M.Tech. DEGREE (Control and Instrumentation) PROGRAM

CURRICULUM AND

DETAILED SYLLABI FOR FIRST SEMESTER SUBJECTS

&

LIST OF ELECTIVE SUBJECTS

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2011-2012 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Govt. Aided ISO 9001-2008 certified Autonomous Institution affiliated to Anna University)

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Passed in BOS meeting held on 30.4.2011 Approved in 43rd AC meeting held on 12.10.2011

Department of Electrical and Electronics Engineering

Graduating Students of M.Tech. program of Control and Instrumentation will be able to:

1. Specify, architect, design and analyze systems that efficiently measure, control and automation of a plant
2. Specify, design, prototype and test modern control systems that perform analog and digital processing functions.
3. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering, Madurai-625015

Department of Electrical and Electronics Engineering

Scheduling of Courses

Sem	Theory Courses						Practical / Project
4th (12)							CN41 Project Phase – II 0:12
3rd (16)	CN31 System Identification and adaptive control 3:1	CN EX Elective V 3:1	CN EX Elective VI 3:1				CN34 Project Phase-I 0:4
2nd (24)	CN21 PC based Instrumentation 3:0	CN22 Digital Control system 3:1	CN EX Elective I 3:1	CN EX Elective II 3:1	CN EX Elective III 3:1	CN EX Elective IV 3:1	CN 27 Seminar /Lab 0:1
1st (24)	CN11 Applied Mathematics for Electrical Engineers 3:1	CN12 Systems Theory 3:1	CN13 Transducer Engineering 3:1	CN14 Process Control and Instrumentation 3:1	CN15 Microcontroller based system Design 3:0	CN16 Advanced Digital Signal Processing 3:1	CN17 Control and Instrumentation laboratory 0:1

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.Tech. DEGREE (Control and Instrumentation) PROGRAM

SUBJECTS OF STUDY
(For the candidates admitted from 2011-2012 onwards)

FIRST SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
CN11	Applied Mathematics for Electrical Engineers	BS	3	1	-	4
CN12	Systems Theory	DC	3	1	-	4
CN13	Transducer Engineering	DC	3	1	-	4
CN14	Process Control Instrumentation	DC	3	1	-	4
CN15	Microcontroller based system Design	DC	3	-	-	3
CN16	Advanced Digital Signal Processing	DC	3	1	-	4
PRACTICAL						
CN 17	Control and Instrumentation Laboratory	DC	-	-	3	1
Total			**18**	**5**	**3**	**24**

BS : Basic Science
DC : Department Core
DE : Departmental Elective

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.Tech. DEGREE (Control and Instrumentation) PROGRAM

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2011-2012 onwards)

FIRST SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	CN 11	Applied Mathematics for Electrical Engineers	3	50	50	100	25	50
2	CN 12	Systems theory	3	50	50	100	25	50
3	CN 13	Transducer Engineering	3	50	50	100	25	50
4	CN 14	Process Control Instrumentation	3	50	50	100	25	50
5	CN 15	Microcontroller based system Design	3	50	50	100	25	50
6	CN 16	Advanced Digital Signal Processing	3	50	50	100	25	50
PRACTICAL								
7	CN 17	Control and Instrumentation Laboratory	3	50	50	100	25	50

* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

List of Elective Subjects – M.Tech. Control and Instrumentation

Departmental Electives			
Sub. Code (CN Ex)	Subject Name	Pre/Co requisites	Credits
A/KEI	Control of Electric Drives	Electrical Machines, Power Electronics	4
B	Bio-Medical Instrumentation	--	4
C	Digital System Design using PLDs	Digital systems	4
D	Advanced Industrial Controllers	Control systems	4
E	Intelligent Controllers	Control systems	4
F	Optimal Control And Filtering	Control systems	4
G	Robust Control	Control systems, system theory	4
H/KEB	Power Plant Instrumentation and Control	Measurements and Instrumentation	4
I/KET	Real Time Operating System	Microprocessor/ Microcontrollers	4
J	MEMS Based Instrumentation	Measurements and Instrumentation	4
K	Robotics And Automation	Control system Microprocessor/ Microcontrollers	4
L	Multi-Sensor Data Fusion	Measurements and Instrumentation	4
M	Data Communication for controllers	Digital systems, Computer Networks	4
N	Embedded System Design	Digital systems	4
O/KEU	SCADA	Microprocessors, Instrumentation, DSP	4

Sub Code	Lectures	Tutorial	Practical	Credit
CN11	3	1	-	4

CN11 Applied Mathematics for Electrical Engineers 3:1
(Common to K11 in M.E. Power Systems Engineering)

Preamble

An engineering PG student needs to have some basic mathematical tools and techniques to apply in diverse applications in Engineering. This emphasizes the development of rigorous logical thinking and analytical skills of the student and appraises him the complete procedure for solving different kinds of problems that occur in engineering. Based on this, the course aims at giving adequate exposure in Linear Algebra to find the singular value decomposition and Pseudo inverse of the matrix, Random Process to deal the Random Experiments with the state space S and parameter set T, stationary Functions, Gaussian Process..., Calculus of Variations to find the maximum or minimum value of a definite integral involving certain functions.

Prerequisite: Matrix, Probability and Statistics, Calculus.

Competencies

At the end of the course the student should be able to:

1. compute the pseudo- inverse of the rectangular matrix
2. decompose the non-square matrix by singular value decomposition.
3. derive the probability density function of a function of random variables.
4. determine the most reliable results of the population based on all the information available in a sample using non-parametric methods.
5. estimate the functions of time when the probability measure is associated through random process.
6. optimize the functional involving several variables and higher derivatives .

