correlation between signals, Orthogonality of signals, Frequency domain representation, Continuous time Fourier series, Continuous time Fourier transform, Using Laplace transform to characterize Transfer function, Stability and Causility using ROC of Transfer transform, Frequency response, Sampling, Aliasing, Z transform, Inverse Z transform, Unilateral Z-transform, Frequency domain representation of discrete time signals, Discrete time Fourier series and discrete time Fourier transform (DTFT), Analysis of discrete time LTI systems using the above transforms.

**Text Books**

1. Alan V. Oppenheim and Alan Willsky, Signals and Systems, PHI, 2/e, 2009

2. Simon Haykin, Signals & Systems, John Wiley, 2/e, 2003

**Reference Books**

1. Anand Kumar, Signals and Systems, PHI, 3/e, 2013.

2. B P. Lathi, Priciples of Signal Processing & Linear systems, Oxford University Press.

3. Gurung, Signals and System, PHI.

4. Mahmood Nahvi, Signals and System, Mc Graw Hill (India), 2015.

5. P Ramakrishna Rao, Shankar Prakriya, Signals and System, MC Graw Hill Edn 2013.

6. Rodger E. Ziemer, Signals & Systems - Continuous and Discrete, Pearson, 4/e, 2013

**Course Contents and Lecture Schedule**

| Module | Topic | Number of lecture hours |
|---|---|---|
| I | Elementary Signals, Classification and representation of continuous time and discrete time signals, Signal operations | 4 |
| | Continuous time and discrete time systems – Classification, Properties. | 3 |
| | Representation of systems: Differential equation representation of continuous time systems. Difference equation representation of discrete systems. | 2 |
| | Continuous time LTI systems and convolution integral. | 2 |

| | | |
|---|---|---|
| | Discrete time LTI systems and linear convolution. | 2 |
| | Stability and causality of LTI systems. | 2 |
| | Correlation between signals, Orthogonality of signals. | 1 |
| **II** | Frequency domain representation of continuous time signals - continuous time Fourier series and its properties. | 4 |
| | Continuous time Fourier transform and its properties. Convergence and Gibbs phenomenon | 3 |
| | Review of Laplace Transform, ROC of Transfer function, Properties of ROC, Stability and causality conditions. | 3 |
| | Relation between Fourier and Laplace transforms. | 1 |
| **III** | Analysis of LTI systems using Laplace and Fourier transforms. Concept of transfer function, Frequency response, Magnitude and phase response. | 4 |
| | Sampling of continuous time signals, Sampling theorem for lowpass signals, aliasing. | 3 |
| **IV** | Frequency domain representation of discrete time signals, Discrete time fourier series for discrete periodic signals. Properties of DTFS. | 4 |
| | Discrete time fourier transform (DTFT) and its properties. Analysis of discrete time LTI systems using DTFT. Magnitude and phase response. | 5 |
| **V** | Z transform, ROC , Inverse transform, properties, Unilateral Z transform. | 3 |
| | Relation between DTFT and Z-Transform, Analysis of discrete time LTI systems using Z transforms, Transfer function. Stability and causality using Z transform. | 4 |

# Simulation Assignments (ECT 204)

The following simulation assignments can be done with Python/MATLAB/ SCILAB/OCTAVE

1. Generate the following discrete signals
   - Impulse signal
   - Pulse signal and
   - Triangular signal
2. Write a function to compute the DTFT of a discrete energy signal. Test this function on a few signals and plot their magnitude and phase spectra.
3. 
   - Compute the linear convolution between the sequences $x = [1, 3, 5, 3]$ with $h = [2, 3, 5, 6]$. Observe the stem plot of both signals and the convolution.
   - Now let $h = [1, 2, 1]$ and $x = [2, 3, 5, 6, 7]$. Compute the convolution between $h$ and $x$.
   - Flip the signal $x$ by $180^\circ$ so that it becomes $[7, 6, 5, 3, 2]$. Convolve it with $h$. Compare the result with the previous result.
   - Repeat the above two steps with $h = [1, 2, 3, 2, 1]$ and $h = [1, 2, 3, 4, 5, 4, 3, 2, 1]$
   - Give your inference.
4. 
   - Write a function to generate a unit pulse signal as a summation of shifted unit impulse signals
   - Write a function to generate a triangular signal as a convolution between two pulse signals.
5. 
   - Relaize a continuous time LTI system with system response

$$H(s) = \frac{5(s+1)}{(s+2)(s+3)}$$

     . One may use *scipy.signal.lti* package in Python.
   - Make it into a discrete system (possibly with *scipy.signal.cont2discrete*)
   - Observe the step response in both cases and compare.

## Model Question Paper

# A P J Abdul Kalam Technological University

Fourth Semester B Tech Degree Examination

## Course: ECT 204 Signals and Systems

**Time: 3 Hrs** **Max. Marks: 100**

### PART A

*Answer All Questions*

| | | | |
|---|---|---|---|
| 1 | Differentiate between energy and power signal with example. | (3) | $K_2$ |
| 2 | Test if the signals $x_1[n] = [1, -2, 3, 1]$ and $x_2[n] = [-1, 2, 1, 2]$ are orthogonal. | (3) | $K_3$ |
| 3 | Compute the Fourier transform of $x(t) = \delta(t) + 0.5\delta(t-1)$ | (3) | $K_2$ |
| 4 | Write the Fourier series for $x(t) = A\cos 2\pi f_c t$ and use it to plot its line spectrum | (3) | $K_2$ |
| 5 | Explain the transfer function of an LTI system in the $s$- domain. | (3) | $K_1$ |
| 6 | What is the discrete frequency resulting when a $2\,kHz$ signal is sampled by an $8\,kHz$ sampling signals? | (3) | $K_2$ |
| 7 | Give three properties of the ROC pertaining to $Z$-transform. | (3) | $K_1$ |
| 8 | Compute the DTFT of $x[n] = \delta[n] - 2\delta[n-1] + 0.5\delta[n-3]$ | (3) | $K_3$ |
| 9 | Write the transfer function $H(z)$ of an LTI system described by $$y[n] = 0.3y[n-1] + 0.1y[n-2] + x[n] + 0.2x[n-1]$$ | (3) | $K_2$ |
| 10 | Give the relation between DTFT and $Z$ transform | (3) | $K_2$ |

### PART B

*Answer one question from each module. Each question carries 14 mark.*

**Module I**

| | | | |
|---|---|---|---|
| 11(A) | Test if the following systems are stable and time invariant<br>i. $y[n] = \cos x[n]$<br>ii. $y[n] = x[n] - x[n-1]$ | (8) | $K_3$ |
| 11(B) | Classify the following signals are energy and power signals<br>i. $x[n] = 0.8^n U[n]$<br>ii. $x[n] = U[n] - U[n-10]$<br>iii. $x[n] = \cos 2\pi f_0 n$ | (6) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 12(A) | Compute the convolution between $U[t] - U[t-5]$ with itself. | (7) | $K_3$ |
| 12(B) | Compute the output of the LTI system with input $x[n] = [1, -1, 2, -2]$ and impulse response $h[n] = [1, 2, 1]$ | (7) | $K_3$ |

**Module II**

| | | | |
|---|---|---|---|
| 13(A) | Compute the Fourier transform of the triangular signal $x(t) = A[1 - \frac{\lvert t\rvert}{T}]$ | (8) | $K_3$ |
| 13(B) | Compute the Fourier series of a half wave rectified sinusoid with period $T$ and amplitude $A$ | (6) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 14(A) | Compute the Laplace transforms of<br>i. $x(t) = 2e^{-t}U[t] + 0.5e^{-3t}U[t]$<br>i. $x(t) = 2e^{-3t} \cos 4tU[t]$ | (8) | $K_3$ |
| 14(B) | Compute the Fourier transform of a rectangukar pulse with unit amplitude and width $T$ and centred around origin. Plot the Fourier tranform in the frequency domain. | (6) | $K_3$ |

**Module III**

| | | | |
|---|---|---|---|
| 15(A) | Define sampling theorem. Determine the Nyquist rate and Nyquist interval for the signal $$x(t) = \cos \pi t + 3 \sin 2\pi t + \sin 4\pi t$$ | (6) | $K_2$ |
| 15(B) | Analyze and characterize the LTI system $x(t)$ using Laplace Transform $$x(t) = \frac{2}{3}e^{-t}u(t) + \frac{1}{3}e^{2t}u(t)$$ | (8) | $K_2$ |

**OR**

| | | | |
|---|---|---|---|
| 16(A) | Obtain the response of an LTI system with impulse response $h(t) = \delta(t)$ with input signal $x(t) = e^{-at}u(t)$ using Fourier transform | (6) | $K_2$ |
| 16(B) | Explain spectral aliasing and the need for anti-aliasing filter with an example spectrum | (8) | $K_2$ |

**Module IV**

| | | | |
|---|---|---|---|
| 17(A) | Describe the magnitude response and phase response of a discrete LTI system with the help of DTFTs. | (7) | $K_2$ |
| 17(B) | Compute the magnitude response of an LTI system described by $$y[n] = 0.1y[n-1] + 0.1y[n-3] + x[n] + 0.2x[n-1] + 0.1x[n-2]$$ in terms of the DTFTs | (7) | $K_2$ |

**OR**

| | | | |
|---|---|---|---|
| 18 | An LTI system has impulse response $h[n] = (\frac{1}{4})^n U[n]$. Use DTFT to compute the output for each of the following inputs: (i) $x[n] = (\frac{3}{4})^n U[n]$ (ii) $x[n] = (n+1)(\frac{1}{4})^n U[n]$ (iii) $x[n] = (-1)^n$. | (14) | $K_2$ |

## Module V

19(A) Compute the inverse $Z$ transform of (7) $K_3$

$$H(z) = \frac{1}{(1-\frac{1}{2}z^{-1})(1-\frac{1}{5}z^{-1})}$$

for all possible ROCs

19(B) Compute the inverse $Z$ transform of (7) $K_3$

$$H(z) = cos(\alpha z^{-1})$$

for all possible ROCs

**OR**

20 Compute the $Z$-transform with ROC of

i. $x[n] = (\frac{1}{3})^n U[n]$ (4) $K_3$

ii. $x[n] = n(\frac{1}{3})^n U[n]$ (5) $K_3$

iii. $x[n] = \sum_{i=-\infty}^{n} (\frac{1}{3})^i U[i]$ (5) $K_3$

| ECT 206 | COMPUTER ARCHITECTURE AND MICROCONTROLLERS* | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PCC | 3 | 1 | 0 | 4 |

**Preamble:** This course aims to impart knowledge of basic computer architecture and modern microcontrollers.

**Prerequisite:** ECT203 Logic Circuit Design

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Explain the functional units, I/O and memory management w.r.t a typical computer architecture. |
| **CO 2** | Distinguish between microprocessor and microcontroller. |
| **CO 3** | Develop simple programs using assembly language programming. |
| **CO 4** | Interface 8051 microcontroller with peripheral devices using ALP/Embedded C |
| **CO 5** | Familiarize system software and Advanced RISC Machine Architecture. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | | | | | | | | | | 3 |
| **CO 2** | 3 | | | | | | | | | | | 3 |
| **CO 3** | 3 | | 3 | | 3 | | | | | | | 3 |
| **CO 4** | 3 | 3 | 3 | | 3 | | | | | | | 3 |
| **CO 5** | 3 | | | | 3 | | | | | | | 3 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 10 | 10 | 10 |
| Understand | 20 | 20 | 20 |
| Apply | 20 | 20 | 70 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| **Total Marks** | **CIE** | **ESE** | **ESE Duration** |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

*Course project* : 15 marks

It is mandatory that a *course project* shall be undertaken by a student for this subject. The course project can be performed either as a hardware realization/simulation of a typical embedded system using Embedded C/ Assembly Language Programming. Instead of two assignments, two evaluations may be performed on the course project along with series tests, each carrying 5 marks. Upon successful completion of the project, a brief report shall be submitted by the student which shall be evaluated for 5 marks. The report has to be submitted for academic auditing. A few sample course projects are listed below:

**Sample Course Projects**

The below projects shall be done with the help of IDE for 8051/PIC/MSP/Arduino/Raspberry Pi-based interfacing boards/sensor modules.

1. Relay control
2. Distance measurement
3. Temperature measurement / Digital Thermometer
4. RF ID tags
5. Alphanumeric LCD display interface.
6. OLED display interfacing

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**SYLLABUS**

**Module 1: Computer Arithmetic and Processor Basics**

Algorithms for binary multiplication and division. Fixed and floating-point number representation. Functional units of a computer, Von Neumann and Harvard computer architectures, CISC and RISC architectures. Processor Architecture – General internal architecture, Address bus, Data bus, control bus. Register set – status register, accumulator, program counter, stack pointer, general purpose registers. Processor operation – instruction cycle, instruction fetch, instruction decode, instruction execute, timing response, instruction sequencing and execution (basic concepts, datapath.

