M.E. (PROCESS CONTROL AND INSTRUMENTATION) DEGREE COURSE

FULL-TIME: 4 SEMESTERS

CHOICE BASED CREDIT SYSTEM

REGULATIONS

1. A candidate who has passed B.E. (Electronics and Instrumentation) or B.E. (Electrical and Electronics Engineering) of this University or B.E. (Control and Instrumentation) or B.E. (Electronics and Communication) of any other University or an examination of any other University recognized as equivalent thereto shall be eligible to appear and qualify for the M.E. (Process Control and Instrumentation) degree examination of this University after a course of study of four semesters duration.

2. Candidates for the M.E. (Process Control and Instrumentation) degree shall be instructed and examined as shown in the Appendix-I; the syllabi of the subjects are given in Appendix-II

3. a) There shall be about 16 weeks of instructions for each of the semesters. At the end of this period there shall be one final examination in each subject at such dates as the Syndicate may prescribe, but usually in November / December and April / May of each year.

   b) In addition to the written examination, every candidate shall be required to submit a thesis on research / development work on a subject to be chosen in consultation with the Research Supervisor and the Head of the Department and also present seminars. The thesis shall be countersigned by the Research Supervisor and the Head of the Department as the bonafide work of the student. Any member of the teaching staff in the Department of Instrumentation Engineering decided by the Head of the Department shall be the Research Supervisor.

   c) The thesis shall be submitted on or before the date fixed by the Head of the Department.

   d) The candidates may be permitted to take a fundamental / industry oriented / Community oriented project.

   e) The thesis shall be valued and viva voce conducted by a Board consisting of the Research Supervisor, the Head of the Department and an External Examiner.

4. a) All candidates before proceeding to third semester shall undergo practical training for a period of four weeks during their vacation in an established process Industry/organisation approved by the Head of the Department.

   b) Such of these candidates who claim to have had such practical experience already, may apply to the Head of the Department supported by evidence requesting for exemption. They may be granted exemption based on the merits of the case.

   c) The satisfactory completion of the practical training will be assessed on the basis of the certificate from the industry /organization concerned and the training report submitted by the candidate.

CREDITS

M.E. full-time programme will have duration of four semesters. The final semester is devoted to thesis work only.

Each course is normally assigned one credit per lecture /tutorial per week and one credit for two periods or part thereof for laboratory or practical.

The number of credits per semester for the full-time programme shall be as follows:

First and Second semester	:	an average of 20 credits per semester
Third semester	:	12 credits.
Fourth Semester	:	13 credits

The total credits for the programme will be 65. For the award of the degree, a student has to earn a minimum of 65 credits.

DURATION OF THE PROGRAMME

A student is normally expected to complete the full-time programme in four semesters but in any case not more than four years from the time of admission.

REGISTRATION FOR COURSES

A newly admitted student will automatically be registered for all the courses prescribed for the first semester, without any option.

Every other student shall submit a completed registration form indicating the list of courses intended to be credited during the next semester. This registration will be done a week before the last working day of the current semester. Late registration with the approval of the Dean on the recommendation of the Head of the Department along with a late fee will be done up to the last working day.

Registration for the project work shall be done only in the pre-final semester.

ASSESSMENT

The break-up of assessment and examination marks for theory subjects is as follows.

First assessment (Term Test 1)	: 10 marks
Second assessment (Term Test 2)	: 10 marks
Third Assessment (Assignment)	: 05 marks
End Semester Examination	: 75 marks

The break-up of assessment and examination marks for Practical subjects is as follows.

First assessment (test)	: 15 marks
Second assessment (test)	: 15 marks
Maintenance of record book	: 10 marks
End Semester Examination	: 60 marks

The project work will be assessed for 40 marks by a committee consisting of the Head of the Department, the guide and a minimum of two members nominated by the Head of the Department. The Head of the Department will be the Chairman. 60 marks are allotted for the project work and viva voce phase-I examination at the end of the pre-final semester. The same procedure will be adopted in the final semester also.

STUDENT COUNSELLOR

To help the students in planning their course of study and for general advice on the academic programme, the Head of the Department will attach a certain number of students to a member of the faculty who shall function as student counsellor for those students throughout their period of study. Such student counsellors shall advise the students, give preliminary approval for the courses to be taken by the students during each semester and obtain the final approval of the Head of the Department.

CLASS COMMITTEE

For each semester, separate class committees will be constituted by the Head of the Department.

The composition of the class committee for each semester except the pre-final and final semesters shall be as follows:

- Teachers of the individual courses.

- A project co-ordinator (in the pre-final and final semester committees only) who shall be appointed by the Head of the Department from among the project supervisors.

- One Professor or Reader, preferably not teaching the class concerned, appointed as Chairman by the Head of the Department.

- The Head of the Department may opt to be a member or the Chairman.

- All student counsellors of the class and the Head of the Department (if not already a member) or any staff member nominated by the Head of the Department may opt to be special invitees.

The class committee shall meet four times during the semester.

The first meeting will be held within two weeks from the date of class commencement in which the type of assessment like test, assignment etc. for the first and third assessments and the dates of completion of the assessments will be decided.

The second meeting will be held within a week after the completion of the first assessment to review the performance and follow-up action.

The second assessment will be the mid-semester test.

The third meeting will be held within a week after the second assessment is completed to review the performance and for follow-up action.

The fourth meeting will be held after all the assessments except the examination are completed for all the courses, and at least one week before the commencement of the examinations. During this meeting the assessment on a maximum of 40 marks will be finalized for every student and tabulated and submitted to the Head of the Department for approval and transmission to the Controller of Examinations.

WITHDRAWAL FROM A COURSE

A student can withdraw from a course at any time before a date fixed by the Head of the Department prior to the second assessment, with approval of the Dean of the Faculty on the recommendation of the Head of the Department.

TEMPORARY BREAK OF STUDY

A student can take a one-time temporary break of study covering the current semester and /or the next semester with the approval of the Dean on the recommendation of the Head of the Department, not later than seven days after the completion of the midsemester test. However the student must complete the entire programme within the maximum period of four years.

SUBSTITUTE ASSESSMENTS

A student who has missed, for genuine reasons accepted by the Head of the Department, one or more of the assessments of a course other than the end of semester examination, may take a substitute assessment for any one of the missed assessments. The substitute assessment must be completed before the date of the fourth meeting of the respective class committees.

A student who wishes to have a substitute assessment for a missed assessment must apply to the Head of the Department within a week from the date of the missed assessment.

ATTENDANCE REQUIREMENTS

To be eligible to appear for the examination in a particular semester, a student must put in a minimum of 80% of attendance in that semester. However, if the attendance is 75% or above but less than 80% in any semester, the authorities can permit the student to appear for the examination in that semester on payment of the prescribed condonation fee.

A student who withdraws from or does not meet the minimum attendance requirement in a semester must re-register for and repeat that semester.

PASSING AND DECLARATION OF EXAMINATION RESULTS

All assessments of all the courses on an absolute marks basis will be considered and passed by the respective Results Passing Boards in accordance with the rules of the University. Thereafter, the Controller of Examinations shall convert the marks for each course to the corresponding letter grade as follows, compute the grade point average and overall grade point average, and prepare the grade cards.

90 to 100 marks	: Grade ‘ S’
80 to 89 marks	: Grade ‘A’
70 to 79 marks	: Grade ‘B’
60 to 69 marks	: Grade ‘C’
55 to 59 marks	: Grade ‘D’
50 to 54 marks	: Grade ‘E’
Less than 50 marks	: Grade ‘F’

Insufficient attendance	: Grade 'I'
Withdrawn from the course	: Grade 'W'

A student who obtains less than 24 marks out of 60 in the examination or is absent for the examination will be awarded grade F

A student who earns a grade of S,A,B,C,D or E for a course is declared to have successfully completed that course and earned the credits for that course. Such a course cannot be repeated by the student.

A student who obtains letter grades I or W in a course must re-register for and repeat the course.