Assessment Pattern

S.No.	Bloom's category	Test 1	Test 2	Test 3 / End Semester Examination
1	Remember	10	10	10
2	Understand	10	10	20
3	Apply	80	80	70
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. Define Generalized eigen vectors.
2. Write the Solution of the Eulers equation v(y(x)) = $\int F(y, \hat{y})$dx.
3. What is meant by independent random variable.
4. Mention the formula to test the hypothesis using Kolmogorov smirnov test.
5. What is wide sense stationary process.

Understand

1. Determine the singular value decomposition of $\begin{pmatrix} 1 & 2 \\ 1 & 1 \\ 1 & 3 \end{pmatrix}$

2. If the joint pdf of X and Y is f(x,y)= x+y,0<x<2,0<y<1

   = 0 else where

   Show that X and Y are statistically dependent.
3. The following arrangement indicates whether sixty consecutive care which went by the toll booth of a bridge had local plates,L,or out-of state plates O:

   L L O L L L L O O L L L L O L O O L L L L O L O O L L L L L O
   L L L O L O L L L L O O L O O O O O L L L L O L O O L L L O.Illustrate whether this arrangement of L's and O's may be regarded as random by using the level of significance $\alpha = 0.05$.
4. Comparing two kinds of emergency flares, a consumer testing service obtained the following burning times(rounded to the nearest tenth of a minute)

   Brand C : 19.4, 21.5, 15.3, 17.4, 16.8, 16.6, 20.3, 22.5, 21.3, 23.4, 19.7, 21.0.
   Brand D : 16.5, 15.8, 24.7, 10.2, 13.5, 15.9, 15.7, 14.0, 12.1, 17.4, 15.6, 15.8 . Use the Mann-Whitney test and a level of significance of 0.01 to check whether it is reasonable to say that there is no difference between the true average burning times of the two kinds of flares.
5. Check whether the random process X(t) =A$e^{i\omega t}$ is a WSS if E[A]=0
6. Determine the extremals of $\int_0^2 (y'^2 + z'^2 + 2y^3)dx$ satisfying the conditions y(0)=0,y($\frac{\pi}{2}$)= 1,z(0)=1 and z($\frac{\pi}{2}$) = 0.

Apply

1. construct QR decomposition of the matrix$\begin{pmatrix} -4 & 2 & 2 \\ 3 & -3 & 3 \\ 6 & 6 & 0 \end{pmatrix}$

2. The current I and resistance R in a circuit are independent continuous RVs with the following density functions.

   f(i) = 2i, 0≤i≤1
   = 0 else where,
   g(r) = $\frac{r^2}{9}$, 0≤ri≤3
   = 0 else where,
   find the p.d.f of the voltage E in the circuit where E IR.
3. The following are the number of minutes it took a sample of 15 men and 12 women to complete the application form for a position.

   Men: 16.5, 20.0, 17.0, 19.8, 18.5, 19.2, 19.0, 18.2, 20.8, 18.7, 16.7, 18.1, 17.9, 16.4, 18.9.
   Women: 18.6, 17.8, 18.3, 16.6, 20.5, 16.3, 19.3, 18.4, 19.7, 18.8, 19.9, 17.6. Apply the Mann-Whitney test at the level of significance $\alpha = 0.05$ to the null hypothesis that the two samples come from identical population.
4. The following are the number of misprints counted on pages selected at random from the Sunday editions of a newspaper:

April 11: 4, 10, 2, 6, 4, 12
April 18: 8, 5, 13, 8, 8, 10
April 25: 7, 9, 11, 2, 14, 7

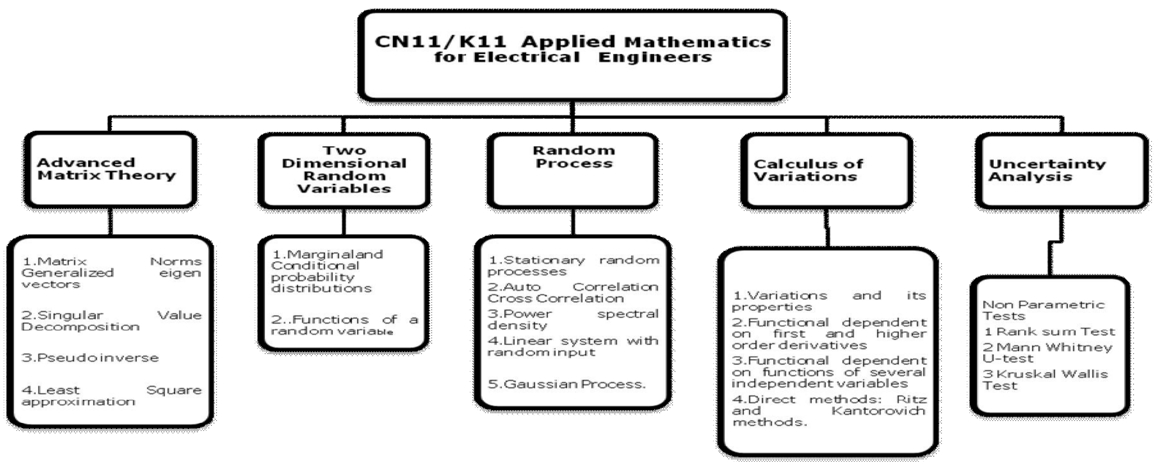
Apply Kruskal-Wallis test at the level of significance $\alpha = 0.05$ to test the null hypothesis that the three samples come from identical populations against the alternative that the compositors and/or proofreaders who worked on the three editions are not equally good.

4.Apply Ritz method to find approximate solution of the problem
$y'' + y + x = 0$, $0 \le x \le 1$,, $y(0) = 0 = y(1)$.