**Module 2: 8051 Architecture**

Microcontrollers and Embedded Processors. Architecture – Block diagram of 8051, Pin configuration, Registers, Internal Memory, Timers, Port Structures, Interrupts. Assembly Language Programming - Addressing Modes, Instruction set (Detailed study of 8051 instruction set is required).

**Module 3: Programming and Interfacing of 8051**

Simple programming examples in assembly language. Interfacing with 8051 using Assembly language programming: LED, Seven segment LED display. Programming in C - Declaring variables, Simple examples – delay generation, port programming, code conversion.

Interfacing of – LCD display, Keyboard, Stepper Motor, DAC and ADC -- with 8051 and its programming.

**Module 4: Advanced Concepts**

8051 Timers/Counters - Modes and Applications. Serial Data Transfer – SFRs of serial port, working, Programming the 8051 to transfer data serially. Introduction to ARM - ARM family, ARM 7 register architecture. ARM programmer's model. System software - Assembler, Interpreter, Compiler, Linker, Loader, Debugger.

**Module 5: The Memory System**

Types of memory - RAM, ROM. Memory Characteristics and Hierarchy. Cache memory – The basics of Caches, Mapping techniques, Improving Cache performance. Virtual memory – Overlay, Memory management, Address translation. Input/Output Organization – Introduction, Synchronous vs. asynchronous I/O, Programmed I/O, Interrupt driven I/O, Direct Memory Access.

**Text Books**


1. Muhammed Ali Mazidi & Janice Gilli Mazidi, R.D. Kinley, The 8051 microcontroller and Embedded System, Pearson Education, 2nd edition.
2. Subrata Ghoshal, Computer Architecture and Organization: From 8085 to Core2Duo and beyond, Pearson, 2011.
3. Steve Furber, ARM System - on-chip Architecture, Pearson Education


**Reference Books**


1. Mano M M, Computer System Architecture, 3rd Ed, Prentice Hall of India.
2. Computer organization and design: The Hardware/Software interface/David A. Patterson, John L. Hennessy. — 5th ed.
3. Computer Organisation V. Carl Hamacher, Zvonko G. Vranesic, Safwat G.Zaky.
4. John P Hayes, Computer Architecture and Organization, McGraw Hill.
5. Ramesh S Goankar, 8085 Microprocessor Architecture, Applications and Programming, Penram International, 5/e.
6. The 8051 Microcontrollers: Architecture Programming and Applications, K Uma Rao & Andhe Pallavi, Pearson, 2011.
7. Stallings W., Computer Organisation and Architecture, 5/e, Pearson Education.


**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|

| | | |
|---|---|---|
| **1** | **Computer Arithmetic and Processor Basics** | |
| 1.1 | Algorithms for binary multiplication and division | 2 |
| 1.2 | Fixed- and floating-point number representation in computers. | 1 |
| 1.3 | Functional units of a computer, Von Neumann and Harvard computer architectures, CISC and RISC architectures. | 1 |
| 1.4 | Processor Architecture – General internal architecture, Address bus, Data bus, control bus. Register set – status register, accumulator, program counter, stack pointer, general purpose registers. | 2 |
| 1.5 | Processor operation – instruction cycle, instruction fetch, instruction decode, instruction execute, timing response, instruction sequencing and execution (basic concepts), data path | 3 |
| | . | |
| **2** | **8051 Architecture** | |
| 2.1 | Microcontrollers and Embedded Processors and Applications | 1 |
| 2.2 | Architecture – Block diagram of 8051, Pin configuration, Registers, Internal Memory, Timers, Port Structures, Interrupts. | 3 |
| 2.3 | Addressing Modes of 8051 | 1 |
| 2.4 | Instruction sets (Detailed study of 8051 instructions) | 4 |
| | | |
| **3** | **Programming and Interfacing of 8051** | |
| 3.1 | Simple programming examples in assembly language. | 2 |
| 3.2 | Interfacing programming in Assembly language | 2 |
| 3.3 | Programming in C - Declaring variables, Simple examples – delay generation, port programming, code conversion. | 3 |
| 3.4 | Interfacing of 7 segment LCD display | 1 |
| 3.5 | Interfacing of Keyboard and stepper motor | 2 |
| 3.6 | Interfacing of DAC and ADC | 2 |
| | | |
| **4** | **Advanced Concepts** | |
| 4.1 | 8051 Timers/Counters - Modes and Applications | 2 |
| 4.2 | Serial Data Transfer – SFRs of serial port, working, Programming the 8051 to transfer data serially | 2 |
| 4.3 | Introduction to ARM - ARM family, ARM 7 register architecture. ARM programmer's model | 2 |
| 4.4 | System software - Assembler, Interpreter, Compiler, Linker, Loader, Debugger. | 2 |
| | | |
| **5** | **Memory System** | |
| 5.1 | Types of memory - RAM, ROM. Memory Characteristics and Hierarchy | 2 |
| 5.2 | Cache memory – The basics of Caches, Mapping techniques, Improving Cache performance | 2 |
| 5.3 | Virtual memory – Overlay, Memory management, Address translation | 2 |
| 5. 4 | Input/Output Organization – Introduction, Synchronous vs. asynchronous I/O, Programmed I/O, Interrupt driven I/O, Direct Memory Access. | 3 |
| | | |

**Simulation assignments**

The following examples may be solved in C program

1. Program to convert the ASCII number into unpacked BCD.
2. Program to swap a number 0 x ab to 0 x ba, where a and b are hex digits.
3. Program to find the number of 1's in an 8-bit data item.
4. Program to display 'M' and 'E' on the LCD connected to 8051 using the BUSY FLAG.
5. Program to rotate a stepper motor $50^0$ in the clock wise direction.
6. Program to toggle pin P1.4 every second using interrupts for a frequency of 22 MHz. Use timer 1 in mode 1.
7. Program to generate a square wave of 1 kHz with duty cycle 33%. Use timer 1 in interrupt mode with a crystal frequency of 11.0592 MHz.

Model Question Paper

A P J Abdul Kalam Technological University

Fourth Semester B Tech Degree Examination

Branch: Electronics and Communication

Course: ECT 206 COMPUTER ARCHITECTURE AND MICROCONTROLLERS

Time: 3 Hrs Max. Marks: 100

Part – A

*Answer all questions. Questions carry **3 marks** each.*

1. Represent 4946.278941 as a 32 bit number in IEEE 754 format.

2. Which is more important for the functioning of a basic processor, Program Counter or Stack Pointer. Justify your answer.

3. List the components of 8051 microcontroller.

4. Write the operations happening in the following instructions:
   ADD A, 56
   XCHD A, @R1
   DJNZ R6, LABEL
   DIV AB
   XRL A, #0FFh
   JB P1.2 LABEL

5. Write an embedded C program for 8051 microcontroller to continously rotate a stepper motor clockwise.

6. Write an embedded C program for 8051 microcontroller to blink P2.5 every 2 seconds

7. List the different modes and give corresponding uses of timers in 8051 microcontroller

8. Which are the SFRs used for serial communication in 8051 microcontroller. Give there functions.

9. Illustrate the memory hierarchy in a computer system.

10. Is ROM a random access memory? Justify your answer.

**Part – B**

*Answer one question each from all modules*

**Module – 1**

11. a) With an example explain the “shift and add” algorithm for multiplying two binary numbers. (5 marks)

    b) With relevant diagrams illustrate the functioning of a basic (non – pipelined) processor. (9 marks)

**OR**

12. a) Differentiate RISC and CISC architectures. (4 marks)

    b) Explain Instruction Cycle with a sample timing diagram (10 marks)

**Module – 2**

13. a) Illustrate the complete memory organisation of 8051 microcontroller (10 marks)

    b) Differentiate microprocessors and microcontrollers. (4 marks)

**OR**

14. a) Explain about the Addressing Modes of 8051 microcontroller with examples. (7 marks)

    b) Describe the classification of the Instruction Set of 8051 microcontroller with examples. (7 marks)

**Module – 3**

15. a) Write an embedded C program for 8051 microcontroller to read an analogue signal from an ADC and reproduce the same using a DAC (9 marks)

    b) Write an assembly language program for 8051 microcontroller to sort N number in ascending order. Assume that the numbers are stored in continuous locations starting from 0x4321 onwards. (5 marks)

**OR**

16. a) Write an embedded C program for 8051 microcontroller to repeatedly display the sequence 1,5,8,0,2,6,4,9,3,7 using a 7 – segment display with a delay of 1.5 seconds between each number. (9 marks)

    b) Write an assembly language program for 8051 microcontroller to find the cube of an 8 – bit number (5 marks)

**Module – 4**

17. a) Assume a switch is connected to pin PL7. Write a embedded C program for 8051 microcontroller to monitor its status and
    send two messages to serial port continuously as follows:
    SW=0 send “NO”
    SW=1 send “YES”
    Assume XTAL = 11.0592 MHz, 9600 baud, 8-bit data, and 1 stop bit. (10 marks)

    b) Describe the ARM 7 register architecture (4 marks)

**OR**

18. a) Write a embedded C program for 8051 microcontroller to send the message "Hello World !" to serial port. Assume a SW is connected to pin P1.2. Monitor its status and set the baud rate as follows:
SW = 0 , 4800 baud rate
SW = 1 , 9600 baud rate
Assume XTAL = 11.0592 Mhz, 8 – bit data, and 1 stop bit (10 marks)
b) Explain how a HLL program is executed as machine language in a processor (4 marks)

**Module – 5**

19. a) Differentiate synchronous and asynchronous I/O.
Which is more efficient with respect to processor utilisation? Justify your answer (8 marks)
b) Explain direct mapping of cache memory with an example (6 marks)

**OR**

20. a) Differentiate interrupt driven and programmed I/O.
Which is more efficient with respect to processor utilisation? Justify your answer (8 marks)
b) Explain about memory management using virtual memory. (6 marks)

| ECL 202 | ANALOG CIRCUITS AND SIMULATION LAB | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PCC | 0 | 0 | 3 | 2 |

**Preamble:** This course aims to

(i) familiarize students with the Analog Circuits Design through the implementation of basic Analog Circuits using discrete components.

(ii) familiarize students with simulation of basic Analog Circuits.

**Prerequisite:** Nil

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Design and demonstrate the functioning of basic analog circuits using discrete components. |
| **CO 2** | Design and simulate the functioning of basic analog circuits using simulation tools. |
| **CO 3** | Function effectively as an individual and in a team to accomplish the given task. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | | | | | | 2 | | | 2 |
| **CO 2** | 3 | 3 | 3 | | 3 | | | | 2 | | | 2 |
| **CO 3** | 3 | 3 | 3 | | | | | | 3 | | | 3 |

**Assessment**

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 75 | 75 | 2.5 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test (Immediately before the second series test) : 30 marks

**End Semester Examination Pattern:** The following guidelines should be followed regarding award of marks

| | |
|---|---|
| (a) Preliminary work | : 15 Marks |
| (b) Implementing the work/Conducting the experiment | : 10 Marks |
| (c) Performance, result and inference (usage of equipments and trouble shooting) | : 25 Marks |
| (d) Viva voce | : 20 marks |
| (e) Record | : 5 Marks |

**General instructions:** End-semester practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the examination only on submitting the duly certified record. The external examiner shall endorse the record.

**Part A : List of Experiments using discrete components [Any Six experiments mandatory]**

1. RC integrating and differentiating circuits (Transient analysis with different inputs and frequency response)
2. Clipping and clamping circuits (Transients and transfer characteristics)
3. RC coupled CE amplifier - frequency response characteristics
4. MOSFET amplifier (CS) - frequency response characteristics
5. Cascade amplifier – gain and frequency response
6. Cascode amplifier -frequency response
7. Feedback amplifiers (current series, voltage series) - gain and frequency response
8. Low frequency oscillators –RC phase shift or Wien bridge
9. Power amplifiers (transformer less) - Class B and Class AB
10. Transistor series voltage regulator (load and line regulation)

**PART B: Simulation experiments [Any Six experiments mandatory]**

The experiments shall be conducted using open tools such as QUCS, KiCad or variants of SPICE.

1. RC integrating and differentiating circuits (Transient analysis with different inputs and frequency response)
2. Clipping and clamping circuits (Transients and transfer characteristics)
3. RC coupled CE amplifier - frequency response characteristics
4. MOSFET amplifier (CS) - frequency response characteristics
5. Cascade amplifier – gain and frequency response
6. Cascode amplifier – frequency response

7. Feedback amplifiers (current series, voltage series) - gain and frequency response
8. Low frequency oscillators – RC phase shift or Wien bridge
9. Power amplifiers (transformer less) - Class B and Class AB
10. Transistor series voltage regulator (load and line regulation)

| ECL 204 | MICROCONTROLLER LAB | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PCC | 0 | 0 | 3 | 2 |

**Preamble:** This course aims to

(i) Familiarize the students with Assembly Language Programming of modern microcontrollers.