The following grade points are associated with each letter grade for calculating the grade point average and overall grade point average:

S – 10; A – 9; B – 8; C – 7; D – 6; E – 5; F – 0;

Course with grades I and W are not considered for calculation of grade point average or overall grade point average. F grade will be considered for computing GPA and OGPA.

A student can apply for retotalling of one or more of his examination answer papers within a week from the date of issue of grade sheet to the student on payment of the prescribed fee per paper. The application must be made to the Controller of Examinations with the recommendation of the Head of the Department.

After results are declared, grade cards will be issued to the students. The grade card will contain the list of courses registered during the semester, the grades scored and the grade point average (GPA) for the semester.

GPA is the sum of the products of the number of credits of a course with the grade point scored in that course, taken over all the courses for the semester, divided by the sum of the number of the credits for all courses taken in that semester. OGPA is similarly calculated considering all the courses taken from the time of admission.

The results of the final semester will be withheld until the student obtains passing grades in all the subjects of all the earlier semesters.

After successful completion of the programme, the degree will be awarded with the following classifications based on OGPA.

For First Class with Distinction the student must earn a minimum of 65 credits within four semesters from the time of admission, pass all the courses in the first attempt and obtain a OGPA of 8.25 or above.

For First Class the student must earn a minimum of 65 credits within two years and six months from the time of admission and obtain a OGPA of 6.75 and above.

For Second Class the student must earn a minimum of 65 credits within four years from the time of admission.

ELECTIVES

Apart from the various elective courses offered in the curriculum of the branch of specialization, a student can choose a maximum of two electives from any specialization under the Faculty during the entire period of study, with the approval of the Head of the Department and the Head of the Department offering the course.

TRANSITORY REGULATIONS

A candidate studying under the old regulations M.E. who could not attend any of the subjects shall be permitted to attend equal number of subjects under the new regulations and will be examined in those subjects. The choice of subjects will be decided by the concerned Head of the Department. However he /she will be permitted to submit the thesis as per the old regulations. The results of such candidates will be passed as per old regulations.

APPENDIX-I
M.E. FULL-TIME (TWO YEAR) DEGREE PROGRAMME IN PROCESS CONTROL AND INSTRUMENTATION ENGINEERING
Subject of Study and Scheme of Examinations

FIRST SEMESTER

Code	Subjects	Period/ Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
PCIC 101	Applied Mathematics	4		3	25	75	100	3
PCIC 102	System Theory	4		3	25	75	100	3
PCIC103	Process Control	4		3	25	75	100	3
PCIC 104	Digital Signal Processing	4		3	25	75	100	3
PCIC105	Industrial Instrumentation	4		3	25	75	100	3
PCIE 106	Elective – I	4		3	25	75	100	3
PCIP 107	Process Control and Instrumentation lab.		3	3	40	60	100	2
	Total	**24**	**3**				**700**	**20**

SECOND SEMESTER

Code	Subjects	Period/ Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
PCIC 201	Industrial Data Communication and Control	4		3	25	75	100	3
PCIC 202	Instrumentation System Design	4		3	25	75	100	3
PCIE 203	Elective - II	4		3	25	75	100	3
PCIE 204	Elective - III	4		3	25	75	100	3
PCIE 205	Elective -IV	4		3	25	75	100	3
PCIE 206	Elective – V	4		3	25	75	100	3
PCIP 207	Advanced Process Control Lab		3	3	40	60	100	2
	Total	**24**	**3**				**700**	**20**

THIRD SEMESTER

Code	Subjects	Period/ Week L	P	Duration of exam. Hrs.	Marks CA	FE	Total	Credits
PCIE 301	Elective-VI	4		3	25	75	100	3
PCIE 302	Elective-VII	4		3	25	75	100	3
PCIT 303	Thesis Phase-I				40	60	100	6
	Total	**8**					**300**	**12**

FOURTH SEMESTER

Code	Subjects	Period/ Week L	P	Duration of exam. Hrs.	Marks CA	FE	Total	Credits
PCI 401	Thesis Phase-II				40	60	100	13
	Total						**100**	**13**

L: Lecture

CA: Continuous Assessment

FE: Final Examination

P: Practical

APPENDIX_II
PCIC 101. APPLIED MATHEMATICS

Probality Theory : Probability – Baye's Theorem for conditional probability – random variable – attribution function – Density function – variance bivariate distribution – covariance – correlation - Regression. Marginal and conditional distribution.

Random Process: stochastic process – classification,auto correction and auto co-variance – cross correlation – stationery process.

Markon charies: - Definition and example – higher transition probabilities – classification of states and chains.

Linear Algebra and Vector Space: Linear system of equation – consistency – test for consistency – linear dependence and independence of vectors – vector space – Bases and dimension – subspace – Inner product space – orthonormal basis – gram – Schmitt orthogonalization process.

Numerical Solution of Partial Differential Equations: Elliptic equation – Poison's equation and laplace equation – liebmann iterative method. Hyperbolic equation; one-dimensional wave equation and radio equation – Parabolic equation – one-dimensional heat equation and telegraph equation – bender – Schmidt method – crank nicolson method.

Topics in Graph Theory: Graphs – Eular paths and circuits, Hamiltonian paths and circuits – trees – undirected trees – spanning trees and minimal spanning trees.

References:

1. Gupta.SC and Kapoor VK. Fundamentals of mathematical statistics, Sultan Chand and sons.
2. Louis A Pipes, Applied mathematics for Enginners and physists, McGraw-Hill.
3. Hoffman and Kanz – Linear Algebra , PHT.
4. N. Deo – Graph Theory, TMH India.
5. M.K. Venkatraman – Numerical methods.
6. J. Medhi – Statistic process – Wiley Eastern Ltd.

PCIC 102. SYSTEM THEORY

Mathematical descriptions of systems: transfer function matrix - state space representation using physical, phase and canonical variables - comparison of input-output description and state-variable description - mathematical description of composite systems.

Solution of dynamical equation - state transition matrix - - impulse response matrix- controllability and observability- linear independence of time functions - Canonical-form dynamical equations for single-variable and multivariable cases - irreducible dynamical equation - controllability and observability of Jordan - form dynamical equation - output controllability.

State feedback: - effects of state feedback, pole placement and feedback gain matrix- State estimators: Full-dimensional state estimator – reduced dimensional state estimator - connection of state feedback and state estimator - decoupling by state feedback.

Non-linear Systems - Behaviour of non-linear systems, jump resonance, subharmonic oscillation- Phase plane analysis: Singular points - construction of phase portraits using isocline, Lienard, Delta and Pells method - limit cycle analysis

Describing Function Techniques: D.F. of nonlinearities - gain function and its determination for analytically and graphically defined nonlinearities- conditions for stability - stability of oscillation - accuracy of D.F. method - stability of systems with multiple nonlinearities - closed-loop frequency response

Stability analysis: Stability in the sense of Liapunov - second method of Liapunov - Liapunov stability analysis of linear time invariant systems and non linear system- Krasovski's theorem- variable gradient method of generating Liapunov functions.

References:

1. Chen. C.T., Linear System Theory and Design, Holt Rinebart and Winston, 1984.
2. Gopal. M., Modern Control System Theory, Wiley Eastern Ltd., 1984.
3. Gopal. M., Digital Control and state variables methods, Tata McGraw-Hill, 1997.
4. Houpis.C.H, Digital Control System- theory, Hardware and Software, 1999.
5. Katsuhiko Ogata, Modern Control Engineering, Prentice Hall of India Pvt. Ltd., 1980.
6. Gibson, J.E, Nonlinear Automatic Control, McGraw Hill Book Co, 1963.
7. Cunningham, W.J., Introduction to Nonlinear Analysis McGraw Hill, 1958.
8. D'Azzo J.J and Houpis. C.H., Linear Control System –Analysis & Design , McGraw Hill, III edition, 1988.

PCIC103. PROCESS CONTROL

Process control – Design aspects – Hardware elements of process control system.

Mathematical modelling of processes: Fundamental laws and equations - level, thermal, flow, gas and mixing process. Interacting and non-interacting process - self-regulation - inverse response - degrees of freedom - linearization - transfer function representation of process - variable gain, variable time constant.