7. Prove that the extremal of the isometric problem $v(y(x)) = \int_1^4 y'^2\, dx$, $y(1)=3$, $y(4)=24$ subject to $\int_1^4 y\, dx = 36$ is a parabola

8. If the random process $X(t) = \sin(\omega t + y)$ where y is a random variable uniformly distributed in the interval $(0, 2\pi)$,prove that for the process X(t),
$C(t_1,t_2) = R(t_1,t_2) = \frac{\cos\omega(t_1 - t_2)}{2}$

Concept Map



Syllabus

Advanced Matrix Theory

Matrix Norms – Jordon canonical form – Generalized eigen vectors – Singular Value Decomposition – Pseudo inverse – Least Square approximation – QR algorithm. (Treatment as per text book 1).

Two Dimensional Random Variables

Marginal and Conditional probability distributions, Independent random Variables, Functions of a random variable, distribution of product and quotient of independent random variables. (Treatment as per text book 2).

Random Process

Classification – Stationary random processes – Auto Correlation – Cross Correlation – Power spectral density – Linear system with random input – Gaussian Process. (Treatment as per text book 3).

Calculus of Variations

Variations and its properties –Euler's equation – Functional dependent on first and higher order derivatives – Functional dependent on functions of several independent variables – Some applications – Direct methods: Ritz and Kantorovich methods. (Treatment as per text book 4).

Uncertainty Analysis

Sign test of paired data**,** Rank Sum test, Mann Whitney U-test, Kruskal Wallis test, One sample run test, Kolmogorov-Smirnov test(Treatment as per text book 5)

Reference Books

1. Bronson,R, " Matrix Operations, Schaums Outline Series", McGraw Hill, New York, 1989.
2. Paul L.Meyer, "Introductory Probability and statistical applications", Addison-Wesley,1981.
3. Peebles JR., P.Z., "Probability Random Variables and Random Signal Principles", McGraw Hill inc.,(1993)
4. Gupta .A.S. ,"Calculus of variations and applications", Prentice Hall of India, New Delhi, 1999.
5. Irwin Miller, John E.Freund "Probability and Statistics for Engineers" Prentice Hall of India Pvt. Ltd.; New Delhi, 1977.
6. T.Veerarajan "Probability, Statistics and Random Processes" Tata McGraw-Hill, New Delhi, 2003.
7. K.Murugesan, P.Gurusamy, "Probability Statistics & Random Processes" , Anuradha Agencies,2000.

Course contents and Lecture schedule

S.No	Topic	No. of Lectures
1.0	**Advanced Matrix Theory**	
1.1	Matrix Norms	1
1.2	Jordon canonical form – Generalized eigen vectors	1
1.3	Singular Value Decomposition	2
1.4	Pseudo inverse	1
1.5	Least Square approximation	1
1.6	QR algorithm	1
2.0	**Two Dimensional Random Variables**	
2.1	Marginal and Conditional probability distributions	1
2.2	Independent random Variables	1
2.3	Functions of a random variable	1
2.4	distribution of product and quotient of independent random variables	2

3.0	**Random Process**	
3.1	Classification	1
3.2	Stationary random processes	2
3.3	Auto Correlation, Cross Correlation	2
3.4	Power spectral density	2
3.5	Linear system with random input	2
3.6	Gaussian Process	1
4.0	**Calculus of Variations**	
4.1	Variations and its properties	2
4.2	Euler's equation	1
4.3	Functional dependent on first and higher order derivatives	2
4.4	Functional dependent on functions of several independent variables, Some applications	2
4.5	Direct methods: Ritz and Kantorovich methods	2
5.0	**Uncertainty Analysis: Non Parametric Tests**	
5.1	Sign test of paired data	1
5.2	Rank Sum test	2
5.3	Mann Whitney U-test	2
5.4	Kruskal Wallis test	2
5.5	One sample run test	1
5.6	Kolmogorov-Smirnov test	1
Total No. of Lectures		40

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CN 12 /K12	3	1	-	4

CN12 Systems Theory 3:1

(common to K12 in M.E. Power System Engineering)

Preamble

Modern control theory is a powerful technique for the analysis and design of linear and nonlinear, time-invariant or time varying MIMO systems. The classical design methods suffer from certain limitations due to the fact that the transfer function model is applicable only to linear time invariant systems, and that there too it is generally restricted to single-input, single-output (SISO) systems. This course aims at giving an adequate exposure in state space analysis, state space controller design, MIMO system, Non-linear system, stability analysis.

Competencies

At the end of the course the student should be able to:

1. Model linear time invariant dynamic system
2. Analyze SISO dynamic system for controllability , Observability, stabilizability, and Detectability using state models
3. Design state feedback controllers to get the desired performance for SISO systems
4. Design of estimators with and without noise for unmeasuarble SISO systems
5. Analyze MIMO dynamic system using frequency domain approach
6. Analyze nonlinear dynamic system behavior using phase –plane and describing function
7. Determine the stability of linear and nonlinear autonomous systems

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	20	20	20
2	Understand	20	20	20
3	Apply	60	60	60
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. What are the advantages of state space of analysis?
2. What is state diagram?
3. Write the properties of state transition matrix.
4. What is free and forced response?
5. Define Stabilisability and detectability.
6. What are the properties of transfer function matrix?
7. Write the condition for asymptotically stable in large?
8. Mention the few applications of non linear problems.
9. Draw the input output characteristics of relay with dead zone and hysterisis.

10. What is meant by bandwidth and critical frequency?

Understand

1. Mention the types of non linearity and derive a describing function for a dead zone and saturation non linearity.
2. Explain the concept of Liapunov's stability criterion with basic theorems.
3. What is the need for different canonical models?
4. Why is state model not unique? Explain
5. What is the need for observer? Explain
6. Why are linear system analysis tools not useful for analyzing nonlinear systems?