(ii) Impart the skills for interfacing the microcontroller with the help of Embedded C/Assembly Language Programming.

**Prerequisite**: Nil

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Write an Assembly language program/Embedded C program for performing data manipulation. |
| **CO 2** | Develop ALP/Embedded C Programs to interface microcontroller with peripherals |
| **CO 3** | Perform programming/interfacing experiments with IDE for modern microcontrollers. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | 3 | | 3 | | | | 3 | | | 3 |
| **CO 2** | 3 | | 3 | 2 | 3 | | | | 3 | | | 3 |
| **CO 3** | 3 | | 3 | 3 | 3 | 3 | | | 3 | | 3 | 3 |

**Assessment**

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 75 | 75 | 2.5 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test (Immediately before the second series test) : 30 marks

**End Semester Examination Pattern:** The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks
(b) Implementing the work/Conducting the experiment : 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting) : 25 Marks
(d) Viva voce : 20 marks

(e) Record : 5 Marks

**General instructions:** End-semester practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the examination only on submitting the duly certified record. The external examiner shall endorse the record.

**PART – A (At least 6 experiments are mandatory)**

These experiments shall be performed using 8051 trainer kit. The programs shall be written either in embedded C or in assembly language.

1. Data transfer/exchange between specified memory locations.
2. Largest/smallest from a series.
3. Sorting (Ascending/Descending) of data.
4. Addition / subtraction / multiplication / division of 8/16 bit data.
5. Sum of a series of 8 bit data.
6. Multiplication by shift and add method.
7. Square / cube / square root of 8 bit data.
8. Matrix addition.
9. LCM and HCF of two 8 bit numbers.
10. Code conversion – Hex to Decimal/ASCII to Decimal and vice versa.

**PART – B (At least 4 experiments are mandatory.)**

Interfacing experiments shall be done using modern microcontrollers such as 8051 or ARM. The interfacing modules may be developed using Embedded C.

1. Time delay generation and relay interface.
2. Display (LED/Seven segments/LCD) and keyboard interface.
3. ADC interface.
4. DAC interface with wave form generation.
5. Stepper motor and DC motor interface.
6. Realization of Boolean expression through port.

# SEMESTER -4

# MINOR

| ECT282 | Microcontrollers | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | Minor | 3 | 1 | 0 | 4 |

**Preamble:** This course aims to impart the overview of a microcontroller-based system design and interfacing techniques.

**Prerequisite**: Nil

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1 K2** | Explain the building blocks of a typical microcomputer/microcontroller system |
| **CO 2 K2** | Familiarize the instruction set of 8051 and perform assembly language programming |
| **CO 3 K3** | Interface the various peripheral devices to the microcontroller using assembly/ C programming |
| **CO4 K3** | Realize external communication interface to the microcontroller |
| **CO5 K2** | Familiarize the building blocks of RISC Processors and ARM microcontrollers |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | | | | | | | | | | 2 |
| **CO 2** | 3 | | | | 3 | | | | | | | 2 |
| **CO 3** | 3 | 2 | 3 | | 3 | | | | | | | 2 |
| **CO 4** | 3 | 2 | 3 | | 3 | | | | | | | 2 |
| **CO5** | 3 | | | | | | | | | | | 2 |

**Assessment Pattern**

| Bloom's Category | | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|---|
| | | 1 | 2 | |
| Remember | K1 | 10 | 10 | 10 |
| Understand | K2 | 20 | 20 | 20 |
| Apply | K3 | 20 | 20 | 70 |
| Analyse | | | | |
| Evaluate | | | | |
| Create | | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.



## Syllabus

**Module 1: Computer Arithmetic and Processor Basics**

Functional units of a computer, Von Neumann and Harvard computer architectures. Processor Architecture – General internal architecture, Address bus, Data bus, control bus. Register set – status register, accumulator, program counter, stack pointer, general purpose registers. Processor operation – instruction cycle, instruction fetch, instruction decode, instruction execute.

**Module 2: 8051 Architecture**

Architecture – Block diagram of 8051, Pin configuration, Registers, Internal Memory, Timers, Port Structures, Interrupts. Addressing Modes, Instruction set (brief study of 8051 instruction set is sufficient).

**Module 3: Programming and Interfacing of 8051**

Simple programming examples in assembly language: Addition, Subtraction, Multiplication and Division. Interfacing of LCD display, Keyboard, Stepper Motor, DAC and ADC with 8051.

**Module 4: Open Source Embedded Development Boards**

Introduction. ATmega2560 microcontroller- Block diagram and pin description. Arduino Mega **256** board – Introduction and pin description. Simple Applications - Solar Tracker, 4-Digit 7-Segment LED Display, Tilt Sensor, Home Security Alarm System, Digital Thermometer, IoT applications.

**Module 5: ARM Based System**

Introduction - ARM family, ARM 7 register architecture, ARM programmer's model. Raspberry pi 4 board – Introduction and brief description. Applications - Portable Bluetooth speaker, Remote-controlled car, Photo Booth, IoT weather station, Home automation centre, Portable Digital eBook Library.

**Text Books**


1. Computer Architecture and Organization: From 8085 to Core2Duo and beyond, Subrata Ghoshal, Pearson, 2011.

2. The 8051 microcontroller and Embedded System, Muhammed Ali Mazidi & Janice Gilli Mazidi, R.D. Kinley, Pearson Education, 2$^{nd}$ edition.


**Reference Books**


1. The 8051 Microcontrollers: Architecture Programming and Applications, K Uma Rao & Andhe Pallavi, Pearson, 2011.

2. ARM System - on-chip Architecture, Steve Furber, Pearson Education

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Computer Arithmetic and Processor Basics** | |
| 1.1 | Functional units of a computer, Von Neumann and Harvard computer architectures | 2 |
| 1.2 | Processor Architecture – General internal architecture | 1 |
| 1.3 | Address bus, Data bus, control bus | 1 |
| 1.4 | Register set – status register, accumulator, program counter, stack pointer, general purpose registers. | 2 |
| 1.5 | Processor operation – instruction cycle, instruction fetch, instruction decode, instruction execute | 3 |
| | | |
| **2** | **8051 Architecture** | |
| 2.1 | Architecture – Block diagram of 8051 | 1 |
| 2.2 | Pin configuration, Registers, Internal Memory, Timers, Port Structures, Interrupts. | 3 |
| 2.3 | Addressing Modes of 8051 | 1 |
| 2.4 | Instruction sets (brief study of 8051 instructions) | 4 |
| | | |
| **3** | **Programming and Interfacing of 8051** | |
| 3.1 | Simple programming examples in assembly language | 1 |
| 3.2 | Addition, Subtraction, Multiplication and Division | 2 |
| 3.3 | Interfacing of 7 segment LCD display | 1 |
| 3.4 | Interfacing of Keyboard and stepper motor | 2 |
| 3.5 | Interfacing of DAC and ADC | 3 |
| | | |
| **4** | **Open Source Embedded Development Boards** | |
| 4.1 | Introduction to open source boards | 1 |
| 4.2 | ATmega2560 microcontroller- Block diagram and pin description | 3 |
| 4.3 | Arduino Mega **256** board – Introduction and pin description | 2 |
| 4.4 | Simple Applications - Solar Tracker, 4-Digit 7-Segment LED Display, Tilt Sensor, Home Security Alarm System, Digital Thermometer, IoT applications | 3 |
| | | |
| **5** | **ARM Based System** | |

| | | |
|---|---|---|
| 5.1 | Introduction - ARM family, ARM 7 register architecture, ARM programmer's model | 3 |
| 5.2 | Raspberry pi 4 board – Introduction and brief description | 2 |
| 5.3 | Applications - Portable Bluetooth speaker, Remote-controlled car, Photo Booth, IoT weather station, Home automation centre, Portable Digital eBook Library | 4 |
| | | |

**MODEL QUESTION PAPER**

| | | | **Total Pages: 2** |
|---|---|---|---|
| Reg No.:_______________ | | | Name:__________________________ |

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

THIRD SEMESTER B.TECH DEGREE EXAMINATION, ____________ 20__

**Course Code: ECT 282**

**Course Name: MICROCONTROLLERS**

Max. Marks: 100 | Duration: 3 Hours

**PART A**

| | | Marks |
|---|---|---|
| | ***Answer all questions; each question carries 3 marks.*** | |
| 1 | Distinguish between Harvard and Von-Neumann architecture. | (3) |
| 2 | Write down the control signal for a register transfer. | (3) |
| 3 | Explain the concept of memory banks in 8051. | (3) |
| 4 | Mention the difference between AJMP, LJMP and SJMP instructions. | (3) |
| 5 | Write a program to multiply two 8 bit numbers from external memory in 8051microcontroller | (3) |
| 6 | Explain the format of SCON special function register. | (3) |
| 7 | Discuss the features of ARM processor. | (3) |
| 8 | How do you interface an ADC with 8051? | (3) |
| 9 | List 5 main features of Atmega 2560 microcontroller | (3) |
| 10 | Give 5 features of ARM processors. | (3) |

**PART B**

***Answer one question from each module; each question carries 14 marks.***

| | | | |
|---|---|---|---|
| | | **Module 1** | |
| 1 | a) | Explain the different stages of microprocessor operations. | (6) |
| | b) | Explain the role of different buses in a processor architecture. | (8) |
| | | **OR** | |
| 2 | a) | Explain the data path for branch execution showing all control signals and sequences. | (6) |
| | b) | Explain the function of following registers: status register, accumulator, program counter, stack pointer, general purpose registers. | (8) |
| | | **Module 2** | |
| 3 | a) | Draw the circuit diagram of port 1 and port 2 and describe their operation briefly. | (8) |
| | b) | Explain the internal architecture of 8051 microcontroller with a block diagram. | (6) |
| | | **OR** | |
| 4 | a) | Briefly explain the following instructions of 8051: (i) MOV A, @Ri (ii) PUSH direct (iii) XCH A, Rn (iv) DAA | (8) |
| | b) | Explain the addressing modes of 8051. | (6) |
| | | **Module 3** | |
| 5 | a) | Write an ALP to find the sum of an array of 8 bit numbers stored in the | (8) |

| | | | |
|---|---|---|---|
| | | external memory of an 8051 microcontroller. | |
| | b) | How a DAC can be interfaced to 8051? Explain. | (6) |
| | | **OR** | |
| 6 | a) | Write an ALP to add two 16 bit numbers, stored in consecutive locations in the external memory of an 8051 microcontrollers. | (8) |
| | b) | Explain the interfacing of LCD display with suitable schematic. | (6) |
| | | **Module 4** | |
| 7 | a) | Explain the pin configuration of Arduino MEGA 256 board using a schematic diagram | (14) |
| | | **OR** | |
| 8 | a) | Write short note on open source boards. | (5) |
| | b) | Explain the working of a four digit 7 segment LED display using an open source board. | (9) |
| | | **Module 5** | |
| 9 | a) | Draw the ARM-7 register architecture and explain. | (7) |
| | b) | Draw and explain the programming model of an ARM processor. | (7) |
| | | **OR** | |
| 10 | a) | Explain the features of a Raspberry pi -4 board. | (8) |
| | b) | Explain any one application using Raspberry pi -4 board and draw a schematic. | (6) |
| | | **** | |

| ECT284 | DIGITAL COMMUNICATION | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | Minor | 3 | 1 | 0 | 4 |

**Preamble:** This course aims to apply the concepts of probability and random processes in communication systems.

**Prerequisite**: ECT 253 Analog communication

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Explain the main components in a digital communication system |
| **CO 2** | Explain the source coding schemes |
| **CO 3** | Explain codes for signaling |
| **CO 4** | Apply the knowledge of digital modulation schemes in digital transmission. |
| **CO 5** | Apply channel coding in digital transmission |
| **CO 6** | Explain digital receivers |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | |
| **CO 2** | 3 | 3 | | 3 | | | | | | | | |
| **CO 3** | 3 | 3 | | 3 | | | | | | | | |
| **CO 4** | 3 | 3 | | | 2 | | | | | | | |
| **CO 5** | 3 | 3 | | 3 | | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 10 | 10 | 20 |
| Understand | 30 | 30 | 60 |
| Apply | 10 | 10 | 20 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1): Main components in digital communication system**
1. Draw the block diagram of a digital communication system and explain the blocks.
2. Compare and contrast analog communication system with a digital system. List the advantages of the latter.