Feedback control of processes: Basic control actions - characteristics of ON/OFF, P, P+I, P+D, P+I+D control modes - non-linear PID control – anti-reset windup - bumpless transfer - practical forms of P+I+D control modes. Selection of control modes for different processes - control schemes for flow, level, pressure and temperature. Methods of controller tuning, Ziegler-Nichols continuous cycling, damped oscillations, process reaction curve methods -Cohen & Coon methods, time - integral criteria.

Advanced control systems: Feedback control of systems with large dead time, dead time compensation - Cascade control- feed forward and ratio control- Adaptive and inferential control systems - internal model control.

Design of control systems for multivariable process: Design equations-degrees of freedom -number of controlled and manipulated variables - generation of alternative loop configurations -extension to systems with interacting units. Interaction of control loops – relative gain array -selection of loops – Design of non-interacting control loops.

Control of typical processes: Distillation column, control of top and bottom product composition, reflux ratio.

Piping and Instrumentation Drawing (P&ID) of control loops.

Reference Books:

1. George Stephanopoulos, Chemical Process Control, An Introduction to the Theory and Practice, Prentice Hall International Inc., 2005.

2. Donald R.Coughanowr, Process Systems Analysis and Control, Second Edition, McGraw-Hill Inc., 1991.

3. Peter Harriott, Process Control, Tata McGraw Hill 26th Reprint, 2005.

4. M. Chidambaram, Applied Process Control, Narosa publishers 2002.
5. D. Patranabis, Principles of Process Control, Tata McGraw Hill, Second Edition,1996.
6. William L Luyben, Michael L Luyben, Essentials of Process Control , Tata McGraw Hill, 1997.
7. Curtis D Johnson, Process Control Instrument Technology, Prentice Hall of India, Seventh Edition, 2003.
8. D.P.Eckman, Automatic Process Control, Wiley Eastern Publication, 1992.

PCIC 104 - DIGITAL SIGNAL PROCESSING

REVIEW OF DISCRETE TIME SYSTEMS:

Discrete - Time Signals -Discrete time Fourier transform (DTFT) - Properties of linear shift invariant discrete systems - Stability and Causality - Frequency response analysis of LSI systems - Structures for discrete time systems -direct, cascade and parallel forms - Lattice structure.

DFT AND FFT ALGORITHMS

Discrete Fourier Transform (DFT): The DFT and its properties Circular convolution - FFT algorithms -Decimation-in-time FFT- Decimation-in-frequency FFT- applications of FFT algorithms-Finite register length effects Quantization noise - round-off effects in digital filters

FILTER FUNDAMENTALS AND DESIGN:

Types of filters - Infinite impulse response and finite impulse response - General design routines - Introduction - Design of IIR digital filters from analog filters – Impulse Invariant and Bilinear transformation techniques - Properties of FIR digital filters - Design of FIR filters using Rectangular, Hann, Hamming and Kaiser windows - comparison of IIR and FIR digital filters-Introduction to adaptive filters.

DSP IN DIGITAL CONTROL

Digital control - Role of DS processor - Advantage of DS processor over Microcontroller - Architecture over view of TMS320F2407 processor - Memory and I/O organization - CPU Addressing Modes - Assembly language Instructions - On chip peripherals - Interface Modules - 2407 DS processor based Fixed point arithmetic -Fixed point filters - Floating point filters - Comparative study- Simulation model study of transfer function - 2407 DS processor as Observers and Estimators.

MULTIRATE DIGITAL SIGNAL PROCESSING

Mathematical description of sampling rate - Interpolation and Decimation - Decimation by as integer factor - Interpolation by an integer factor - Polyphase realization - Application to sub band coding - Wavelet transforms and filter bank (Brief ideas) .

REFERENCE BOOKS:

1. Lonnie C. Ludeman, "Fundamentals of Digital Signal Processing", Harper and Row
   Publishers, 1996.
2. John.G. Proakis, Dimitris G.Manolakis, "Digital Signal Processing - Principles, Algorithms and Applications", Second Edition, Prentice Hall of India, 1995.
3. Sanjith K.Mitra," Digital Signal Processing - A computer Based Approach, Second Edition ", Tata -McGraw-Hill, 2000.
4. Emmanuel C.Ifeachor and Berrie W,Jervis,"Digital Signal Processing - A Practical Approach", Person Education,2003.
5. Venkatramani .B and Bhaskar.M - Digital Signal Processors - TMH- 2002.
6. N J Fliege , Multirate Digital Signal Processing, John Wiley & Sons, 1999.
7. Soman K P, Ramachandran K I, "Insight Into Wavelets: From Theory To Practice", Prentice Hall of India, 2004.

PCIC 105. INDUSTRIAL INSTRUMENTATION

Generalized measurement system- Basic methods of measurement- static and dynamic characteristics of measurement system- Calibration- standards-least square and chi-square test-classification of transducers.

Measurement of Pressure: Fluid properties relating to pressure measurement - manometer -Bourdon gauge - diaphragm gauge - bellows gauge - bell gauge -electrical types - vacuum gauge - Mcleod gauge - Pirani gauge -ionization gauge - thermocouple gauge - pressure transducers and pressure transmitters - differential pressure measurement -instrument calibration principles -instrument mounting , IC Pressure sensor .

Measurement of Flow: Variable head and variable area type flow meters: Orifice plate, Venturi tube, Dahl tube, Flow nozzle, Pitot tube-Rota meter-positive displacement meter-turbine flow meter- electromagnetic flow meter-mass flow meter - ultrasonic flow meter- solid flow measurement-calibration of flow meters - installation and maintenance-selection factors for flow meters.

Measurement of Level: Sight glass - float gauges - displacer and torque tube - bubbler tube - D/P methods - hydrostatic head level measurement - electrical methods: resistance, capacitance type, nucleonic and ultrasonic type level gauges, solid level measurement-Installation , testing and maintenance of level measuring instrument.

Measurement of Temperature: Bimetallic thermometers, filled system thermometers - resistance thermometer, 3-lead and 4-lead arrangement-thermistor-thermocouple types and ranges-cold junction compensation-linearization of thermocouple-radiation pyrometer- optical pyrometers-primary and secondary standards for calibration of temperature measuring devices-installation, testing and calibration of thermocouple and RTD based transmitters , IC Temperature sensor.

Measurement of weight, density, and vibration: Load cell method- strain gauge, LVDT, Piezo electric pneumatic and hydraulic load cell- null balance method-conveyer belt weighing for online measurement- Constant volume hydrometer – gamma ray density measurement-vibrating probe liquid densitometer-Installation , testing and maintenance of weight and density measuring instrument.

Intrinsic Safety: Definition - zone classification - intrinsically safe pneumatic measurement systems - intrinsically safe electronic system.

References:

1. D. Patranabis, Principles of Industrial Instrumentation, Tata MCGraw Hill, 1998.
2. Donald P.Eckman, Industrial Instrumentation, Wiley Eastern Limited, 1991.
3. R.Donald Gillum, Industrial Pressure Measurement, ISA, 1982.
4. R.Donald Gillum, Industrial Level Measurement, ISA, 1984.
5. David W.Spitzer, Industrial Flow Measurement, ISA, 1990.

6. John P.Bentely, Principles of Measurement System, Longman Scientific and Technical,1995.

7. Jone's, Instrument Technology, Vol. 1: Mechanical Measurements, English Language Book Society, Fourth Edition, 1985.

8. Douglas M.Considine,Editor-in-Chief, Process Instruments and Controls Handbook, Fourth Edition, McGraw-Hill Book Co., 1994.

9. Doebelin, E.O., Measurement Systems, McGraw Hill, Fourth edition, Singapore,1990.

10. R.K. Jain, Mechanical and Industrial measurements, Khanna publishers, Delhi, 1990

PCIP 107 : PROCESS CONTROL AND INSTRUMENTATION LAB

The list of experiments for the subject PCIP 107 Process Control and Instrumentation Lab will be decided by Head of Department of Instrumentation Engineering time to time depending on the current trends

PCIC 201. INDUSTRIAL DATA COMMUNICATION AND CONTROL

Data Acquisition Systems(DAS): Review of A/D and D/A Converters - Sampling and digitizing - Review of Analog Communication Systems and techniques - multiplexing –TDM & FDM- Data Communication - transmission lines and digital signals - practical line interface circuits - serial asynchronous communication protocol - Intel 8251A - current loop, RS 232 C- RS 485 - GPIB - USB.