Apply

1. Determine the transfer function and impulse response of the scalar system described by the state model of

$$\overset{0}{X} = \begin{bmatrix} 0 & 1 \\ 0 & -5 \end{bmatrix} X(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t); \quad y(t) = [1 \ 0]X(t)$$

2. For the linear autonomous system given by determine the stability of the equilibrium using direct method of Lyapunov.

$$X(k+1) = \begin{bmatrix} 0.5 & 1 \\ -1 & -1 \end{bmatrix} X(t)$$

3. For a system represented by static equation $\dot{X}$ (t) =A X (t). The response is X (t) $= \begin{bmatrix} e^{-2t} \\ -2e^{-2t} \end{bmatrix}$ when X (0) = $\begin{bmatrix} 1 \\ -2 \end{bmatrix}$ and X (t) = $\begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix}$ when X (0) = $\begin{bmatrix} 1 \\ -1 \end{bmatrix}$. Determine the system matrix A and the state transition matrix.

4. Determine the impulse response matrix for the following MIMO system.

$$G(s) = \begin{bmatrix} \dfrac{1}{s(s+2)} & \dfrac{1}{(s+1)} \\ \dfrac{1}{(s+1)} & \dfrac{1}{s(s+1)} \end{bmatrix}$$

5. Obtain the minimal realization of the given MIMO system

$$G(s) = \frac{1}{(s+1)(s+2)(s+3)} \begin{bmatrix} 6s^2 + 21s + 17 & 4s^2 + 14s + 10 \\ 14s^2 + 49s + 41 & 7s^2 + 23s + 16 \end{bmatrix}$$

6. Consider the hydraulic system shown in fig.1. Derive state space equations for the system with water levels h_1 and h_2 in the two tanks as the state variables x_1 and x_2 respectively and discharges q_1, q_{12} and q_2 as the outputs y_1, y_2 and y_3 respectively.

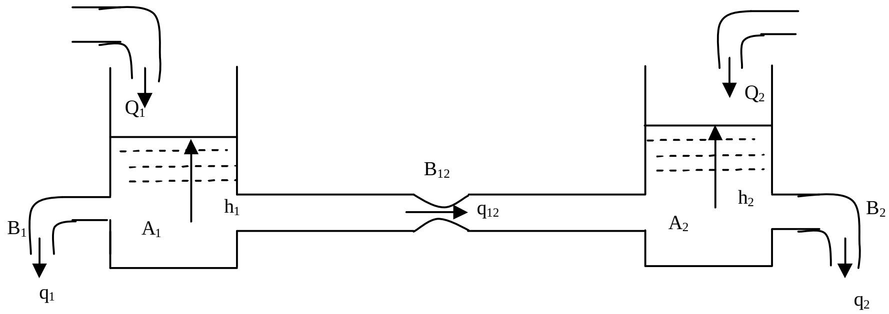


fig.1

7. Obtain the state model of the electrical network shown in fig.2 by choosing v1 (t) and v2 (t) as state variables.

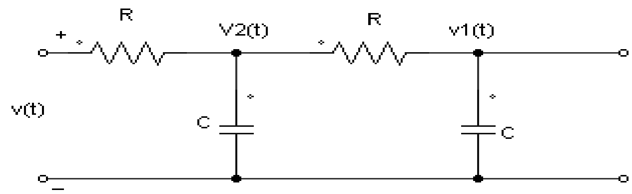


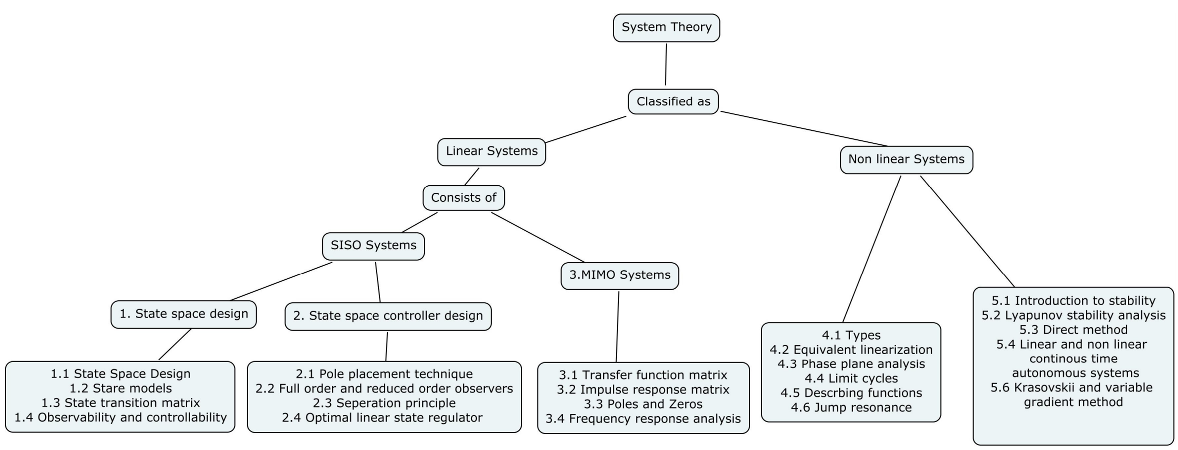
fig.2

8. Comment about the stability of given nonlinear system governed by the equations

$$\dot{x}_1 = -x_1 + 2x_1^2 x_2$$

$$\dot{x}_2 = -x_2$$

Concept Map



Syllabus

State Space Analysis

Introduction - Concept of state space model for dynamic systems – Time invariance and Linearity- Non-uniqueness - Minimal realization – Canonical state models - Solution of state equations – State transition matrix - Free and forced responses – Controllability and observability- Stabilisability and detectability.

State Space Controller Design

Introduction – State Feedback control – Pole Placement by State Feedback – Full Order and Reduced Order Observers – Separation principle –Optimal linear state regulator – Stochastic optimal linear estimator.