**Course Outcome 2 (CO2): Source Coding**
1. Draw the block diagram of a linear PCM system and explain the functions of all blocks.
2. Explain the a-law and mu-law quantization
3. State sampling theorem and explain the reconstruction of signals

**Course Outcome 3 (CO3): Signaling Code**
1. Explain the principle of alternate mark inversion coding. Give an example with an arbitrary binary data pattern
2. Explain B3ZS code. Give an example with an arbitrary binary data pattern

**Course Outcome 4 (CO4): Apply the knowledge of digital modulation schemes in digital transmission.**
1. Explain the BPSK transmitter and receiver. Apply its principle to draw the output waveform of a BPSK transmitter that is fed with the bit pattern {1,0,0,1,1,00}.
2. Explain a baseband BPSK system. Give its probability of error. Draw the BER-SNR curve
3. Explain the QPSK transmitter and receiver. Apply its principle to draw the output waveform of a QPSK transmitter that is fed with the bit pattern {1,0,0,1,1,00}.

**Course Outcome 5 (CO5): Digital Receivers**
1. Explain encoding and decoding with (7,4) block codes
2. Explain the working of a matched filter receiver. Draw the BER-SNR curve at the output.
3. Explain Cyclic codes with an example.

## SYLLABUS

**Module 1: Linear Source Coding [1]**
Elements of digital communication system. Sources, channels and receivers. Classification of communication channels. Discrete sources. Source coding techniques. Waveform coding methods. Sampling theorem. Sampling and reconstruction. Pulse code modulation. Sampling, quantization and encoding. Different quantizers. A-law and mu-law quantization. Practical 15 level mu and A law encoding.

**Module 2: Nonlinear Source Coding [1,2]**
Differential PCM, adaptive PCM, Delta modulator and adaptive delta modulator. Issues in delta modulation. Slope overload.

**Module 3: Signaling Codes in Telephony [1]**
Signalling codes in digital telephony. T1 signalling system. AMI and Manchester codes. Binary N-zero substitution, B3ZS code, B6ZS code.

**Module 4: Digital Modulation Schemes [1,2]**
Digital modulation schemes. Baseband BPSK system and the signal constellation. BPSK transmitter and receiver. Base band QPSK system and Signal constellations. Plots of BER Vs SNR (Analysis not required). QPSK transmitter and receiver. Quadrature amplitude modulation.

**Module 5: Channel Coding and Receivers [1,2]**
Transmission through AWGN Channel. Capacity of an AWGN channel. Receivers. Correlation and matched filter receiver. Channel coding schemes. Repetition code. Block codes Cyclic codes.

**Text Books**

1. John C. Bellamy, "Digital Telephony",Wiley
2. Simon Haykin, "Communication Systems", Wiley.
3. Sklar, "Digital Communications: Fundamentals and Applications", Pearson.


**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Linear Source Coding** | |
| 1.1 | Block diagram of digital communication system, Sorces, channel and receivers. Classification of Channels | 2 |
| 1.2 | Source coding , waveform coding , sampling and reconstruction | 2 |
| 1.3 | PCM, Compression, 15 level A and mu-law coding | 4 |
| 1.4 | Uniform and Gaussian Pdf and correspoding CDF. Properties | 1 |
| | | |
| **2** | **Nonlinear Source Coding** | |
| 2.1 | DPCM,Adaptive DPCM | 4 |
| 2.2 | Delta modulation, slope overload | 3 |
| **3** | **Signaling Codes** | |
| 3.1 | Overview of T1 signaling systems. Need for signaling codes, AMI and Manchestre codes | 4 |
| 3.2 | Binary N-zero substitution, B3ZS code, B6ZS code | 3 |
| 3.5 | Mutual information and channel capacity. Capacity of AWGN channel | 2 |
| **4** | **Digital Modulation** | |
| 4.1 | Need of digital modulation in modern communication. | 1 |
| 4.2 | Baseband BPSK system, signal constellation. Effect of AWGN, probability of error. BER-SNR curve, BPSK transmitter and receiver. | 4 |
| 4.3 | Baseband QPSK system, signal constellation. Effect of AWGN, probability of error. BER-SNR curve, QPSK transmitter and receiver. | 4 |
| 4.4 | QAM system | 2 |
| **5** | **Channel Coding and Receivers** | |
| 5.1 | Mutual information and channel capacity | 2 |
| 5.2 | Correlation and matched filter receiver, BER-SNR curve | 2 |
| 5.3 | Channel coding schemes. Repetition code. Block codes. Cyclic codes | 5 |

# Simulation Assignments

The following simulations can be done in MATLAB, Python,R or LabVIEW.

**A-Law and $\mu$-Law Characteristics**

- Create a vector with say 1000 points that spans from $-1$ to 1.
- Apply A-Law companding on this vector get another vector. Plot it against the first vector for different A values and appreciate the transfer characteristics.
- Repeat the above steps for $\mu$-law as well.

**Practical A-Law compander**

- Implement the 8-bit practical A-law coder and decoder in Appendix B 2 (pp 583–585) in *Digital Telephony by Bellamy*
- Test it with random numbers and speech signals. Observe the 15 levels of quantization.

**Practical $\mu$-Law compander**

- Implement the 8-bit practical $\mu$-law coder and decoder in Appendix B 1 (pp 579–581) in *Digital Telephony by Bellamy*
- Test it with random numbers and speech signals. Observe the 15 levels of quantization.

**B3ZS Encoder and Decoder**

- Implenet a B3ZS encoder and decoder.
- Test it with random bits.
- Decode and compare the result with the original bit pattern.

**B6ZS Encoder and Decoder**

- Implenet a B6ZS encoder and decoder.
- Test it with random binary vector.
- Decode and compare the result with the original bit pattern.

**Base Band BPSK System**

- Cretae a random binary sequence of 5000 bit. Convert it into a bipolar NRZ code.
- Create a BPSK mapper that maps bit 0 to zero phase and bit 1 to $\pi$ phase.
- Plot the real part of the mapped signal against the imaginary part to observe the signal constellation
- Add AWGN of difference variances to the base band BPSK signal and observe the changes in constellation.
- Realize the BPSK transmitter and receiver in Fig. 6.4 in pager 352 in *Communication Systems by Simon Haykin* .
- Add AWGN of different variances and compute the bit error rate (BER) for different SNR values.
- Plot the BER Vs. SNR.
- Plot the theoretical BER-SNR curve, using Eq. 6.19 in pager 351 in *Communication Systems by Simon Haykin* .

**Model Question Paper**

# A P J Abdul Kalam Technological University

Fourth Semester B Tech Degree Examination

## Course: ECT 284 Digital Communication

**Time: 3 Hrs** **Max. Marks: 100**

### PART A

*Answer All Questions*

| | | | |
|---|---|---|---|
| 1 | State sampling theorem | (3) | $K_2$ |
| 2 | Give the classification of communication channels | (3) | $K_2$ |
| 3 | Explain the term slope overload | (3) | $K_2$ |
| 4 | Why is a logarithmic quantizer preferred in DPCM? | (3) | $K_2$ |
| 5 | Explain the needs for signalling codes | (3) | $K_1$ |
| 6 | Draw the Manchester code for the bit pattern $\{1,0,1,1,0,0\}$ | (3) | $K_3$ |
| 7 | Draw the BER-SNR curve for a BPSK system | (3) | $K_2$ |
| 8 | Draw the signal constellation for a baseband QPSK system | (3) | $K_2$ |
| 9 | Define mutual information and channel capacity | (3) | $K_2$ |
| 10 | Explain a (7,4) block code. | (3) | $K_2$ |

### PART B

*Answer one question from each module. Each question carries 14 mark.*

#### Module I

| | | | |
|---|---|---|---|
| 11(A) | Draw the block diagram of a linear PCM system and explain the blocks | (8) | $K_2$ |
| 11(B) | Explain $\mu$-law companding | (6) | $K_2$ |

**OR**

| | | | |
|---|---|---|---|
| 12(A) | Explain how companding is achieved practically using different levels | (8) | $K_2$ |

| | | | |
|---|---|---|---|
| 12(B) | Explain mid-rise and mid-tread quantizers | (6) | $K_2$ |

**Module II**

| | | | |
|---|---|---|---|
| 13(A) | Explain the need for differential PCM. What is the advantage over linear PCM | (6) | $K_2$ |
| 13(B) | Draw the block diagram of a DPCM transmitter and receiver and explain the functions of ech block. | (8) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 14(A) | Draw the block diagram of a delta modulator and explain the functions of each block | (8) | $K_2$ |
| 14(B) | Explain the principle of adaptive delta modulation | (6) | $K_2$ |

**Module III**

| | | | |
|---|---|---|---|
| 15(A) | What is binary zero substitution? Explain the B3ZS line coding scheme | (8) | $K_2$ |
| 15(B) | Encode {101000010000000001} using B3ZS code | (6) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 16(A) | Explain the principle of alternate mark inversion coding. Give an example with an arbitrary binary data pattern | (8) | $K_2$ |
| 16(B) | Encode {101000010000000001} using B6ZS code | (6) | $K_3$ |

**Module IV**

| | | | |
|---|---|---|---|
| 17(A) | Draw the block diagram of BPSK transmitter and receiver and explain the functions of each block. Draw the BER-SNR curve. | (8) | $K_2$ |
| 17(B) | Draw the signal constellation of base band BPSK and indicate the effect of AWGN on it | (6) | $K_2$ |

**OR**

| | | | |
|---|---|---|---|
| 18(A) | Draw the block diagram of QPSK transmitter and receiver and explain the functions of each block. Draw the BER-SNR curve. | (8) | $K_2$ |
| 18(B) | Explain the QAM modulation and demodulation. | (6) | $K_2$ |

**Module V**

| | | | |
|---|---|---|---|
| 19(A) | Explain how matched filter is used in digital reception? Draw the BER-SNR curve at the output. | (8) | $K_3$ |
| 19(B) | Explain how correlation receiver is used in digital reception? | (6) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 20 | Explain channel encoding and decoding with (7,4) block codes | (14) | $K_3$ |

| ECT286 | INTRODUCTION TO DIGITAL SIGNAL PROCESSING | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | Minor | 3 | 1 | 0 | 4 |

**Preamble:** This course aims to give an introduction to digital signal processing

**Prerequisite**: ECT255 Introduction to Signals and Systems

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Explain how digital signals are obtained from continuous time signals. |
| **CO 2** | Apply Fourier transform in the analysis of signals |
| **CO 3** | Implement digital filters |
| **CO 4** | Explain the practical limitations in DSP implementations |
| **CO 5** | Explain the structure of a DSP processor. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 1 | | | | | | | | | | |
| **CO 2** | 3 | 3 | 2 | 2 | 3 | | | | 3 | | | 1 |
| **CO 3** | 3 | 2 | 3 | 3 | 3 | | | | 3 | | | |
| **CO 4** | 3 | 1 | | | | | | | | | | |
| **CO 5** | 3 | 1 | | | 1 | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 10 | 10 | 20 |
| Understand | 25 | 25 | 50 |
| Apply | 15 | 15 | 30 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1): Discrete Signals and Sampling Theorem**

1. Define a digital signal. Give the frequency range of digital signal. Explain the sampling theorem and show graphically how samples are generated from a continuous time signal.

2. What should be the minimum frequency to sample a 2.5kHz analog signal? Explain graphically how the continuous time signal is reconstructed from samples.

**Course Outcome 2 (CO2): Application of Fourier Transform**

1. Give the expression for DFT of an N-point sequence. Compute the 10 point DFT of a unit impulse sequence.

2. Derive the raddix-2 decimation in time algorithm for N=8.

**Course Outcome 3 (CO3): Implementation of Digital Filters**

1. Give the difference equation of an IIR filter. Give an example and draw its structure

2. Design an IIR Butterworth filter for passband frequency 5kHz and stopband frequency 10kHz. The stop band and passs band attenuations are 0.1 respectively.

**Course Outcome 4 (CO4): Practical Limitations of Digital Filters**

1(A). Explain the limit cycle oscillations in IIR filters

(B) Explain the effects of coefficient quantization in IIR filters

2. (A) Explain the effects of round of noise in digital filters
2(B) Explain the fixed and floating point arithmetic used in DSP processors.

**Course Outcome 5 (CO5): Structure of Digital Signal Processors**

1(A). Explain the function of the MAC unit in a DSP

(B) Explain the differences between Harvard and Von Neumann architecture.

2. Draw the internal structure of a floating point processor and explain its functional blocks

# Syllabus

**Module 1: Signal Processing Fundamentals**
Discrete-time and digital signals. Basic elements of digital processing system- ADC, DAC and Nyquist rate. Frequency aliasing due to sampling. Need for anti-aliasing filters. Discrete Time Fourier Transforms – Properties. Computation of spectrum.