Transmission Characteristics of a wire telephone network - MODEM - Data coding methods - error detection, correction and encryption. Fiber Optic transmission - Optical fiber Cables - connectors and couplers - light sources and detectors - Introduction to SCADA

Architecture of a PLC – Analog and digital types of I/O modules – PLC system memories - Program and data organization inside a PLC - Networking of multiple PLC.

Methods of Computer Control of Processes, their configuration and comparison: Direct Digital Control, Supervisory Digital Control, Distributed Control System (DCS).

DCS :- Local Control Unit(LCU) and architecture - LCU languages - LCU - Process interfacing issues. Operator interface - requirements Engineering interface - requirements - displays - alarms and alarm management. Factors to be considered in selecting a DCS.

Network topology and media - switching systems – OSI model - Data link Control protocol. Media access protocol: Command/response - Token passing - CSMA/CD, TCP/IP. Bridges - Routers - Gateways. Standard ETHERNET and Industrial ETHERNET Configuration - Special requirement for networks used for Control.

HART: Introduction - Evolution of Signal standard - HART Communication protocol - Communication modes - HART Commands – HART and the OSI model.

Field Bus: Introduction - General Field bus architecture - basic requirements of field bus standard - field bus topology - Interoperability - Interchangeability.

Introduction to MODBUS, CANBUS, LON WORKS, FIP

References :

1. William L. Schweber, Data Communications, McGraw-Hill, 1988.
2. Michale P. Lucas, Distributed Control Systems,Van Nostrand Reinhold Co., 1986.
3. Romilly Bowden, HART Application Guide, HART Communication Foundation,1999.
4. M.Chidambaram, Computer control of processes, Narosa publishing house, 2002.
5. Lawerence M.Thompson, Industrial data Communications, ISA Press 1997.
6. Behrouz A. Forouzan, Data communications and Networking, Tata Mcgraw Hill , 2000.

PCIC 202. INSTRUMENTATION SYSTEM DESIGN

Orifice meter - design of orifice for given flow condition - design of rotameter - design of RTD measuring circuit - design of cold junction compensation circuit for thermocouple using RTD - Transmitters - zero and span adjustment in D/P transmitters and temperature transmitters- Design of flapper-nozzle and design of Pneumatic amplifiers- Design of V-I, P-I, I-P and I-V converters.

Bourdon gauges - factors affecting sensitivity - design of Bourdon tube - design of Air purge system for level measurement.

Electronic P+I+D controllers - design - adjustment of set point, bias and controller settings.

Control valves - design of actuators and positioners - types of valve bodies - valve characteristics - materials for body and trim - sizing of control valves - selection of body materials and characteristics of control valves for typical applications.

Design of logic circuits for alarm and annunciator circuits interlocks - design of microprocessor based system for data acquisition - design of microprocessor based P+I+D controller.

References:

1. J.P.Bentley, Principles of Measurement Systems, Longman Inc., 1983.
2. C.D. Johnson, Process Control Instrumentation Technology, Prentice Hall of India, 1998
3. N.A.Anderson, Instrumentation for Process Measurement and Control, Chilton Company, 1980.
4. D.M.Considine, Process Instruments and Controls Handbook, McGraw-Hill., 1994.

PCIP 207 : ADVANCED PROCESS CONTROL LAB

The list of experiments for the subject PCIP 207 Advanced Process Control Lab will be decided by Head of Department of Instrumentation Engineering time to time depending on the current trends

LIST OF ELECTIVES

1. Embedded Systems
2. Neural Networks and Fuzzy Logic
3. System Modeling and Identification
4. Optimal Control
5. Advanced Process Control
6. Computer Control of Process
7. Real Time Embedded System
8. Industrial Drives and Control
9. Advanced Digital Signal Processing
10. Advanced Instrumentation Systems
11. Adaptive Control
12. Fault Tolerant Control
13. VLSI System Design
14. Digital Image Processing
15. MEMS Design and Fabrication
16. Bio Signal Processing
17. Modelling of Physiological Systems.

1. EMBEDDED SYSTEMS

EMBEDDED CONTROLLER ARCHITECTURE

Embedded System Concepts – Embedded Hardware Devices – 8051 and it's derivatives – Architecture of MCS-51 series of embedded controller – Memory Organization – Flash Memory – Addressing Modes – Assembly Language Instructions – RISC Embedded Controller –PIC 16F877 Architecture – Memory Organization – Assembly Instruction.

EMBEDDED PERIPHERALS INTERFACING

Embedded peripherals in MCS51 & PIC16F877 – General Purpose I/O – Timer – Counter –UART/USART – Interrupts – Modern industrial peripherals – RS485 – I^2 C – SPI –USB – CAN – LIN – Wireless LAN – IEEE 802.11 – Blue tooth – Embedded Networking – Peripheral interfacing with input / output devices – LED – LCD – Keyboard – ADC – DAC.

EMBEDDED PROGRAMMING

Embedded Software Tools – Assembler - Compiler – Simulator – Debugger – In-circuit Emulator – Target Programming – Integrated Development Environment – Embedded 'C' Programming – Software IDEs for 8-bit Embedded Controller – RIDE – CCS – Software IDEs for 32-bit Embedded Controller – GNU 'C' – Keil.

ADVANCED EMBEDDED CONTROLLER

32-bit RISC Controllers – ARM – ARM Architecture – Modes of Operations – Instruction Formats – ARM Derivatives – Programming with ARM Embedded Controllers – Software Tools for ARM – GNU 'C' – Keil – Peripheral Interfacing – ARM Applications.

EMBEDDED REAL TIME SOFTWARE DESIGN

Embedded Operating System – Comparison with General Purpose OS – Real Time Operating System – RTOS Tasks – Kernel – RT Scheduling – Interrupt Processing – Memory Management using RTOS – Synchronization – Message Queues – Control Blocks – Porting of RTOS to the target board – Comparison and study of various RTOS like Windows CE, Embedded Linux, μcos, QNX, VXWORKS, Nucleus.

REFERENCE BOOKS:

1. Kenneth J. Ayala- The 8051 Microcontroller Architecture, Programming & Applications.
2. Myke Predko - Programming & Customizing PIC Microcontrollers
3. David Seal ARM Architecture Manual –

2. NEURAL NETWORKS AND FUZZY LOGIC

ARTIFICIAL NEURAL NETWORKS

Introduction to Artificial Neural Networks - Fundamental concepts, weights, Biases and thresholds - Artificial models - Linear capability - Common activation functions - Learning rules and Learning methods of ANN. Single Layer, Multilayer Feed forward network - Recurrent Network.

NEURAL NETWORK ARCHITECTURES AND ALGORITHMS

Muculloch pitts neuron - Hebbnet - Perceptron - Adaline - Hopfeld net -Maxnet - Mexican Hat - Hamming net - Kohonen self organising Map-Adaptive resonnce theory - Back propogation neural net

NEURAL COMPUTING

Terminology -Adaptive co-efficient connection - Learning law - Processing element - Schduling function - Trasferfunction - Transformations - Weights - Application of neural computing for pattern classification and recognition

FUZZY THEORY

Fuzzy set theory -Fuzzy relations -Linguistic Variables - Membership functions - Fuzzy to Crisp Conversions -Fuzzy rule base -Choice of Variables - Derivation of rules -Defuzzification methods. Fuzzy Logic Control - Structure of FLC -Mandani and Sugeno type Fuzzy Systems.

NEURO FUZZY CONTROL

Cognitron and Neocognitron Architecture - Training algorithm and application - Fuzzy associative Memories -Fuzzy and Neural function estimators - FAM System Architecture - Comparison of Fuzzy and Neural systems.- Adaptive Neuro, Adaptive Fuzzy, Adaptive Neuro- Fuzzy interface Systems. Neuro Controller, Fuzzy logic Controller for a temperature process and aircraft landing problem.