MIMO Systems

Properties of transfer functions Matrix – Impulse response matrices – Poles and zeros of transfer function matrices – Critical frequencies – Resonance – Steady state and dynamic response – Bandwidth- Nyquist plots – Singular value analysis.

Non-Linear Systems

Types of non-linearity – Typical examples – Equivalent linearization – Phase plane analysis – Limit cycles – Describing functions- Analysis using Describing functions – Jump resonance.

Stability

Introduction – Equilibrium Points – Stability in the sense of Lyapunov – BIBO Stability – Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems – The Direct Method of Lyapunov and the Linear Continuous Time Autonomous Systems – Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems – Krasovskii and Variable-Gradient Method.

Reference Books

1. M. Gopal, "Modern Control System Theory", New Age International Publications, revised 2nd edition, 2005.
2. K. Ogatta, "Modern Control Engineering", PHI Publications, 2002.
3. I.J.Nagarath , M. Gopal, "Control Systems Engineering", New Age International Publications, 4th edition, New Delhi, 2006.
4. M.Gopal, "Digital Control and state variable methods – conventional and intelligent control systems", Tata Mcgraw Hill 3rd edition, New Delhi, 2008.
5. Stanley M. Shinners, "Modern control system theory and design" Wiley-IEEE 2nd edition, 1998.

Course contents and Lecture schedule

Sl.No.	Topic	No. of Lectures
1.0	**State Space Analysis**	**09**
1.1	Introduction - Concept of state space model for dynamic systems	1
1.2	Time invariance and Linearity, Non-uniqueness, Minimal realization, Canonical state models	2
1.3	Solution of state equations – State transition matrix	2
1.4	Free and forced responses	1
1.5	Controllability and Observability	2
1.6	Stabilisability and Detectability	1
2.0	**State Space Controller Design**	**10**
2.1	Introduction – State Feedback control	1

2.2	Pole Placement by State Feedback	2
2.3	Full Order and Reduced Order Observers	2
2.4	Separation principle	2
2.5	Optimal linear state regulator	2
2.6	Stochastic optimal linear estimator	1
3.0	**MIMO Systems**	**08**
3.1	Properties of transfer functions Matrix	1
3.2	Impulse response matrices	2
3.3	Poles and zeros of transfer function matrices	1
3.4	Critical frequencies, Resonance, Steady state and dynamic response, Bandwidth	1
3.5	Nyquist plots	2
3.6	Singular value analysis	1
4.0	**Non-Linear Systems**	**09**
4.1	Types of non-linearity – Typical examples	2
4.2	Equivalent linearization	1
4.3	Phase plane analysis	2
4.4	Limit cycles	1
4.5	Describing functions- Analysis using Describing functions	2
4.6	Jump resonance	1
5.0	**Stability**	**09**
5.1	Introduction – Equilibrium Points	1
5.2	Stability in the sense of Lyapunov – BIBO Stability – Stability of LTI Systems	2
5.3	Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems	2
5.4	The Direct Method of Lyapunov and the Linear Continuous Time Autonomous Systems	1
5.5	Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems	1
5.6	Krasovskii and Variable-Gradient Method	2
	Total	**45**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CN13	3	1	-	4

CN13 Transducer Engineering 3:1

Preamble

The main purpose of offering this course is:

1. To elaborate on the Theoretical and practical aspects of transducers and their classifications and also the applications of transducers in real life and in industries.
2. To explain the static and dynamic characteristics of transducers.
3. Discuss on electrical, magnetic, piezoelectric, fiber optic transducers and their operation.
4. To impart knowledge about digital transducers and their applications.
5. In view of present day technologies fundamental concepts of some of the smart sensors in day to day applications and also in industries are included

Competencies

At the end of the course students should be able to:

1. To explain the basic characteristics, types of transducers and their practical aspects in industries.
2. Explain the operation and application of digital transducers.
3. Explain the application of smart sensors.
4. Find the application of smart sensors in automation
5. Select digital transducers to the given physical system
6. realize the importance of standard of calibaration

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	40	40	20
2	Understand	40	40	60
3	Apply	20	20	20
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. What is a transducer?
2. What is a thermistor?

3. Name some pressure Sensors
4. What is role of gray code in optical and shaft encoders?
5. Define stress and strain.
6. Recall Hall Effect principle
7. Give some real time application of strain gauge
8. Classify the different methods of measuring temperature
9. Write the relation for temperature coefficient of resistance for thermistor.
10. What is a load cell?