**Module 2: Discrete Fourier Transform – Properties and Application**
Discrete Fourier transform - DFT as a linear transformation, Properties - circular convolution. Filtering of long data sequences - FFT-Radix-2 DIT and DIF algorithms. Computational complexity of DFT and FFT -application.

**Module 3: Digital Filters**
Digital FIR Filter: Transfer function - Difference equation, Linear phase FIR filter, Concept of windowing, Direct form and cascade realization of FIR and IIR filters. Digital IIR Filters - Transfer function, Difference equation. Direct and parallel Structures. Design of analogue Butterworth filters, Analog frequency transformations, Impulse invariance method. Bilinear transformation, Analog prototype to digital transformations.

**Module 5: Finite word length effects in digital filters and DSP Hardware**
Fixed point arithmetic, Floating point arithmetic, Truncation and Rounding, Quantization error in ADC, Overflow error, Product round off error, Scaling , Limit cycle oscillation.

General and special purpose hardware for DSP: Computer architectures for DSP – Harvard, pipelining, MAC, special instruction, replication, on chip cache. General purpose digital signal processors (TMS 320 family) - Implementation of digital filtering on dsp processor. Special purpose DSP hardware

**Text Books**
1. Proakis, J.G. & Manolakis, D.G., "Digital Signal Processing: Principles, Algorithms,& Applications", 3/e Prentice Hall of India, 1996.
2. Ifeachor, E.C., & Jervis, B.W., "Digital Signal Processing: A Practical Approach",2/e, Pearson Education Asia, 2002.
3. Chen, C.T., "Digital Signal Processing: Spectral Computation & Filter Design", Oxford Univ. Press, 2001.
4. Mitra, S.K., "Digital Signal Processing: A Computer-Based Approach", McGraw Hill, NY, 1998
5. Monson H Hayes, Schaums outline: Digital Signal Processing.

## Course Contents and Lecture Schedule

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Signal Processing Fundamentals** | |
| 1.1 | Overview of signals. Frequency elements of DSP sytems | 2 |
| 1.2 | Conversion of analog signals to digital signals, Sampling theorem, reconstruction ADC and DAC , spectra and antialiasing filter | 3 |
| 1.3 | DTFT properties, spectrum | 3 |

| | | |
|---|---|---|
| **2** | **DFT** | |
| 2.1 | DFT from DTFT, DFT as a linear transformation. W matrix. Properties of DFT, Computational challenges. | 3 |
| 2.2 | FFT for comptational advantage, Radix -2 DIT and Dif algorith, in place computation. Bit reversal permutation. complexity | 4 |
| 2.3 | Filtering of long sequences | 2 |
| **3** | **Digital Filters** | |
| 3.1 | Model of FIR and IIR filters. Direct form I and II of FIR filter, simple FIR design | 4 |
| 3.2 | IIR filter, design of Butterworth filter, Direct and parallel realization | 4 |
| 3.3 | Analog to digital transformation, impulse invariance and bilinear transformation. | 4 |
| **4** | **Finite Word-length Effects** | |
| 4.1 | Number representation Truncation - Rounding - Quantization error in ADC - Overflow error- product round off error - Scaling - Limit cycle oscillation. | 2 |
| 4.2 | Truncation-Rounding - Quantization error in ADC - Overflow error - product round off error - Scaling - Limit cycle oscillation. | 5 |
| **5** | **DSP Architecture** | |
| 5.1 | Von Neumann and Harvard architecture, Comparison | 1 |
| 5.2 | Data paths of fixed and floating point DSP processors. Functions of various blocks Architecture of a typical DSP processor | 5 |
| 5.3 | Implementation of systems on DSP chip | 2 |

# Simulation Assignments

The following simulation assignments can be done with Python/MATLAB/ SCILAB/OCTAVE

1. Generate the following discrete signals
   - Impulse signal
   - Pulse signal and
   - Triangular signal
2. Write a function to compute the DFT of a discrete energy signal. Test this function on a few signals and plot their magnitude and phase spectra.
3. - Compute the linear convolution between the sequences $x = [1, 3, 5, 3]$ with $h = [2, 3, 5, 6]$. Observe the stem plot of both signals and the convolution.
   - Now let $h = [1, 2, 1]$ and $x = [2, 3, 5, 6, 7]$. Compute the convolution between $h$ and $x$.
   - Flip the signal $x$ by $180^\circ$ so that it becomes $[7, 6, 5, 3, 2]$. Convolve it with $h$. Compare the result with the previous result.
   - Repeat the above two steps with $h = [1, 2, 3, 2, 1]$ and $h = [1, 2, 3, 4, 5, 4, 3, 2, 1]$
   - Give your inference.
4. - Compute the DFT matrix for $N = 8, 16, 64, 1024$ and 4098
   - Plot the first 10 rows in each case and appreciate these basis functions
   - Plot the real part of these matrices as images and appreciate the periodicities and half periodicities in the pattern
   - Normalize each matrix by dividing by $\sqrt{N}$. Compute the eigenvalues of every normalized matrix and observe that all eigenvalues belong to the set $\{1, j, -j, -1\}$.
5. - Realize a continuous time LTI system with system response

     $$H(s) = \frac{5(s+1)}{(s+2)(s+3)}$$

     . One may use *scipy.signal.lti* package in Python.
   - Make it into a discrete system (possibly with *scipy.signal.cont2discrete*)
   - Observe the step response in both cases and compare.
6. - Download a vibration signal in *.wav* format.
   - Load this signal into an array. One may use the *scipy.io.wavfile* module in Python.
   - understand the sampling rate of this signal.

- Plot and observe the vibration signal waveform.
- Compute the absolute squared value of the FFT of the vibration signal.
- Plot it and observe the spectral components in the discrete frequency domain.
- Multiply prominent discrete frequencies by the sampling rate and observe and appreciate the major frequency components in $Hz$.

**Model Question Paper**

# A P J Abdul Kalam Technological University

Fourth Semester B. Tech. Degree Examination

Branch: Electronics and Communication

## Course: ECT 286 Introduction to Digital Signal Processing

**Time: 3 Hrs** **Max. Marks: 100**

**PART A**

*Answer All Questions*

| | | | |
|---|---|---|---|
| 1 | Define frequency of a discrete signal and identify its range. | (3) | $K_1$ |
| 2 | State Nyquist sampling theorem for low pass signals and the formula for signal reconstruction. | (3) | $K_3$ |
| 3 | Explain why DFT operation is a linear transformation. | (3) | $K_2$ |
| 4 | Explain how FFT reduces the computational complexity of DFT. | (3) | $K_2$ |
| 5 | Write the expresssion for the Hamming window and plot it. | (3) | $K_1$ |
| 6 | Give the expression for bilinear tranformation and explain the term frequency warping. | (3) | $K_2$ |
| 7 | Explain the quantization error in ADCs. | (3) | $K_2$ |
| 8 | Explain the 1s and 2s complement representation of numbers in DSP processor. | (3) | $K_2$ |
| 9 | Compare floating point and fixed point data paths in a DSP processor. | (3) | $K_2$ |
| 10 | Explain function of a barrel shifter in a DSP processor. | (3) | $K_2$ |

## PART B

*Answer one question from each module. Each question carries 14 mark.*

### Module I

| | | | |
|---|---|---|---|
| 11(A) | Explain how analog signals are converted to digital signals. | (10) | $K_2$ |
| 11(B) | What all digital frequencies are obtained when a $1\,kHz$ signal is sampled by $4\,kHz$ and $8\,kHz$ impulse trains? | (4) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 12(A) | Give the expression for DTFT. Compute the DTFT of the signal $x[n] = [1, -1, 1, -1]$ | (8) | $K_3$ |
| 12(B) | Explain how sampling affects the spectrum of the signal and the need of antialiasing filter | (6) | $K_3$ |

### Module II

| | | | |
|---|---|---|---|
| 13(A) | Give the radix-2 decimation in time algorithm for 8-point FFT computation | (10) | $K_3$ |
| 13(B) | How is in place computation applied in FFT algorithms? | (4) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 14(A) | Find the DFT of the sequence $x(n) = \{1, 2, 3, 4, 4, 3, 2, 1\}$ using radix-2 DIF algorithm | (10) | $K_3$ |
| 14(B) | How is bit reverse addressing used in FFT computations? | (4) | $K_3$ |

### Module III

| | | | |
|---|---|---|---|
| 15(A) | Write the difference equation representation of IIR filter and explain how its impulse response is infinite in duration | (7) | $K_3$ |

| | | | |
|---|---|---|---|
| 15(B) | Convert the analog filter $$H(s) = \frac{1}{(s+1)(s+2)}$$ into digital filter using impulse invariance method. | (7) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 16(A) | Implement the FIR filter $h[n] = [1, 2, 4, 6, 4, 2, 1]$ with minimum multipliers in directform | (6) | $K_3$ |
| 16(B) | Design an IIR Butterworth filter for passband frequency $5\,kHz$ and stopband frequency $10\,kHz$. The stop band and passs band attenuations are 0.1 respectively. | (8) | $K_3$ |

**Module IV**

| | | | |
|---|---|---|---|
| 17(A) | Explain the limit cycle oscillations in IIR filters | (6) | $K_3$ |
| 17(B) | Derive the quantization noise power in an ADC | (8) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 18(A) | Find the output noise variance of a first order system with transfer function $$H(z) = \frac{1}{1 - \alpha z^{-1}}$$ that is driven by a zero mean white Gaussian noise of variance $\sigma_N^2$ | (8) | $K_3$ |
| 18(B) | Explain the fixed and floating point arithmetic used in DSP processors. | (6) | $K_3$ |

**Module V**

| | | | |
|---|---|---|---|
| 19 | Draw and explain the functional blocks in a floating point DSP processor. | (14) | $K_2$ |

**OR**

| | | | |
|---|---|---|---|
| 20(A) | Compare Von Neumann architecture with Harvard architecture | (7) | $K_2$ |
| 20(B) | Explain the significance and operation of the MAC unit in a DSP processor | (7) | $K_2$ |

# SEMESTER -4
# HONOURS

| ECT292 | NANOELECTRONICS | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | Honors | 3 | 1 | 0 | 4 |

**Preamble:** This course aims to understand the physics behind mesoscopic systems and working of nanoelectronic devices.

**Prerequisite**: PHT100 Engineering Physics A, ECT201 Solid State Devices

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Explain quantum mechanical effects associated with low dimensional semiconductors. |
| **CO 2** | Explain the different processes involved in the fabrication of nanoparticles and nanolayers. |
| **CO 3** | Explain the different techniques for characterizing nano layers and particles |
| **CO 4** | Explain the different transport mechanisms in nano structures |
| **CO 5** | Illustrate the operating principle of nanoscale electronic devices like SET, Resonant tunnelling devices, Quantum lasers etc. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | | | | | | | | | | | |
| **CO 2** | 2 | | | | | | | | | | | |
| **CO 3** | 1 | | | | | | | | | | | |
| **CO 4** | 2 | | | | | | | | | | | |
| **CO 5** | 2 | | | | | | | | | | | |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 10 | 10 | 20 |
| Understand | 35 | 35 | 70 |
| Apply | 5 | 5 | 10 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1): Explain the quantum mechanical effects associated with low dimensional semiconductors.**

1. Derive the expression for density of states in a 1D nanomaterial.

2. Compare and contrast triangular, square and parabolic quantum wells.

3. Solve numerical problems to find whether the given material is a nanometric one.

**Course Outcome 2 (CO2) : Explain the different processes involved in the fabrication of nanoparticles and nanolayers.**

1. Explain Sol-Gel process for synthesis of nanoparticles.
2. Explain the different steps involved in CVD process for fabricating nanolayers.
3. DC sputtering cannot be used for the coating of non- conducting materials. Justify.

**Course Outcome 3 (CO3): Explain the different techniques for characterizing nano layers and particles.**

1. Illustrate the working principle of an AFM.
2. Explain the different emission and interactions between electron beam and the specimen.
3. Explain the principle of operation of an XRD.

**Course Outcome 4 (CO4): Explain the different transport mechanisms in nano structures.**

1. Explain Kronig Penney model of a super lattice.

2. Explain modulation doping with an example.

3. Explain the different scattering events encountered by a carrier during parallel transport under the influence of electric field.

**Course Outcome 5 (CO5): Illustrate the operating principle of nanoscale electronic devices like SET, Resonant tunnelling devices, Quantum lasers etc.**

1. Explain Coulomb blockade effect. Illustrate the working of a single electron transistor.

2. Draw the schematic representation of the conduction band of a resonant tunnel diode for (a) no voltage applied (b) increasing applied voltages. Explain its I-V characteristics.

3. MODFETS are high electron mobility transistors. Justify.

## Syllabus

**Module I**

Introduction to nanotechnology, Limitations of conventional microelectronics, characteristic lengths in mesoscopic systems, Quantum mechanical coherence.