REFERENCE BOOKS

1. Lawrene Fausett, "Fundamentale of neural networks" Prentice Hall, 1994.
2. D.Driankov,H.Hellendoorn arow M.Reinfrank. "An introduction to Fuzzy Control "Narosa Publishing co., New Delhi,1996.
3. Timothy J.Ross,"Fuzzy Logic with Engineering Applications",McGraw-Hill, Newyork,1996.
4. G.J. Klin and T.A. Folger,"Fuzzy sets, uncertainty and information", Prentice Hall,.
5. J.M.Zurada,"Introduction to Artificial Neural Systems",Jaico Publishing House, NewDelhi,1994.
6. Stamatios V.Kartalopoulos,"Understanding Neural Networks and Fuzzy Logic - Basic concepts and Applications", IEEE Press, Newyork,1996.
7. Simon Haykin,"Neural Networks",Macmillan College Publishing Co.,

New york,1994.
8. JSR Targ,CT Sur,E.mezutori- Neuro Fuzzy and Soft Computing - PHI 2002.
9. Jun Hong NIE and Derek Linkers - Fuzzy - Neural Control - PHI , New Delhi 1998.

3. SYSTEM MODELLING AND IDENTIFICATION

Mathematical modeling of dynamic system: Modeling in state space - state space models – canonical state space forms- mechanical systems –Electrical systems – Liquid level systems- Thermal systems.

Model for time varying and nonlinear systems: linear time varying models – nonlinear model as linear regressions – nonlinear state space model. Linearization of nonlinear models – single variable –one state variable and one input variable – linearization of multi state models – interpretation of linearization.

Process Identification (Non-Parametric methods): Transient response analysis - frequency response analysis - correlation analysis.

Discrete time system models for control: ARX models - bilinear parametric models - ARMAX models - NARMAX models - Hammerstein models – Wienner model - linear and non-linear model structure selection. Selection of pseudo random binary sequence.

Recursive plant model identification in open-loop: Identification methods - least squares - recursive least squares - extended least squares – generalized least squares - maximum likelihood method - model validation identified in open-loop – Model order selection .

Recursive plant model identification in closed-loop: Identification methods - closed-loop output error algorithms - filtered closed-loop error algorithms - filtered open-loop identification algorithms - model validation identified in closed-loop - comparative evaluation of various algorithms.

Robust parameter identification – Input Output data filtering – effect of disturbancePAA with projection – data normalization – robust parameter estimation scheme.

State estimation using Kalman Filter and extended Kalman filter for parameter Identification.

Practical aspects of system identification and control: Selection of input signals - offline and online identification – comparison of parameter estimation methods – model order testing and verification .

References:

1. I.D. Landou, R. Lozano and M.M. Saad, Adaptive Control, Springer-Verlag, 1998.
2. W.D.T. Davies, System Identification for self adaptive control, Wiley – Interscience,
3. Lennart Ljung, System Identification, PTR Prentice Hall, Englewood Cliff, New Jersey, 1987.
4. R. Iserman, Practical aspects of process identification, International federation of automatic control, Pergamon Press Ltd., Automatica, Vol16 pp575 – 585,
5. Katsuhiko Ogato,Modern Control Engineering , Prentice Hall of India, 4th Edition,2003.

6. M.Chidambaram, Computer control of processes, Narosa publishing house, 2002.
7. Kannan M Moudgalaya, Digital Control, QIP course on digital control, 2005.

4. OPTIMAL CONTROL

Optimal Control Problems and Performance Measures: Statement of optimal control problem - problem formulation and forms of optimal control - selection of performance measures.

Calculus of Variation: Fundamental concepts - extremum functionals involving single and several independent functions - piecewise smooth extremals - constrained extrema.

Variational Approach to Optimal Problems: Necessary conditions for optimal control - Pontriyagin's minimum principle - state inequality constraints - minimum time problem - minimum control effort problems.

Quadratic Optimal Control – Quadratic optimal Control problems – steady state quadratic Optimal Control – Quadratic optimal control of servo systems.

LQ Control Problem: Linear optimal regulator problem - Matrix Riccati equation and solution method - choice of weighting matrices - steady state properties of optimal regulators - linear tracking problem.

Dynamic Programming: Principle of optimality - recurrence relation of dynamic programming for optimal control problem - computational procedure for solving optimal control problems - characteristics of dynamic programming solution - dynamic programming application to discrete and continuous systems - Hamilton Jacobi Bellman equation. Numerical Techniques: Numerical solution of two-point boundary value problem and Fletcher Powell method - solution of Ricatti equation by iterative method.

References:

1. M.Gopal, Modern Control Systems Theory, Second Edition, Wiley Eastern Ltd., 1984.

2. D.E.Kirk, Optimal Control Theory-An Introduction, Prentice Hall, 1970.

3. Katruhiko Ogata, Modern Control Engineering, Prentice Hall of India Ltd.,

4. Sage A.P. and White CC, Optimum System Control, Prentice Hall, New Jersey, 1977.

5. ADVANCED PROCESS CONTROL

Introduction to process control – Review of advancements in process control – Statistical process control – Introduction to Multivariable process control – selection of controlled outputs manipulation and measurements – RGA for non-square plant – Control configuration elements – decentralized feedback control – Trade-offs in MIMO feedback design – LQG control – H_2 and H_∞ control – H_∞ loop-shaping design – Optimization and control.

Robust control – plants with uncertain parameter: Introduction – Crane, four-wheel car steering – Automatic car steering – A flight control problem – notation for uncertain plants. Analysis and design: Eigen value specification – Introduction to Robustness analysis – Introduction to robust controller design – Three basic rules of robust control.

Single loop feedback structures: Interval plants with a compensator – positive interval plant with a positive comparator – Tree structural transfer function – robustness with respect to sector non-linearities.

Parameter space design: Introduction to design by simultaneous gamma stabilization – Pole region assignment – Interactions in controller parameter space – solution of a controller from the admissible set – case study – Automatic steering of a bus – Flight control.

Model based predictive control: MPC strategy – MPC elements – prediction models – objective function – obtaining the control law – review of some MPC algorithms – Introduction to Non-linear predictive control.

Implementation of Multi Variable control and Model Predictive Control for Heat exchanger, Distillation column and batch process.

References:

1. Sigurd skogestad Ian postlethwaite, Multivariable Feedback Control, John wiley & sons, 2000.

2. Jurgen-Ackermann, Robust Control Systems with uncertain physical parameters, third edition, Springer – Verlog London limited, 1997.

3. E.F.Camacho and Bordom, Model Predictive Control, Second edition, Springer – Verlog London limited, 2000.

6. COMPUTER CONTROL OF PROCESSES

Introduction to Computer control system: Need for computer in a control system- Building blocks of a computer control system - Sequential control – Direct digital control – Supervisory control.

Representation and analysis of sampled data control systems: Z-transform and properties - inverse Z-transform - pulse transfer function - data holds-sampling theorems, aliasing - sampling frequency considerations - analysis of closed loop sampled data control systems - modified Z-transform and applications - stability analysis - multirate sampling.

Digital control algorithms: Design of control algorithm using Z-transform - deadbeat algorithm - Dahlin’s method - ringing - Kalman's approach - discrete equivalent to an analog PID controller - design for set point and load changes. - position and velocity forms of PID controllers – tuning - selection of sampling time - algorithms incorporating antireset windup and bumpless transfer - Deadtime compensation and
Smith predictor algorithm.

Programmable Logic Controllers (PLCs): Basic components and configuration - discrete, analog and digital types of I/O modules: typical input and output field devices and modules of each type - I/O signal types and typical signal conditioning circuits - common electrical devices and symbols - intelligent I/O modules like control loop module - Communication I/O modules, network communication module - distributed I/O - AS-interface. Memory types used in PLCs - memory map - assigning I/O address and internal address - scan sequence.