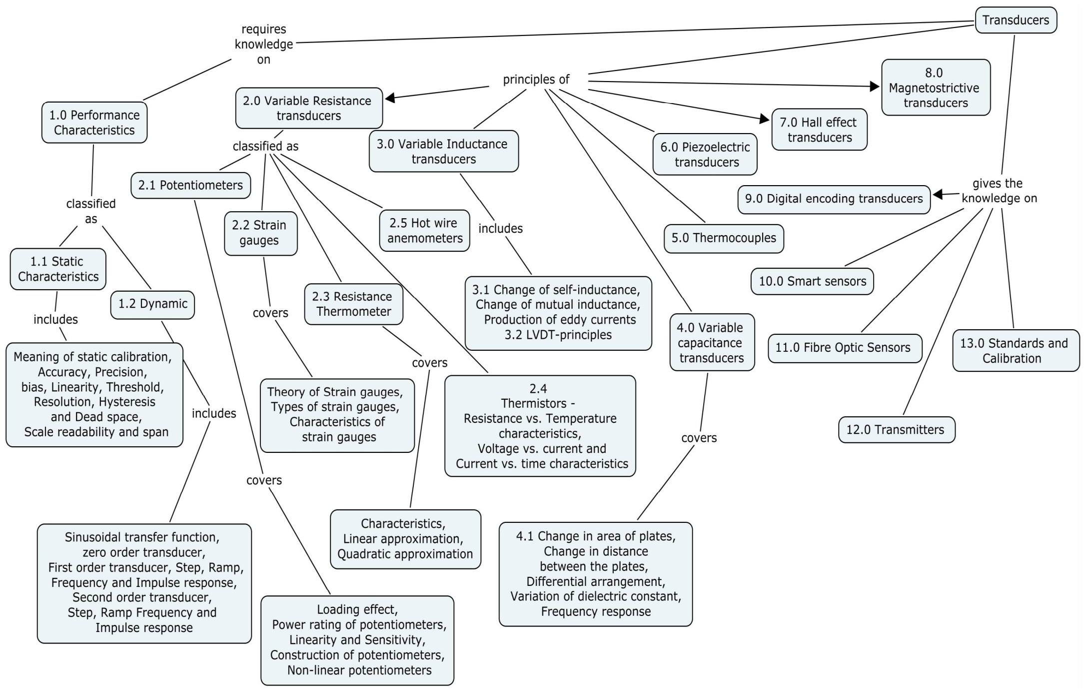
Understand

1. A digital meter has 10 bit accuracy. What is the resolution on the 16V range?
2. A liquid container has a total weight of 152 kN, and the container has 8.9 m^2 base. What is the pressure on the base?
3. Identify what pressure in psi corresponds to 98.5 kPa
4. State the three different temperature scales to measure relative hotness.
5. Write some applications of position sensors.(rolling mills, conveyors..,)
6. What is the change in resistance in a copper wire when the strain is 5500 micro strains? Assume the initial resistance of the wire is 275 ohms and the gauge factor is 2.7.
7. State the limitations of contact type shaft encoders.
8. Sketch the cross section of 3 wire RTD and explain its operation.
9. Describe about cold junction compensation of Thermocouple.
10. Illustrate in detail about three effects associated with Thermocouple

Apply

1. Illustrate the role of smart sensors in automated applications.
2. Develop a pressure sensor using capacitance principle and explain its operation
3. Explain how force is measured using Pressure transducer.
4. Describe the application of strain gauge as load sensor.
5. Describe the application of fiber optic sensor for temperature measurement.
6. Describe the about the general calibration procedure.

Concept Map



Syllabus

PERFORMANCE CHARACTERISTICS OF TRANSDUCERS

Static characteristics

Meaning of static calibration, Accuracy, Precision, bias, Linearity, Threshold, Resolution, Hysteresis and Dead space, Scale readability and span

Dynamic characteristics

Sinusoidal transfer function, zero order transducer, First order transducer, Step, Ramp, Frequency and Impulse response, Second order transducer, Step, Ramp Frequency and Impulse response.

VARIABLE RESISTANCE TRANSDUCERS

Potentiometers

Loading effect, Power rating of potentiometers, Linearity and Sensitivity, Construction of potentiometers, Non-linear potentiometers,

Strain gauges

Theory of Strain gauges, Types of strain gauges, Characteristics of strain gauges

Resistance thermometers

Characteristics, Linear approximation, Quadratic approximation,

Thermistors

Resistance vs. Temperature characteristics, Voltage vs. current and Current vs. time characteristics,

Hot wire anemometers

Constant current mode and Constant resistance

Variable Inductance transducers

Change of self-inductance, Change of mutual inductance, Production of eddy currents, Linear Variable Differential Transformer Construction, Working principle

Variable capacitance transducers

Change in area of plates, Change in distance between the plates, Differential arrangement, Variation of dielectric constant, Frequency response.

Thermocouples

Construction, Measurement of thermocouple output, Compensating circuits, Reference junction compensation, Lead compensation

Piezoelectric transducers

Modes of operation of piezoelectric crystals, Properties, Equivalent circuit of piezoelectric transducers, Loading effects and frequency response, Impulse response.

Hall effect transducers

working principle, application,

Magnetostrictive transducers

Principle of operation

Digital encoding transducers

Classification of encoders, Construction of encoders, Brush type, Optical displacement transducers

Smart sensors

Introduction, primary sensors, Excitation, Amplification, Filters, Convertors, Compensation, Information coding process, Data communication

Fibre optic sensors

Temperature sensors, Liquid level sensing, Fluid flow sensing, Microbend sensors

List of applications of various transducers

Transmitters

Standards and Calibration

Instrumentation current Standards, Instrumentation Pressure Standards, NIST Standards, Calibrators

Parametric Transducers –PH and Gas measurements

Reference Books

1. E.O.Doubelin, Measurement Systems, McGraw Hill Book Company, 2008.
2. A.K.Sawheney, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpatrai & Co. Pvt. Ltd., 2007.
3. D. Patranabis, Sensors and Transducers, Wheeler Publishing, 2006.

4. Hermann, K.P. Neubert, Instrument Transducers, Oxford University Press, 1988.
5. S. Renganathan, Transducer Engineering, Allied Publishers, 1999
6. D.V.S. Murthy, Transducers and Instrumentation, Prentice Hall of India Pvt. Ltd., 2008.
7. M. Arumugam, Optical Fiber Communication and Sensors, Anuradha Agencies, 2002
8. B.G. Liptak, Instrumentation Engineer's Handbook, Process Measurement and Analysis, Volume 1