Low dimensional structures - Quantum wells, wires and dots, Density of states of 1D and 2D nanostructures.

Basic properties of square quantum wells of finite depth, parabolic and triangular quantum wells

**Module II**

Introduction to methods of fabrication of nano-layers: physical vapour deposition- evaporation & Sputtering, Chemical vapour deposition, Molecular Beam Epitaxy, Ion Implantation, Formation of Silicon Dioxide- dry and wet oxidation methods.

Fabrication of nano particle- grinding with iron balls, laser ablation, reduction methods, sol gel, self assembly, precipitation of quantum dots.

**Module III**

Introduction to characterization of nanostructures: Principle of operation of Scanning Tunnelling Microscope, Atomic Force Microscope, Scanning Electron microscope - specimen interaction, X-Ray Diffraction analysis

**Module IV**

Quantum wells, multiple quantum wells, Modulation doped quantum wells, concept of super lattices Kronig - Penney model of super lattice.

Transport of charge in Nanostructures - Electron scattering mechanisms, Hot electrons, Resonant tunnelling transport, Coulomb blockade, Effect of magnetic field on a crystal. Aharonov-Bohm effect, the Shubnikov-de Hass effect.

**Module V**

Nanoelectonic devices - MODFETS, Single Electron Transistor, CNT transistors – Properties of graphene
Resonant tunnel effect, RTD, RTT, Hot electron transistors
Quantum well laser, quantum dot LED, quantum dot laser

**Text Books**

1. J.M. Martinez-Duart, R.J. Martin Palma, F. Agulle Rueda Nanotechnology for Microelectronics and optoelectronics , Elsevier, 2006
2. W.R. Fahrner, Nanotechnology and Nanoelctronics, Springer, 2005

**Reference Books**

1. Chattopadhyay, Banerjee, Introduction to Nanoscience & Technology, PHI 2012
2. Poole, Introduction to Nanotechnology, John Wiley 2006.
3. George W. Hanson, Fundamentals of Nanoelectronics, Pearson Education, 2009.
4. K. Goser, P. Glosekotter, J. Dienstuhl, Nanoelectronics and nanosystems, Springer 2004.
5. Supriyo Dutta, Quantum Transport- Atom to transistor, Cambridge, 2013.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **MODULE 1** | |
| 1.1 | Introduction to nanotechnology, Limitations of conventional microelectronics | 1 |
| 1.2 | Characteristic lengths in mesoscopic systems | 1 |
| 1.3 | Quantum mechanical coherence, Schrodinger's equation, Low dimensional structures - Quantum wells, wires and dots | 3 |
| 1.4 | Density of states of 1D and 2D nanostructures | 2 |
| 1.5 | Basic properties of square quantum wells of finite depth, parabolic and triangular quantum wells | 3 |
| | | |
| **2** | **MODULE 2** | |
| 2.1 | Introduction to methods of fabrication of nano-layers: physical vapour deposition- evaporation & Sputtering, | 2 |
| 2.2 | Chemical vapour deposition, Molecular Beam Epitaxy | 2 |
| 2.3 | Ion Implantation, Formation of Silicon Dioxide- dry and wet oxidation methods | 2 |
| 2.4 | Fabrication of nano particle- grinding with iron balls, laser ablation, reduction methods | 2 |
| 2.5 | Sol - Gel, self assembly, precipitation of quantum dots. | 2 |
| | | |
| **3** | **MODULE 3** | |
| 3.1 | Introduction to characterization of nanostructures: Principle of operation | 2 |

| | | |
|---|---|---|
| | of Scanning Tunnelling Microscope | |
| 3.2 | Atomic Force Microscope | 1 |
| 3.3 | Scanning Electron microscope - specimen interaction. | 1 |
| 3.4 | X-Ray Diffraction analysis | 1 |
| | | |
| **4** | **MODULE 4** | |
| 4.1 | Quantum wells, multiple quantum wells, Modulation doped quantum wells, concept of super lattices | 2 |
| 4.2 | Kronig - Penney model of super lattice. | 1 |
| 4.3 | Transport of charge in Nanostructures - Electron scattering mechanisms, Hot electrons | 1 |
| 4.4 | Resonant tunnelling transport, Coulomb blockade | 2 |
| 4.5 | Quantum transport in nanostructures - Coulomb blockade | 1 |
| 4.6 | Effect of magnetic field on a crystal. Aharonov-Bohm effect | 2 |
| 4.7 | Shubnikov-de Hass effect | 1 |
| | | |
| **5** | **MODULE 5** | |
| 5.1 | Nano electonic devices- MODFETS | 2 |
| 5.2 | Single Electron Transistor | 1 |
| 5.3 | CNT transistors , Properties of graphene | 2 |
| 5.4 | RTD, RTT, Hot electron transistors | 3 |
| 5.5 | Quantum well laser, quantum dot LED, quantum dot laser | 2 |

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**MODEL QUESTION PAPER**

**ECT 292 NANOELECTRONICS**

**Time: 3 hours** **Max. Marks:100**

**PART A**

Answer ***all*** questions. Each question carries ***3 marks***.

1. Explain any three characteristic lengths in mesoscopic systems.
2. Explain the terms (i) coherence length (ii) phase coherence.
3. Explain Laser ablation method for nanoparticle fabrication.
4. DC sputtering cannot be used for coating of non-conducting materials. Justify
5. Explain two different modes of operation of a STM.
6. Explain XRD method for characterizing nano materials.
7. Differentiate between the two types of multiple quantum wells.
8. Explain Aharonov-Bohm effect.
9. Explain why MODFETs are called high electron mobility transistors.
10. List any six properties of graphene.

**PART B**

Answer ***any one*** question from each module. Each question carries 14 marks.

**MODULE I**

**11.** (a) Show that DOS in a 2D material is independent of energy. (8 marks)
(b) Explain any three physical limitations in reducing the size of devices in Nano metric scale. (6 marks)

**12.** Compare and contrast square, parabolic and triangular quantum wells (14 marks)

**MODULE III**

**13.** (a) Illustrate the process of Molecular Beam Epitaxi for fabricating nano layers. (8 marks)
(b) Differentiate between dry oxidation and wet oxidation techniques (6 marks)

**14.** (a) Sketch and label a CVD reactor and explain the different steps involved in the CVD process. (8 marks)
(b) Explain the reduction method for nano particle fabrication (6 marks)

## MODULE III

**15.** Explain the different specimen interactions of an electron beam and illustrate the working of a SEM (14 marks)

**16.** Explain the principle of operation of an AFM. Explain the different modes of operation. (14 marks)

## MODULE IV

**17.** (a) Explain Kronig–Penney model of a super lattice. What is meant by Zone folding? (10 marks)

(b)Explain the concept of hot electrons in parallel transport (4 marks)

**18.** (a) Explain Coulomb Blockade effect (8 marks)

(b) Illustrate resonant tunneling effect. (6 marks)

## MODULE V

**19.** (a) ) Draw the schematic and explain the working of a single electron transistor (8 marks)

(b) Explain working of resonant tunneling diodes (6 marks)

**20.** (a) Illustrate the working of a quantum well laser (6 marks)

(b) Explain the different types of Carbon Nanotube transistors (8 marks)

| ECT294 | STOCHASTIC PROCESSES FOR COMMUNICATION | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | Honors | 3 | 1 | 0 | 4 |

**Preamble:** This course aims to apply the concepts of probability and random processes in communication systems.

**Prerequisite**: None

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Explain the concepts of probability, random variables and stochastic processes |
| **CO 2** | Apply the knowledge in probability to ststistically characterize communication channels. |
| **CO 3** | Apply probability to find the information and entropy |
| **CO 4** | Explain source coding and channel coding theorem. |
| **CO 5** | Apply stochastic processes in data transmission |

**Mapping of course outcomes with program outcomes**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** | **PO 11** | **PO 12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | |
| **CO 2** | 3 | 3 | | 3 | 2 | | | | | | | |
| **CO 3** | 3 | 3 | | 3 | 2 | | | | | | | 2 |
| **CO 4** | 3 | 3 | | | | | | | | | | |
| **CO 5** | 3 | 3 | | 3 | 2 | | | | | | | |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 10 | 10 | 20 |
| Understand | 25 | 25 | 50 |
| Apply | 15 | 15 | 30 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| **Total Marks** | **CIE** | **ESE** | **ESE Duration** |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1): Concepts in probability**

1. Give frequentist and axiomatic definitions of probability. State the demerits of frequentist definition.
2. What is a random variable? Illustrate with an example how it becomes useful in studying engineering problems?
3. A six faced die with P(1)=P(3)=1/3, P(4)=P(5)=1/4 is thrown in a game with outcomes listed in the table.

| Face | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Payoff(Rs) | +50 | -40 | +60 | -60 | -20 | +100 |

The + and - signs indicates gain and loss for the the player respectively.

1.Draw the CDF and PDF

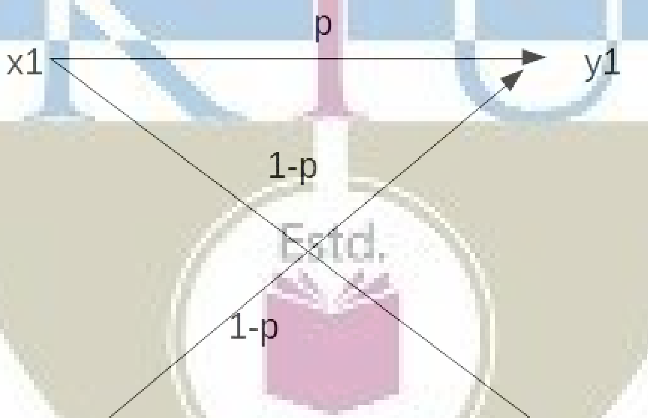
2. Compute the expected value of gain/loss. Is it worthwhile to play the game?
3. Compute the entropy of the random variable.

**Course Outcome 2 (CO2) : Review of random processes**

1. Give the conditions for WSS and SSS.
2. Test if the sinusoid $X(t)=A\cos(2\pi ft+\theta)$ with θ variying uniformly in the interval $[-\pi,\pi]$ is WSS.
3. Define white Gussian noise.
4. State central limit theorem. Why is Guassian model suitable in additive noise channels?

**Course Outcome 3 (CO3): Entropy and Information**

1. Define discrete memoryless source and discrete menoryless channel.
2. Define entropy and conditional entropy.
3. See the binary symmetric channel in the figure below.




Let p(x1)=1/3 and p =1/4. Compute the mutual information betweeen X and Y.

**Course Outcome 4 (CO4): Source coding and Channel Coding**

1. State the souce coding theorem.
2. Compute the mutual information between the input and output of an AWGN channel. What is its capacity.
3. Find the capacity of an AWGN channel with 4kHz bandwidth and the noise power spectral density $10^{-12}$W/Hz. The signal power at the receiver is 0.1mW.

**Course Outcome 5 (CO5): Stochastic processes in data transmission**

1. Derive Chapman – Kolmogorov equation.

2. Explain the packet transmission in a slotted ALOHA network
3. Consider a Markov chain with three possible states 1,2,3 with transition probability matrix

$$\begin{pmatrix} \frac{1}{4} & \frac{1}{2} & \frac{1}{4} \\ \frac{1}{3} & 0 & \frac{2}{3} \\ \frac{1}{2} & 0 & \frac{1}{2} \end{pmatrix}$$

a) Draw the state transition diagram.
b) Find $P(X_4=3|X_3=2)$
c) If $P(X_0=1)=1/3$ Find $P(X_0=1,X_1=2)$

## SYLLABUS

**Module 1 : Review of Probability and Random Variables [1,2]**

Review of probability. Relative frequency and Axiomatic definitions of probability, Significance of axiomatic definition. Bayes theorem and conditional probability. Independence. Discrete random variables. The cumulative distribution and density functions for discrete random variables. Joint distribution and conditional distribution. Statistical averages. Mean, Variance and standard deviation, Gaussian density function, Pdf of envelop of two gaussian variables – Rayleigh pdf.

**Module 2 : Review of Random Processes [1-3]**

Stochastic Processes. Stationarity and ergodicity. WSS and SSS processes. Gaussian Random process, Mean and autocorrelation and power spectral density functions. Weiner Kinchine theorem, Bandwidth of a random process, PSD of a Pulse Amplitude Modulated wave. White noise, Filtering of discrete WSS process by LTI systems. Noise-equivalent bandwidth, Signal to Noise Ratio, Matched Filter, Bandlimited and narrowband random process.

Sum of random variables, Markov Inequality, Chebyshev Inequality, Convergence, The central limit theorem (statement only). Gaussianity of thermal noise.