Programming Languages: Ladder diagram - boolean - function blocks - programming devices: hand-held programmer - industrial programming terminal - personal computer based programmer - development of programmes for typical applications - editing and testing by simulation of programmes. Basic design aspects of I/O systems - electrical, mechanical and environmental specifications. Installation and maintenance of PLCs.

Interlocks and alarms: Interlock design principles, fail-safe design - alarms and their types.

Case Study: Computer control of a thermal process .

Reference Books:

1. P.B.Deshpande and R.H. Ash, Computer Process Control, Second Edition, Instrument Society of America, 1988
2. T.A. Hughes, programmable controllers ISA 1989.
3. B.C.Kuo, Digital Control Systems, Holt, Rinehart and Winston Inc., 1980.
4. C.L. Smith, Digital Computer Process Control, Intext Educational Publishers, 1972.
5. M.Gopal, Digital Control Engineering, Wiley Eastern Publishers, 1989.
6. K.J.Astrom and B.Wittenmark, Computer- Controlled Systems, Second Edition, Prentice-Hall of India, 1994
7. S.K. Singh, Computer Aided Process Control, Prentice Hall of India, 2003.

8. M. Chidambaram, Computer Control of Processes, Narosa Publications, 2003.
9. D.R. Coughanowr, Process Systems Analysis and Control, Second Edition, McGraw Hill, 1991.

7. Real Time Embedded Systems

Introduction: Definition of an embedded system – difference between general purpose computer and an embedded system – typical examples of an embedded system – basic components of an embedded system – definition and features of a real time embedded system – design parameters of an embedded system: NRE cost, unit cost, time to prototype, time to market, size, performance, power, flexibility and maintainability – product development cycle of an embedded system.

Microcomputer Architecture: Selection criteria of a processor for an embedded system - Architecture of 6811 and 6812 microcontrollers – memory allocation – 6811/6812 instruction set – programming – assembly language programming – I/O programming.

Programming Techniques for Embedded System: Need for advanced programming techniques in the embedded system development – static and dynamic efficiency of software of an embedded system – modular design concept: advantages of modular programming techniques – definition and components of a module – coupling and its minimization in modular design – layered architecture for embedded system software. **Data Structures:** Elementary data structure – memory allocation and initialization – global and local variable creation using C – random access and sequential access data structures – arrays , strings, matrices, tables, queues and trees and their implementation using C – FIFO queues – buffers – dynamically allocated structures.

Program Structures: Local variable implementation using C – parameter passing in C – C compiler implementation of local and global variables – control structures – finite state machines with statically allocated linked structures – stepper motor controller and traffic controller implementation. **Debugging:** Debugging theory **-** Hardware debugging tools – functional debugging: Single stepping – Breakpoints without filter – Conditional breakpoints – Print statements - dumb into array with filtering - monitor using the LED display – performance debugging: measuring with an independent counter, TCNT - instrumentation output port - measurement of dynamic efficiency – profiling: profiling using a software dump to study execution pattern – profiling using an output port – thread profile and reentrant behavior.

Real Time Operating Systems: Internals of an operating system – multi tasking operating systems – scheduler algorithms – priority inversion – tasks – threads and processes – memory management and address translation - commercial operating systems: pSOS+ - pSOS+ kernel - pSOS+ multiprocessor kernel – Vxworks - QNX.

Reference Books

1. **Jonathan W. Valvano,** Introduction to Embedded Microprocomputer Systems, *Thomson Asia Private Ltd.,* 2004.

2. **Steve Heath,** Embedded Systems Design, *Newns (An imprint of Elsevier),* 2005.

8. INDUSTRIAL DRIVES AND CONTROL

Introduction to electric drives – Classification, characteristics and advantages of electric drives – Speed- torque characteristics of various types of loads and drive motors – Joint speed-torque characteristics - Selection of power rating for drive motor based on thermal limits – Overload capacity – Starting, braking and reversing methods for various types of motors.

DC Drives: Comparison between conventional and solid state DC drives – Transfer function of DC separately excited motor with single phase semi and full converters –Reversible DC drive –Review of chopper operation –Analysis of chopper fed DC separately excited motor.

AC Drives: Stator voltage control of induction motor–Stator frequency control–Slip controlled drives-Rotor resistance control of induction motor.

Synchronous motor drives – Modes of operation

Stepping motors –Types Modes of excitation – Torque production –Servo control of stepping motors

Servo motors: AC and DC servomotors.

Open loop, closed loop and error transfer functions of generic drive – Specifications for transient and steady-state responses - P, PI and PID controllers- Analysis of closed loop system – Stability analysis – Design of control algorithms for load changes-

Digital techniques in speed control – Advantages and limitations – Microprocessor, microcontroller and PLC based control of drives – Selection of drives and Control schemes for paper mills, cement mills, sugar mills.

References :

1. Vedam Subrahmaniam, Electric drives – Concepts and applications, Tata McGraw Hill Publishing House, Chennai, 1994

2. G.K. Dubey, Fundamental of electrical drives, Narosa Publishing House, Chennai, 1995.

3. J.M.D Murphy & F.G. Turnbull, Power Electronic Control of AC motors, Pergamum Press, New York,1988

4. T.Kenjo, Stepping motors and their microprocessor control, Clarendon press, Oxford, 1984.

9. ADVANCED DIGITAL SIGNAL PROCESSING

Discrete Random Signal Processing: Discrete Random Processes, Expectations, variance, Co-variance, scalar product, energy of discrete signals- Parseval's theorem. Wiener Khintchine relation- power spectral density Periodogram sample autocorrelation-sum decomposition theorem, spectral factorization theorem- discrete random signal processing by linear systems- simulations of white noise-low pass filtering of white noise.

Spectrum Estimation: Non-parametric methods-correlation method --co-variance estimator - performance analysis of estimators-unbiased, consistent estimators Periodogram Estimator-Barlett spectrum estimation-Welch estimation Model based approach- AR,MA,ARMA Signal Modeling -Parameter estimation using Yule - Walker method.

Linear Estimation And Prediction: Maximum likelihood criterion- efficiency of estimator - least mean squared error criterion-wiener filter discrete wiener Hoff equations-Recursive estimators - Kalman filter- linear prediction, prediction error- whitening filter, inverse filter-Levin son recursion, Lattice recursion, Lattice realization and Levinson recursion algorithm for solving Toeplitz system of equations.

Adaptive Filters: FIR adaptive filters - Newton's steepest decent method - adaptive filter based on steepest descent method Window-Hoff LMS adaptive algorithm - Adaptive channel equalization- Adaptive echo chancellor- adaptive noise cancellation- RLS adaptive filters-Exponentially weighted RLS- sliding window RLS-simplified IIR LMS adaptive filter.

Maltirate and Wavelet Transform: Review of Decimation and Interpolation Process. Sub band filter theory – PR condition – Cosine modulated filters – Para-unitary filters. Application of wavelet transform with Sub band filter theory. Wavelet transform as a correlator. Multiresolution theory – Heisenberg uncertainty principle – Two dimensional wavelet transform.

References:

1. Manson H.Hayes, Statistical Digital Signal Processing and Modelling, John Wiley and sons, Inc., New York, 1996.

2. Sopocles J. Orfanidis, Optimum Signal Processing, McGraw Hill, 1990.

3. John G. Proakis, Dimitris G. Manolakis, Digital Signal processing, prentice Hall of India, 1995.

4. N. J Fliege , Multirate Digital Signal Processing, John Wiley & Sons, 1999.

5. Soman K P, Ramachandran K I, “Insight Into Wavelets: From Theory To Practice”, Prentice

Hall of India, 2004.

10. ADVANCED INSTRUMENTATION SYSTEM

Virtual Instrumentation: Review of Virtual Instrumentation: Historical perspective, advantages etc, block diagram and architecture of a Virtual Instrument. Data-flow techniques: Graphical programming in data flow, comparison with conventional programming.

Virtual instrumentation programming techniques: VIs and sub VIs, loops and charts, arrays, structures, clusters and graphs case and sequence structures, formula nodes, local and global Variables, string and file I/O– PC for DAQ and Instrument Control- Instrument drives- VXI Bus.