Course contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1.0	**Performance characteristics of Transducers**	
1.1	**Static characteristics** Meaning of static calibration, Accuracy, Precision, bias, Linearity, Threshold, Resolution, Hysteresis and Dead space, Scale readability and span	2
1.2	**Dynamic characteristics –** Sinusoidal transfer function, zero order transducer, First order transducer, Step, Ramp, Frequency and Impulse response, Second order transducer, Step, Ramp Frequency and Impulse response	2
2.0	**Variable Resistance transducers**	
2.1	**Potentiometers -** Loading effect, Power rating of potentiometers, Linearity and Sensitivity, Construction of potentiometers, Non-linear potentiometers	2
2.2	**Strain gauges -** Theory of Strain gauges, Types of strain gauges, Characteristics of strain gauges,	2
2.3	**Resistance thermometers**, Characteristics, Linear approximation, Quadratic approximation	2
2.4	**Thermistors** - Resistance vs. Temperature characteristics, Voltage vs. current and Current vs. time characteristics	2
2.5	**Hot wire anemometers**	
3.0	**Variable Inductance transducers**	
3.1	Change of self-inductance, Change of mutual inductance, Production of eddy currents	2
3.2	Linear Variable Differential Transformer Construction, Working principle	2
4.0	**Variable capacitance transducers**	
4.1	Change in area of plates, Change in distance between the plates, Differential arrangement, Variation of dielectric constant, Frequency response	2
5.0	**Thermocouples**	
5.1	Construction, Measurement of thermocouple output	2
5.2	Compensating circuits, Reference junction compensation, Lead compensation	2
6.0	**Piezoelectric transducers**	
6.1	Modes of operation of piezoelectric crystals, Properties, Equivalent circuit of piezoelectric transducers	2
6.2	Loading effects and frequency response, Impulse response	2
7.0.	**Hall effect transducers**	
7.1	working principle, application	2

8.0	**Magnetostrictive transducers**	
8.1	Principle of operation	2
9.0	**Digital encoding transducers**	
9.1	Classification of encoders, Construction of encoders, Brush type, Optical displacement transducers	2
10.	**Smart sensors**	
10.1	Introduction, primary sensors, Excitation, Amplification, Filters, Convertors, Compensation, Information coding process, Data communication	2
11.	**Fibre Optic Sensors** - Temperature sensors, Liquid level sensing, Fluid flow sensing, Microbend sensors	2
12	**Transmitters**	1
13	**Standards and Calibration**	
13.1	Instrumentation current Standards, Pressure Standards	3
13.2	NIST Standards, Calibrators	2
13.3	List of applications of various transducers	2
14	**Parametric Transducers –**PH and Gas measurements	1
	Total	**45**

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Sub Code	Lectures	Tutorial	Practical	Credit
CN14	3	1	-	4

CN14 Process Control and Instrumentation 3:1

Preamble

Process control plays a vital role in any process industries. Almost all the process need to be controlled to ensure better quality of the product in most useful form. Process control is essential to get an effective feedback, the controller are tuned and the performance , stability analysis are done in time domain and frequency domain approaches based on basic control strategies.

Competencies

At the end of the course the student should be able to:

1. Understand the concept of various processes
2. Explain the commercial controllers
3. Know the recent trends in Instrumentation systems
4. Apply the knowledge of instrumentation systems to various control in the plant
5. Analyze the given process and suggest a suitable control and measurement techniques
6. Design a controller and measuring system for a given process.

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3 /End-semester examination
1	Remember	10	10	10
2	Understand	10	10	10
3	Apply	10	10	40
4	Analyze	20	20	40
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. Define mathematical modeling.
2. What is Degrees of freedom?
3. What is multivariable control
4. What is feedforward controller?
5. What is tuning?
6. State sampling theorem.

Understand

1. What is dynamic matrix control?

2. Sketch the step response of the first order system.
3. State the effects of sampling.
4. Draw MPC control scheme and explain the concept.
5. What are the advantages of time domain approach?
6. What is process identification?

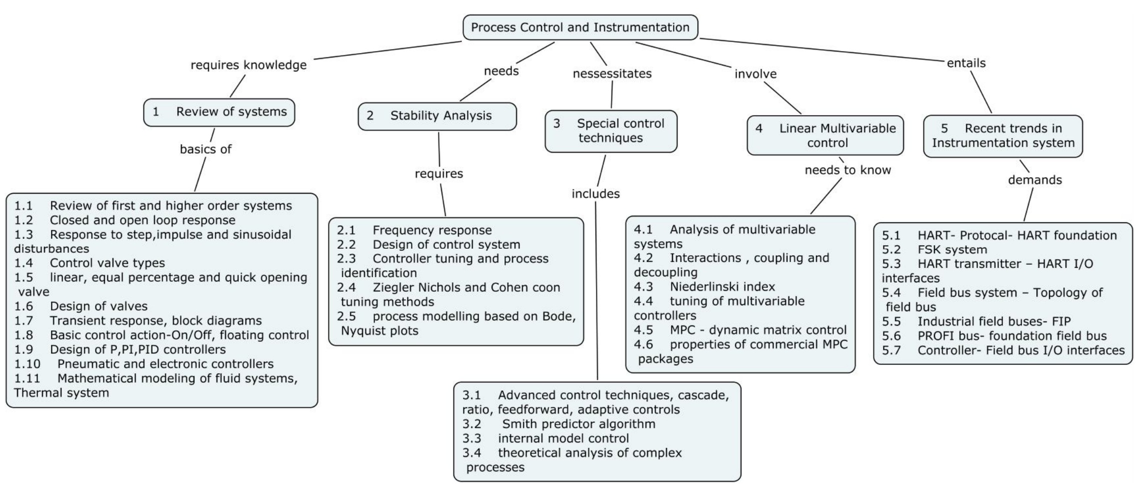
Apply

1. How is ZN tuning used for first-order delay process?
2. How Cohen- Cohn tuning method is applied to PID controllers?
3. Discuss the simple implementation scheme for On/Off control
4. Discuss smith predictor algorithm.
5. What is need for Niedirlinski index?
6. How is RGA determined for 2X2 multivariable process?