**Module 3: Entropy and Information [1-3]**

Basics of discrete communication system, Sources, channels and receivers. Discrete memoryless sources. Entropy. Source coding theorem (statement only). Mutual Information. Discrete memoryless channels. Matrix of channel transmission probabilities. Noiseless and noisy channels, binary symmetry channels. Channel coding theorem (statement only) Channel capacity for BSC (derivation reqruired), Differential entropy, Channel capacity of AWGN channel (statement only).

**Module 4 : Markov Process and Queuing Theory [4,5]**

Markov process. Definition and model. Markov chain. Transition probability matrix. State diagram and characteristics of a Markov chain. Chapman Kolmogorov equation. Poisson process.

**Module 5 : Queues in Communication Networks [4,5]**

Overview of queuing theory. M/M/1, M/M/∞, Application to packet transmission in a slotted ALOHA computer communication network.

**Text Books**

1. Papaulis and Unnikrishna Pillai, "Probability, Random Variables and Stochastic Processes", MH
2. Analog and Digital Communication Systems, Hsu, Schaum Outline Series, MGH.
3. Digital Communication, John G Proakis, John Wiley
4. Probability and Random Processes, Miiller and Childers, Ed., 2, Academic Press
5. Data Networks, Bertsekas and Gallager, Ed. 2, PHI

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Module 1** | |
| 1.1 | Review of probability. Relative frequency and Axiomatic definitions of probability, Significance of axiomatic definition. | 1 |
| 1.2 | Bayes theorem and conditional probability. Independence. | 1 |
| 1.3 | Discrete random variables. | 1 |
| 1.4 | The cumulative distribution and density functions for discrete random variables. Joint distribution and conditional distribution. | 3 |
| 1.5 | Statistical averages. Mean, Variance and standard deviation, | 2 |
| 1.6 | Gaussian density function, Pdf of envelop of two gaussian variables – Rayleigh pdf. | 2 |
| | | |
| **2** | **MODULE 2** | |
| 2.1 | Stochastic Processes. Stationarity and ergodicity. WSS and SSS processes. Gaussian Random process | 2 |
| 2.2 | Mean and autocorrelation and power spectral density functions. Weiner Kinchine theorem, Bandwidth of a random process, PSD of a Pulse Amplitude Modulated wave. | 3 |
| 2.3 | White noise, Filtering of discrete WSS process by LTI systems. Noise-equivalent bandwidth, Signal to Noise Ratio, Matched Filter, Bandlimited and narrowband random process. | 3 |
| 2.4 | Sum of random variables, Markov Inequality, Chebyshev Inequality, Convergence, The central limit theorem (statement only). Gaussianity of thermal noise. | 2 |
| | | |
| **3** | **MODULE 3** | |
| 3.1 | Basics of discrete communication system, Sources, channels and receivers. | 1 |
| 3.2 | Discrete memoryless sources. Entropy. Source coding theorem (statement only). | 1 |

| | | |
|---|---|---|
| 3.3 | Mutual Information. Discrete memoryless channels. Matrix of channel transmission probabilities. Noiseless and noisy channels, binary symmetry channels. | 2 |
| 3.4 | Channel coding theorem (statement only) Channel capacity for BSC (derivation reqruired), | 1 |
| 3.5 | Differential entropy, Channel capacity of AWGN channel (statement only). | 2 |
| | | |
| **4** | **MODULE 4** | |
| 4.1 | Markov process. Definition and model. | 1 |
| 4.2 | Markov chain. Transition probability matrix. State diagram and characteristics of a Markov chain. Chapman Kolmogorov equation. | 4 |
| 4.3 | Poisson process | 3 |
| | | |
| **5** | **MODULE 5** | |
| 5.1 | Overview of queuing theory. | 2 |
| 5.2 | M/M/1, M/M/∞ systems | 3 |
| 5.3 | Application to packet transmission in a slotted ALOHA computer communication network. | 3 |

# Simulation Assignments



The following simulations can be done Python/R/MATLAB/SCILAB.

**Generation of Discrete Stochastic Signals**

1. Simulate stochastic signals of
   - Uniform
   - Binomial
   - Gaussian
   - Rayleigh
   - Ricean

   probability density functions and test their histograms.

2. Compute the statistical averages such as mean, variance, standard deviation etc.

3. To compute the autocorrelation matrix for each signals. Compare the autocorrelation of Gaussian signal with others.

4. To observe the spectrum of the signal and relate it with the autocorrelation function.

**Central Limit Theorem–Gaussianity of Channels**

- Simulate a coin toss experiment that generates a string of length N of 0s and 1s that are uniformly distributed.
- Toss the coin M times and sum up the string in every toss.
- Plot the normalized histogram of the sum values for $M = 100, 1000, 5000$.Observe that it is a Binomial distribution.
- Plot the function $q = \binom{M}{r} p^r (1-p)^{M-r}$ and compare with the histogram.
- Make $M$ very large and observe that the histogram tends to become Gaussian, justifying the central limit theorem.

**Frequency of Characters in English Text and the Entropy**

1. It is required to understand the probabilities of occurrence of characters in English text say an English novel say with more than 300 pages(that contains text only) in .txt format(student may download one such file.).
2. Read the novel in *.txt* format into a single string or array and to identify the unique symbols(all letters, numbers, punctuation marks etc.) in the file and to plot their frequencies of occurrence.
3. Aprreciate the probabilities of occurrences of all symbols.
4. Compute the entropy and the information content in the book.

**Simulation of a Point Process**

1. It is required to simulate a point Poisson process, say the arrival of packets in a queue.
2. Let the rate of arrival of packets be say 100 per second.
3. Simulate the Poisson process using small time bins of say 1 millisecond.
4. Since Poisson process has no memory, the occurrence of an event is independent from one bin to another.
5. Binary random signals can be used to represent success or failure.
6. Simulate and dispaly each event with a vertical line using say *matplotlib*
7. Generate the couting process $N(t)$ which is the sum of the events until time $t$.
8. Plot $N(t)$ against $t$ and appreciate it.

**Simulation of a Discrete Markov Chain**

1. It is required to simulate a birth death process as a discrete Markov chain.
2. Let us consider that the total population cannot exceed 1000 and the initial poulation is 100.
3. Set equal birth and death rates.
4. Iterate for say 10000 steps and plot the population against the iteration number.
5. Repeat the simulation for different rates and different population aand iteration sizes and appreciate the results.

**Model Question Paper**

# A P J Abdul Kalam Technological University

Fourth Semester B Tech Degree Examination

Branch: Electronics and Communication

**Course: ECT 294 Stochastic Processes for Communication**

**Time: 3 Hrs** **Max. Marks: 100**

**PART A**

*Answer All Questions*

| | | | |
|---|---|---|---|
| 1 | Give the three definitions of probability | (3) | $K_2$ |
| 2 | In the toss of an unnfair coin, the probability of head is $\frac{1}{3}$.The player gets Rs. 100 if head turns up and loses Rs. 200 if tail turns up. Draw the CDF and PDF of this random variable | (3) | $K_3$ |
| 3 | Write the conditions for strict sense and wide sense stationarity | (3) | $K_2$ |
| 4 | Explain the Gaussian statistics of communication channels | (3) | $K_2$ |
| 5 | State the two source coding theorems | (3) | $K_1$ |
| 6 | Give channel matrix of a noiseless binary channel | (3) | $K_2$ |
| 7 | With mathematical model, explain Markov process | (3) | $K_2$ |
| 8 | Give an example of a Markov chain with its transition probability matrix | (3) | $K_2$ |
| 9 | Explain an M/M/1 queue system in packet transmission | (3) | $K_2$ |
| 10 | Explain the statistics of packet arrival in M/M/1 queue system | (3) | $K_2$ |

**PART B**

*Answer one question from each module. Each question carries 14 mark.*

**Module I**

11 A random variable $\mathbf{X}$ has the following pdf.

$$f_{\mathbf{X}}(\lambda) = \begin{cases} A[1 - \frac{|\lambda|}{3}]; & -3 \leq \lambda \leq 3 \\ 0; & \text{else} \end{cases}$$

Find the probability $P[|\lambda| < 1.5]$ (4) $K_3$

Find the probability $P[1.2 \leq \lambda \leq 2.3]$ (4) $K_3$

Find $E[\mathbf{X}]$ (6) $K_3$

**OR**

12. A six faced die with $P(1) = P(3) = \frac{1}{6}$, $P(4) = P(5) = \frac{1}{8}$, $P(2) = \frac{1}{12}$ is thrown in a game with outcomes listed in the table.

| Face | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Payoff | 50 | -40 | 60 | -60 | -20 | 100 |

The + and - signs indicates gain and loss for the player respectively.

A Draw the CDF and PDF of the Payoff random variable. (6) $K_3$

B Compute the expected value of gain/loss. Is it worthwhile to play the game? (5) $K_3$

C Compute the variance of Payoff. (3) $K_3$

**Module II**

13(A) Test if the random process (8) $K_3$

$$X(t) = A\cos(2\pi f_c t + \theta)$$

is WSS with $\theta$ a uniformly distributed random variable in the interval $[-\pi, \pi]$.

| | | | |
|---|---|---|---|
| 13(B) | If a random signal is applied as input to an LTI system, how is the power spectral density of the output related to that of the input? Explain. | (6) | $K_2$ |

**OR**

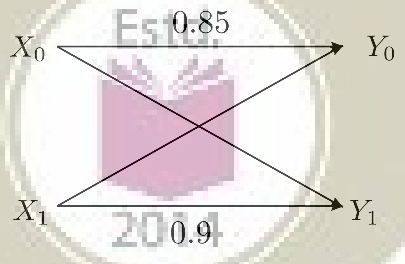
| | | | |
|---|---|---|---|
| 14(A) | State and prove Wiener Kinchine theorem . | (8) | $K_3$ |
| 14(B) | Justify the suitability of using white Gaussian model for noise in a communication system. | (6) | $K_2$ |

## Module III

| | | | |
|---|---|---|---|
| 15(A) | State source coding theorem for a discrete memoryless source. | (6) | $K_2$ |
| 15(A) | Show that mutual information is always positive. | (3) | $K_2$ |
| 15(C) | What is channel capacity in terms of the conditional entropy? Write down the capacity of an AWGN channel. | (5) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 16(A) | Define entropy of a discrete memoryless source. If the alphabet is finite with size $K$, show that $H(X) \leq \log_2 K$ | (6) | $K_2$ |
| 16(B) | For the binary channel below, compute the channel transition matrix and $P(Y_0)$ and $P(Y_1)$, given that $P(X_0) = P(X_1) = 0.5$ | (8) | $K_3$ |




## Module IV

| | | | |
|---|---|---|---|
| 17(A) | Explain a Poisson random process. Give two practical examples of a Poisson process | (7) | $K_2$ |
| 17(B) | Derive Chapman – Kolmogorov equation. | (7) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 18 | Consider a Markov chain with three possible states 1,2,3 with transition probability matrix | | |
| | (A) Draw the state transition diagram. | (4) | $K_2$ |
| | (B) Find $P(X4 = 3 \mid X3 = 2)$ | (5) | $K_3$ |
| | (C) If $P(X0 = 1) = \frac{1}{3}$, find $P(X0 = 1, X1 = 2)$ | (5) | $K_3$ |

**Module V**

| | | | |
|---|---|---|---|
| 19 | Explain the packet transmission in a slotted ALOHA network | (14) | $K_2$ |

**OR**

| | | | |
|---|---|---|---|
| 20 | Explain the M/M/1 queue system pertaining to packet transmission | (14) | $K_2$ |

| ECT296 | STOCHASTIC SIGNAL PROCESSESING | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | Honours | 3 | 1 | 0 | 4 |

**Preamble:** This course aims to study stochastic signals and their interactions with LTI systems

**Prerequisite**: None

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Explain the concepts of probability, random variables and stochastic processes |
| **CO 2** | Apply the knowledge in probability to ststistically characterize communication channels. |
| **CO 3** | Use the properties of WSS for finding the LTI system response |
| **CO 4** | Model discrete signals using various methods |
| **CO 5** | Estimate the spectra of signals using various methods. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | |
| **CO 2** | 3 | 3 | | 3 | 2 | | | | | | | |
| **CO 3** | 3 | 3 | | 3 | 2 | | | | | | | |
| **CO 4** | 3 | 3 | | | | | | | | | | |
| **CO 5** | 3 | 3 | | 3 | 2 | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 10 | 10 | 20 |
| Understand | 15 | 15 | 30 |
| Apply | 25 | 25 | 50 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1): Concepts in probability**

1. Give frequentist and axiomatic definitions of probability. State the demerits of frequentist definition.
2. What is a random variable? With an example, illustrate how it finds application in defining engineering problems?
3. A six faced die with P(1)=P(3)=1/3, P(4)=P(5)=1/4 is thrown in a game with outcomes listed in the table.

| Face | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Payoff(Rs) | +50 | -40 | +60 | -60 | -20 | +100 |

The + and - signs indicates gain and loss for the the player respectively.