Fiber Optic and Laser Instrumentation: Fiber optic sensors, Intrinstic & extrinsic type(Temperature, flow, pressure, level) Characteristics and laser generation, Types of lasers, Industrial applications of lasers: laser for measurement of distance and length, velocity, acceleration – Calculation of power requirements of laser for material processing

Smart Instrumentation: Introduction to Intelligent sensors – smart sensors for temperature and pressure – Smart transmitters for measurement of differential pressure, flow and temperature- self diagnosis and remote calibration features.

References:

1. Allen. H.C. An Introduction to optical fibers, McGraw Hill International Book Co., 1993.
2. D.C. oshes and W. Russel callen, Introduction to Laser and applications, Addison Wesley, 1978.
3. Whereelt B.S. Laser Advances and applications John Willey, 1979.
4. Skoog, Holler & Nieman, Principles of Instrumental Analysis, Fifth Edition- Standers College Publisher, Harcourt Brace College publishing, 1998.
5. Leonard Sokolof, Basic concepts of LabVIEW4, Prentice Hall, 1998.

11. ADAPTIVE CONTROL

Introduction to System Identification: – Adaptive Control Vs Conventional feedback control - adaptive control schemes.

Direct adaptive control: Introduction – Adaptive tracking and regulation with independent objectives – Basic design – Extensions of the design – Adaptive tracking and regulation with weighted input – Adaptive minimum variance tracking and regulation – The Basic Algorithms – Asymptotic convergence analysis – Martingale convergence analysis – Adaptive generalized minimum variance control – Robust direct adaptive control – The problem – Direct adaptive control with bounded disturbances – Direct adaptive control with unmodelled dynamics – An example.

Indirect adaptive control: Introduction – Adaptive pole placement – The basic algorithm – Analysis of the indirect adaptive pole placement – The "Singularity" problem – Adding external excitation – Robust indirect adaptive control - Standard robust adaptive pole placement – Modified robust adaptive pole placement – Adaptive generalized predictive control – Adaptive linear quadratic control – Iterative identification in closed loop and controller redesign – An example.

Model Reference Adaptive systems: Introduction – The MIT rule – Determination of the adaptation gain Lyapunov theory – Design of MRAS using Lyapunov theory – Bounded input bounded output stability – output feedback – Relation between MRAS and STR – Non-Linear systems. Gain Scheduling: Introduction – the principle – Design of gain scheduling controllers – Non-linear transformation – Application of gain scheduling – Introduction to self oscillating adaptive system.

Practical aspects of Adaptive Control system.

Case studies : Temperature control in a distillation column, chemical reactor control, pulp dryer control & control of a rolling mill.

References :

1. I.D.Landau, R.Lozano and M.M'Saad, Adaptive Control, Springer – Verlog London limited, 1998.
2. Karl J.Astron Bjorn Wittenmark, Adaptive Control, second edition, Pearson Education pte. Llimited. 1995**.**
3. Wellsted P.E. and Zarop. M.B., Self tuning systems, John wiley & sons, 1991.

12. FAULT TOLERANT CONTROL

Definition of fault: - Classification and types of fault – Fault detection and Identification – Classification of fault detection and identification schemes – Model based and Model free methods.

Implementation of FDI approach – residual generation – residual evaluation

Quantitative model based FDI- State and parameter estimation based FDI- Parity space approach based FDI - structured residual approach:- directive residual approach- statistical approach based FDI:- Generalized likelihood ratio- sequential probability ratio test.

Introduction to fault tolerant control - active Fault tolerant control – passive fault tolerant control approach- eigen structure assignment- Introduction to Neural Network and Fuzzy based fault tolerant control.

Introduction to qualitative model based FDI – introduction to neural network and fuzzy based FDI.

References:

1). Gertler M. Fault detection in dynamic system, Marcel Decker Inc corp. 1998.

13. VLSI SYSTEM DESIGN

VLSI DESIGN CONCEPTS

Evolution of VLSI - VLSI design process - Architectural design - Logical design - Physical design - Lay-out styles - Full custom - Semi custom approches - Need for design rules - Types of design rules - Design for MOS & CMOS circuits - Simple layout examples - Sheet resistance, area capacitance, wiring capacitance - Dry capacitive loads.

VLSI FABRICATION TECHNIQUES

Wafer fabrication - Wafer processing - Oxidation - Patterning - Silicon gate NMOS process - CMOS process - Nwell - Pwell - Twintub - Silicon on insulator - CMOS Process enhanchments - Analytical techniques - Ion beam techniques - Chemical methods - Package fabrication technology - Reliability requirements - Field loss - Failure mechanism - Design automation.

ANALOG VLSI

Introduction to analog VLSI - Analog circuit building blocks - Switches,active resistors - Current sources and sinks - Current mirrors/amplifiers - MOS & BJT,inverting amplifiers - CMOS and BJT two stage op-amp - Analog signal processing circuits - Sensors - D/A and A/D converters.

DIGITAL VLSI

Logic design - Switch logic - Gate logic - Dynamic CMOS logic - Structured design - Simple combinational logic design - Clocked sequential design - Sub-system design - Design of shifters - Arithmetic processors - ALU - Serial,Parallel and pipelined multiplier arrays.

ASIC DESIGN AND VHDL

Architecture and Programing technologies of ROMs , EPROMs, PLA, PAL , Gate arrays , CPLDs and FPGAs - Xilinx family. LCA - I/O block - programmable interconnect - Configuration memory. VHDL-Syntax and semantics-Identifiers and literals-Entities and

Architectures-Packages and libraries interface-sequential statements - Arithmetic operators-VHDL and logic synthesis- Introduction to structural model-Verilog:Basics of verilog- Operators, hierarchy procedures and assignments-Timing controls and delays-Tasks and functions-Control statements- Verilog and logic synthesis.

REFERENCE BOOKS:

1. Douglas A.pucknell and kamran Eshranghiaon., "Basic VLSI Design" Prentice Hall of India,New Delhi,3'rd Edition, 1994.
2. Eugene D Fabricus., "Introduction to VLSI Design" Mc Graw Hill International Edition.
3. Malcolm R.Haskard,Lan C.May., "Analog VLSI design - nMOS and CMOS" Prentice Hall,1988.

4. Caver Mead and Lynn Conway., "Introduction to VLSI systems" Addison-Wesley, USA,1980.
5. James E.Palmor,Darid E.Perlman., "Introduction to Digital systems" Tata Mc Graw Hill,1996.
6. Kevin skahill., "VHDL for programmable logic device" Addison Wesley,1996.
7. Smith., "Application specific Integrated circuits" Addison-Wesley, 2nd reprint,2000.
8. Bhaskar.J. "A VHDL Primer", PHI, 1999.
9. David Pellaris,Douglas Taylor., "VHDL Made easy", PHI Inc, 1997.
10. AMAR Mukherjee., "Introduction to nMOS and CMOS VLSI system Design" Prentice Hall,USA,1986
11. Douglas Perry, VHDL, Mc_Graw Hill International, Third edition, 1999.

14. DIGITAL IMAGE PROCESSING

Digital Image Processing: Origin– components - examples of fields that use DIP. Digital Image Fundamentals: Elements of visual perception, light and the EM spectrum, a simple image formation model, image sampling and quantization, some basic relationships between pixels. Image transforms - Two dimensional orthogonal and unitary transforms - properties of unitary transform.

Image enhancement: Point operations - contrast stretching - clipping and thresholding - digital negative intensity level slicing - bit extraction. Histogram: modelling - eqalization - modification. Spatial operations: smoothing techniques - magnification and interpolation. Transform operations.

Image Compression: Compression models - elements of information theory - error free compression - run length coding - loss less and lossy predictive coding - image compression standards.
Image Segmentation - Detection of discontinuities, point, line and edge detections, gradient operators, Laplacian, edge linking and boundary detection, thresholding, region based segmentation.

Image filtering and restoration: Inverse and weiner filters – filtering using image transforms. Splines and interpolation. Maximum entropy restoration. Bayesian methods. Image analysis- spatial feature extraction - transform features. Edge detection – boundary extraction, shape features image segmentation**.**

Image reconstruction from projections: (CT reconstruction): Radon transform-inverse radon transform back projection operator-convolution back projection- parallel beam geometry-Fan beam geometry. MRI Fourier reconstruction.