1.Draw the CDF and PDF

2. Compute the expected value of gain/loss. Is it worthwhile to play the game?

3. Compute the entropy of the random variable.

**Course Outcome 2 (CO2) : Review of random processes**

1. State central limit theorem. Explain the validity of using Gaussian model for additive communication channels.
2. Give the conditions for WSS and SSS.
3. Test if the sinusoid $X(t)=A\cos(2\pi ft+\theta)$ with θ variying uniformly in the interval [-π,π] is WSS.

**Course Outcome 3 (CO3): WSS and LTI systems**

1. Derive Wiener Hopf equations.
2. Solve Wiener-Hopf equation to get a third order discrete system for a an RV X whose autocorrelation is Rx=[0.89,0.75,0.7,0.6]
3. Prove that autocorretion and power spectral density are Fourier transform pairs

**Course Outcome 4 (CO4): Signal modeling**

1. Use Prony method to model a unit pulse x[n]=U[n]-U[n-N] as a system with one pole and one zero.
2. Use Pade apprimation to model the signal x whose fisrt six values are [1,1.2,0.9,0.5,0.6,0.25] using a second order all pole model (p=2 and q=0)

**Course Outcome 5 (CO5): Stochastic processes in data transmission**

1. Explain the periodogram method of spectrum estimation
2. Explain the need pf spectrum estimation
3. Use ARMA(p,q) model to estimate the spectrum

## Syllabus

**Module 1 : Review of Probability and Random Variables [1]**

Review of probability. Relative frequency and Axiomatic definitions of probability, Significance of axiomatic definition. Bayes theorem and conditional probability. Independence. Discrete random variables. The cumulative distribution and density functions for random variables. Joint distribution and conditional distribution. Statistical averages. Mean, Variance and standard deviation, Functions of random variables. Multivariate Gaussian density function.

**Module 2 : Review of Random Processes [1]**

Stochastic Processes. Stationarity and ergodicity. WSS and SSS processes. Discrete Gaussian, Rayleigh and Ricean processes.

Sums of random variables, Convergence, Markov and Chebyshev inequality, The central limit theorem (statement only).

**Module 3: The Autocorrelation Matrix and its Significance [2]**

Statistical averages of discrete stationary stochastic processes. Mean and autocorrelation and power spectral density functions. Weiner Kinchine theorem, Filtering of discrete WSS process by LTI systems. The autocorrelation matrix and the significance of its eigen vectors. Whitening. Properties of autocorrelation matrix, its inversion and Levinson-Durbin Recursion. Wiener-Hopf equation. Brownian motion, its mathematical model and its autocorrelation and power spectral density

**Module 4 : Signal Modeling - Deterministic and Stochastic [1]**

The least square method of signal modeling. The Pade approximation. Prony's method. Stochastic models, AR, MA and ARMA models.

**Module 5 : Spectrum Estimation [1,2]**

Periodogram method of spectrum estimation. Parametric methods AR, MA and ARMA methods

**Text Books**

1. Monson Hayes, “Statistical Digital Signal Processing”, Wiley
2. A. Papaulis and Unnikrishna Pillai, “Probability, Random Variables and Stochastic Processes”, McGraw Hill

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Probability and Random Processes** | |
| 1.1 | The three definitions. Critique to classical definition. Probability as a function. The domain of probability function. Event and probability space | 2 |
| 1.2 | Conditional probability, Bayes theorem, Meaning and significance of prior. Random variable. Definition. Random variable as a function and its domain. Comparison with probability function. | 2 |
| 1.3 | Examples of RV. Discrete and continuous RV. CDF and PDF of RV(both discrete and continuous) Examples. Relation between the two and properties | 1 |
| 1.4 | Uniform and Gaussian Pdf and correspoding CDF. Properties | 1 |
| | Expectation, variance and standard deviation, Examples | 2 |
| 1.5 | Functions of random variables. | 2 |
| | | |
| **2** | **Stochastic Processes** | |
| 2.1 | Stochastic process, Definition. Stationarity and ergodicity | 2 |
| 2.2 | WSS and SSS conditions. Example problems | 2 |
| 2.3 | Sums of random variables, Convergence, Markov and Chebyshev inequality | 2 |
| 2.4 | Gaussian Process. Envelope of Gaussian process. Rayleigh pdf. Example | 2 |

| | | |
|---|---|---|
| 2.5 | Central limit theorem. Application in AWGN channel | 1 |
| | | |
| **3** | **Autocorrelation Matrix** | |
| 3.1 | Expectation, variance, autocorrelation and power spectral density | 2 |
| 3.2 | Autocorrelation matrix, properties eigen values | 2 |
| 3.3 | Filtering of WSS, output auotocorrelation and PSD | 2 |
| 3.4 | Inversion of autocorrelation matrix. LD recursion | 2 |
| 3.5 | Whitening | 1 |
| 3.6 | Wiener Hopf equation, Brownian motion. Model and spectral density | 3 |
| **4** | **Signal Modeling** | |
| 4.1 | Least squares method | 2 |
| 4.2 | Pade method, Prony method | 3 |
| 4.3 | Stochastic models | 3 |
| **5** | **Spectrum Estimation** | |
| 5.1 | Periodogram | 3 |
| 5.2 | Parametric methods | 4 |

# Simulation Assignments

The following simulations can be done Python/R/MATLAB/SCILAB.

**Generation of Discrete Stochastic Signals**

1. Simulate stochastic signals of
   - Uniform
   - Binomial
   - Gaussian
   - Rayleigh
   - Ricean

   probability density functions and test their histograms.
2. Compute the statistical averages such as mean, variance, standard deviation etc.
3. To compute the autocorrelation matrix for each signals. Compare the autocorrelation of Gaussian signal with others.
4. To observe the spectrum of the signal and relate it with the autocorrelation function.

**Gambler's Trouble**

- It is observed by gamblers that although the number of triples of integers from 1 to 6 with sum 9 is the same as the number of such triples with sum 10, when three dice are rolled, a 9 seemed to come up less often than a 10.
- Simulate a die throwing experiment. One may use the *randint* command in Python.
- Roll three dice together N times.
- Compute the number of times the sum of outcomes is 9 and the corresponding probability.
- Repeat the experiment for the sum of outcomes equal to 10 and observe if the hypothesis is true.
- Compute the two probabilities for $N = 100; 1000; 10000; 50000; 100000$ and plot the two probabilities against N and appreciate.

**Central Limit Theorem**

- Simulate a coin toss experiment that generates a string of length N of 0s and 1s that are uniformly distributed.
- Toss the coin M times and sum up the string in every toss.
- Plot the normalized histogram of the sum values for $M = 100, 1000, 5000$.Observe that it is a Binomial distribution.
- Plot the function $q = \binom{M}{r} p^r (1-p)^{M-r}$ and compare with the histogram.
- Make $M$ very large and observe that the histogram tends to become Gaussian, justifying the central limit theorem.

**Labouchere system**

- Labouchere system is a betting game in which a sequence of numbers is written and the player bets for an amount equal to the first and last number written.
- The game may be tossing a coin.
- If the player wins, the two numbers are removed from the list and the player is free to continue. If the list has only one number that becomes the stake amount.
- If he fails the amount at stake is appended to the list and the game continues until the list is completely crossed out, at which point the player has got the desired money or until he runs out of money
- Simulate this game and observe the outcomes for different sequences on the list

**Levinson Durbin Recursion**

1. It is required to invert large autocorrelation matrices with LD recursion.
2. Realize Gaussian and uniformly distributed random signals and compute their autocorrelation matrices.
3. Load a speech signal in say *.wav* format and compute its autocorrelation matrix.
4. Create a function to perform LD recursion on the above three matrices.

**Simulation of Brownian Motion**

1. The task is to realize the differential/difference equation for Brownian motion in two dimensions with and without gravity.
2. Observe the particle movement on the GUI and understand.
3. Compute the autocorrelation and power spectral density and appreciate.

**Spectrum Estimation**

1. Generate a cosinusoid of say 100 $Hz$ frequency and bury it in AWGN of comparable variance.
2. Write functions for periodogram and ARMA method to estimate the spectrum of the cosinusoid.
3. The student may install the Python package *spectrum* and repeat the estimations steps using its modules and compare the plot of spectra with those resulted by your functions.

**Model Question Paper**

# A P J Abdul Kalam Technological University

Fourth Semester B Tech Degree Examination

Branch: Electronics and Communication

**Course: ECT 296 Stochastic Signal Processing**

**Time: 3 Hrs** **Max. Marks: 100**

**PART A**

*Answer All Questions*

| | | | |
|---|---|---|---|
| 1 | Give the three axioms of probability | (3) | $K_2$ |
| 2 | You throw a coin and if head turns up you get Rs. 100 and loses Rs. 40 if tails turns up. The probability of a head is is 0.2. Draw the CDF and PDF of the random variable representing gain/loss. | (3) | $K_3$ |
| 3 | State central limit theorem. Give its significance. | (3) | $K_2$ |
| 4 | Draw the pdf of Rayleigh density function. | (3) | $K_2$ |
| 5 | Write and explain the differential equation for Brownian motion | (3) | $K_2$ |
| 6 | Give the output mean and autocorrelation of a an LTI system that is driven by a WSS process. | (3) | $K_2$ |
| 7 | Explain the term signal modeling | (3) | $K_2$ |
| 8 | Explain ARMA model of a signal | (3) | $K_2$ |
| 9 | Explain the need for power spectrum estimation | (3) | $K_2$ |
| 10 | List the various parametric spectrum estimation methods. | (3) | $K_2$ |

**PART B**

*Answer one question from each module. Each question carries 14 mark.*

**Module I**

| | | | |
|---|---|---|---|
| 11(A) | Derive mean and variance of a Gaussian distribution with parameters $\mu$ and $\sigma^2$ | (8) | $K_3$ |
| 11(B) | Write down the probability density of a bivariate Gaussian random variable. What is the signifance of the correlation coefficient? | (6) | $K_3$ |

**OR**

12. A six faced die with $P(1) = P(5) = \frac{1}{6}$, $P(4) = P(3) = \frac{1}{8}$, $P(2) = \frac{1}{12}$ is thrown in a game with outcomes listed in the table.

| Face | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Payoff | 50 | -40 | 60 | -60 | -20 | 100 |

The + and - signs indicates gain and loss for the the player respectively.

| | | | |
|---|---|---|---|
| A | Draw the CDF and PDF of Payoff random variable. | (6) | $K_3$ |
| B | Compute the expected value of gain/loss. Is it worthwhile to play the game? | (6) | $K_3$ |
| C | What is the variance of Payoff? | (3) | $K_3$ |

**Module II**

13(A) Test if the random process (7) $K_3$

$$X(t) = A\cos(2\pi f_c t + \theta)$$

is WSS with $A$ a random variable in the interval $[-\pi, \pi]$.

13(B) If $\mathbf{X}$ and $\mathbf{Y}$ are zero mean Gaussian RVs, compute the pdf of $\mathbf{Z} = \sqrt{\mathbf{X^2} + \mathbf{Y^2}}$ (7) $K_2$

**OR**

| | | | |
|---|---|---|---|
| 14(A) | Express a Binomial random variable $X$ as a sum of many Bernoulli random variables. Derive the mean of X using this connection. | (4) | $K_3$ |
| 14(B) | Derive Chebyshev inequality. How is it helpful in estimating tail probabilities? | (6) | $K_3$ |
| 14(B) | List the conditions for a stochastic process to be WSS. | (4) | $K_3$ |

**Module III**

| | | | |
|---|---|---|---|
| 15(A) | State and prove three properties of autocorrelation matrix. | (8) | $K_3$ |
| 15(B) | Prove that the power spectrum of a real process $\mathbf{X(t)}$ is real. | (6) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 16 | Give the mathematical model and compute the autocorrelation of the Brownian motion | (14) | $K_3$ |

**Module IV**

| | | | |
|---|---|---|---|
| 17 | Use Pade approximation to model the signal $x$ whose fisrt six values are $[1, 1.6, 0.7, 0.4, 0.6, 0.25]$ using a second order all pole model ($p = 2$ and $q = 0$) and a second order MA model ($p = 0$ and $q = 2$) | (14) | $K_3$ |

**OR**

| | | | |
|---|---|---|---|
| 18 | Use Prony method to model a unit pulse $x[n] = U[n]-U[n-N]$ as a system with one pole and one zero. | (14) | $K_3$ |

**Module V**

| | | | |
|---|---|---|---|
| 19 | Explain the periodogram method of spectrum estimation | (14) | $K_2$ |

**OR**

| | | | |
|---|---|---|---|
| 20 | Explain the three nonparametric methods of spectrum estimation | (14) | $K_2$ |