References Books

1. Jain Anil K, Fundamentals of Digital Image Processing, Prentice Hall of India, New Delhi, 1995.
2. Rafael C Gonzalez and Richard E Woods, Digital Image Processing, 2nd Edition, Pearson Education, 2003.
3. Rosenfield Azriel and Kak Avinash C, Digital Picture Processing, Academic Press Inc., NY,1991
4. Pratt William K, Digital Image Processing, John Wiley and Sons, 2001
5. Chanda Dutta Magundar, Digital Image Processing and Applications, Prentice Hall of India, New Delhi, 2000.

15.MEMS Design and Fabrication

Introduction to MEMS Design

Microsystems vs. MEMS - Markets for Microsystems and MEMS, Scaling Principles. MEMS Design: Device categories - High level design issues – design process – Modelling levels: Analytical modeling - numerical modeling.

MEMS materials Fabrication Methods

Silicon material system: Substrates and material properties-Doping– Oxidation – Concepts of Bulk Micro machining and Surface Micro machining **Additive Processes:** Evaporation and sputtering – Chemical vapor deposition (CVD) **Lithography- Wet etching:** Isotropic– Anisotropic – Etch stops- **Dry etching:** Vapour – Plasma / RIE – DRIE- **Other processing techniques and materials:** LIGA– Lift-off– Chemical-Mechanical Polishing (CMP)– Soft Lithography and polymers – Wafer Bonding **-Process integration:**– Process flows– Commercial surface micromachining– Design rules and Mask making- Sample Process Flows- A Bulk Micro machined Diaphragm Pressure Sensor-A Surface-Micro machined Suspended Filament.

MEMS mechanics, Modelling, Dynamics, Structures and Electrostatics

Mechanics of materials: Stress and strain - Plane stress -. Anisotropic materials - Thermal expansion Thin film stress - Material properties - Typical values of MEMS materials- Design limits and safety factors - **Lumped element modelling:** Conjugate power variables, co-energy, mapping to electrical circuits- **Dynamics :** Linear first order systems -Linear second order systems - **Structures :** Bending of beams -Torsion of beams - Axial load and buckling of beams - Effect of residual stress and stress gradient Bending of Plates - Stiffness and natural frequencies – **Electrostatics:** Parallel plate capacitor -electrostatic actuator - Pull-in.

Advanced MEMS for Sensing and Actuation

Electromechanical effects: Piezoresistance - Piezoelectricity - Shape memory alloy-

Thermal effects: Temperature coefficient of resistance - Thermo-electricity – Thermocouples – **Micro fluidics:** Low Reynolds number fluid flow - Pressure-driven flows - Squeeze film damping - Surface tension and bubbles -Devices: pumps, valves, mixers - **Integrated fluidic systems**: BioMEMS.

Design of Pressure Sensors and Accelerometers

Piezoresistive Pressure Sensor: Sensing Pressure, Piezoresistance- Analytic Formulation in Cubic Materials-Longitudinal and Transverse Piezoresistance - Piezoresistive Coefficients of Silicon- Structural Examples- Signal Conditioning and Calibration.

Capacitive Accelerometer: Fundamentals of Quasi-Static Accelerometers, Position Measurement with Capacitance- Circuits for Capacitance Measurement-Demodulation Methods- Case Study- Specifications- Sensor Design and Modeling- Fabrication and Packaging.

References

1. Stephen D. Senturia, Micro system Design, Springer International Edition, 2001.
2. Chang Liu, Foundations of MEMS, (ILLINOIS ECE Series), Pearson Education International, 2006.
3. Gregory TA Kovacs, Micro machined Transducers Source Book, WCB McGraw Hill, Singapore, 1998.
4. Tai-Ran-Hsu, MEMS & Microsystems Design and Manufacture, TATA McGraw-Hill, New Delhi, 2002.

16 . BIO SIGNAL PROCESSING

Objectives:

This course is meant to enable the students to conceive and understand the basics of signal processing in general and in particular when used in few biomedical engineering fields through use of relevant transforms and filters

Syllabus:

Signal conversion Systems: Sampling theory - sample and hold circuits - conversion requirements for biomedical signals.

Signal averaging: Typical signal average - signal averaging as a digital filter - limitations. Data compression algorithms: Turning point, AZTEC, CORTES and KL transforms. Frequency domain representation: properties, spectral analysis, linear filtering, AR model, MA model, ARMA model.

Adaptive filters: general structure, LMS adaptive filter, noise cancellation, 60 Hz adaptive cancelling, feature extraction and pattern recognition.

Cardiac Signal Processing: ECG Data Acquisition (Preprocessing), ECG interpretation, Power spectrum of ECG, QRS detection algorithm, ST segment analyzer, rhythm analysis. Arrhythmia detection algorithms. Automated ECG analysis. ECG pattern recognition. ECG acquisition and transmission.

Electromuscular Signal Processing: Basic electromyography, EMG data acquisition, rectification and averaging.

Neurological signal processing: EEG Signals – Characteristics. EEG Analysis: time and frequency domain method, linear prediction theory, autoregressive (AR) method. Detection of spikes and spindles. Detection of alpha, beta and gamma waves. Least squares and polynomial modeling: Markov Model and Markov Chain, Dynamics of Sleep-Wake Transition, Hypnogram Model Parameters.

Prony's method: Original Prony's method. Prony's method based on least squares estimate. Analysis of evoked potential using Prony's method.

References:

1. D.C.Reddy, Biomedical Signal Processing – Principles and Techniques, McGraw-Hill, 2008.
2. Metin Akay, Biomedical Signal Processing Academic Press, 2004.
3. Wills J. Tompkins, Biomedical Digital Signal Processing, Prentice-Hall Inc., Upper Saddle River, NJ, USA, 1999.
4. Rolf Weitkunat, Digital Biosignal Processing. Elsevier, 2001.
5. Peter W. Macfarlane, Computer Techniques in Clinical Medicine, Butterworths, 1998.
6. Cohen A, Biomedical signal processing. Vol-I, Time frequency analysis, CRC Press, UK, 1999.

17. MODELING OF PHYSIOLOGICAL SYSTEMS

Objectives:

This course aims at the modeling of physiological systems and enables the students to conceive and understand the basics of modeling of such systems through use of relevant case studies

Syllabus:

Biological control system - similarities and differences - components of living control system, Model and Analogy of system properties, resistance, storage, distributed and lumped systems. Mathematical approach, electrical analogues.

Bio process controls ; cardiac rate, blood pressure, respiratory rate. Blood - Glucose regulation. Pharmacokinetic modeling-compartmental models, blood-tissue models.

Equivalent circuit model: Electromotive, resistive and capacitive properties of cell membrane, change in membrane potential with distance, voltage clamp experiment and Hodgkin and Huxley's model of action potential, voltage dependent membrane constant and simulation, model for strength-duration curve, model of the whole neuron. Huxley model of isotonic muscle contraction, modeling of EMG. Motor unit firing: amplitude measurement, motor unit and frequency analysis.

Physiological modeling: Electrical analog of blood vessels, model of systematic blood flow, model of coronary circulation, transfer of solutes between physiological compartments by fluid flow, counter current model of urine formation, model of Henle's loop - Linearized model of the immune response: Germ, Plasma cell, Antibody, system equation and stability criteria.

Respiratory system: Modeling of oxygen uptake by RBC and pulmonary capillaries, mass balancing by lungs, gas transport mechanism of lungs - O_2 and CO_2 transport in blood and tissues.

Case studies on modeling of physiological systems:

Modeling of nerve action potential: Hodgkin-Huxley model.
Modeling of skeletal muscle contraction: Huxley Cross Bridge Model.
Modeling of myoelectrical activity.
Modeling of cardiovascular system: Block diagram representation.
Electrical circuit model of blood pressure and oxygenation.
Modeling of immune response to disease : Block diagram representation.

References:

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