Analyze

1. Analyze the cascade control scheme with feed forward control scheme with suitable example.
2. With neat sketch, explain internal model scheme.
3. Compare and contrast between different types of control valves
4. Examine the stability of s system.
5. Discuss the FSK technique in HART protocol signal transmission system.
6. Discuss how FIP and foundation field bus is interfaced with process Instrumentation system.

Concept Map



Syllabus

Review of systems

Review of first and higher order systems – Closed and open loop response-Response to step, impulse and sinusoidal disturbances- Control valve types- linear, equal percentage and quick opening valve- Design of valves- Transient response- block diagrams-Basic control action-On/Off, floating control- Design of P,PI,PID controllers, Pneumatic and electronic controllers, Mathematical modeling of Thermal system

Stability Analysis
Frequency response- Design of control system-Controller tuning and process identification-Ziegler Nichols and Cohen coon tuning methods- Bode, Nyquist plots-process modelling

Special control techniques
Advanced control techniques- cascade, ratio, feedforward, adaptive controls- selective control- Smith predictor algorithm- internal model control- theoretical analysis of complex processes

Linear Multivariable control
Analysis of multivariable systems- interactions- coupling and decoupling – Niederlinski index- tuning of multivariable controllers- MPC - dynamic matrix control- properties of commercial MPC packages

Recent trends in Instrumentation system
HART- Protocal- HART foundation- FSK system- HART transmitter – HART I/O interfaces-Field bus system – Topology of field bus- Industrial field buses- FIP- PROFI bus-foundation field bus – Controller- Field bus I/O interfaces

Reference Books

1. George Stephanopolus, "Chemical Process Control", Prentice Hall India,2000.
2. D.R.Coughanour, “Process systems analysis and control”, Mc.Graw Hill , second edition ,1991
3. W.L.Luyben, “Process modeling simulation and control for chemical engineers”, McGraw Hill, second edition,1990.
4. M.Chidambaram, “Computer control of processes”, Narosa publishing house, 2010.
5. Harriot P., “Process Control”, Tata McGraw-Hill, New Delhi, 1991.
6. Dale E. Seborg, Thomas F Edgar, Duncan A Mellichamp, “Process dynamics and control”, Wiley John and Sons, 1989.
7. B.W.Bequtte, “Process dynamics- modeling , analysis and simulation”, PHI, New Delhi.1998
8. C.A.Smith,A.B.Corripio, “Principle and practice of automatic process control”, John Wilay and sons,1985
9. F.G.Shinskey, “Process control systems” application design and tuning, Mcgrawhill,1996.

Course contents and Lecture Schedule

S. No.	Topic	No. Of Lectures
1	**Review of systems**	
1.1	Review of first and higher order systems	1
1.2	Closed and open loop response	1
1.3	Response to step, impulse and sinusoidal disturbances	1
1.4	Control valve types	1
1.5	linear, equal percentage and quick opening valve	1
1.6	Design of valves	1

1.7	Transient response, block diagrams	1
1.8	Basic control action-On/Off, floating control	1
1.9	Design of P,PI,PID controllers	1
1.10	Pneumatic and electronic controllers	4
1.11	Mathematical modeling of Thermal system	2
2	**Stability Analysis**	
2.1	Frequency response	1
2.2	Design of control system	1
2.3	Controller tuning and process identification	2
2.4	Ziegler Nichols and Cohen coon tuning methods	1
2.5	process modelling based on Bode, Nyquist plots	2
3	**Special control techniques**	
3.1	Advanced control techniques, cascade, ratio, feedforward, adaptive controls	3
3.2	Smith predictor algorithm	1
3.3	internal model control	2
3.4	theoretical analysis of complex processes	1
4	**Linear Multivariable control**	
4.1	Analysis of multivariable systems	1
4.2	Interactions , coupling and decoupling	2
4.3	Niederlinski index	1
4.4	tuning of multivariable controllers	1
4.5	MPC - dynamic matrix control	1
4.6	properties of commercial MPC packages	1
5	**Recent trends in Instrumentation system**	
5.1	HART- Protocal- HART foundation	1
5.2	FSK system	1
5.3	HART transmitter – HART I/O interfaces	1
5.4	Field bus system – Topology of field bus	1
5.5	Industrial field buses- FIP	1
5.6	PROFI bus- foundation field bus	1
5.7	Controller- Field bus I/O interfaces	1
	Total No. Of Lectures	**45**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CN15	3	-	-	3

CN15 Micro Controller based System Design 3:0

Preamble

This course provides a broad and systematic introduction to microcontroller based system design. It explores the hardware architecture, programming and applications of C8051F040. Both assembly and C languages are used in programming. The details about hardware and software development tools (SiLab IDE) are discussed.

Competencies

At the end of the course, the student will be able to:

1. Acquire knowledge about architecture and peripherals of C8051F040
2. Know about Assembly and C programming of C8051F040
3. Write C8051F040 programs for various applications.
4. Select a suitable micro controller to the system given
5. Apply a suitable tool for a given system to control using µC.

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test3 / End-semester examination
1	Remember	40	20	20
2	Understand	40	40	20
3	Apply	20	40	60
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. Write assembler directives to reserve 20 bytes starting from the program-memory
   Location 0x1200 and initialize them to 0x20.
2. What is the instruction sequence to output the value of input port P4? and write the value to P5 of the C8051F040.
3. Write assembler directives to construct a table of the ASCII code of uppercase letters starting from the program-memory location at 0x40.
4. DAC can be build around PWM module by using a suitable RC low pass filter. What are the design considerations to select the RC component values?
5. How to initialize USART in asynchronous mode? What are the registers associated with USART operation?
6. What are the registers associated with the operation of the AD module? What is the function of ADON bit? What is right and left justification of AD results?
7. Compare SPI, I^2C, and USART stating the possible application areas.
8. Write a function that will convert an uppercase to lowercase.
9. What is an interrupt?

10. What is a function prototype ?

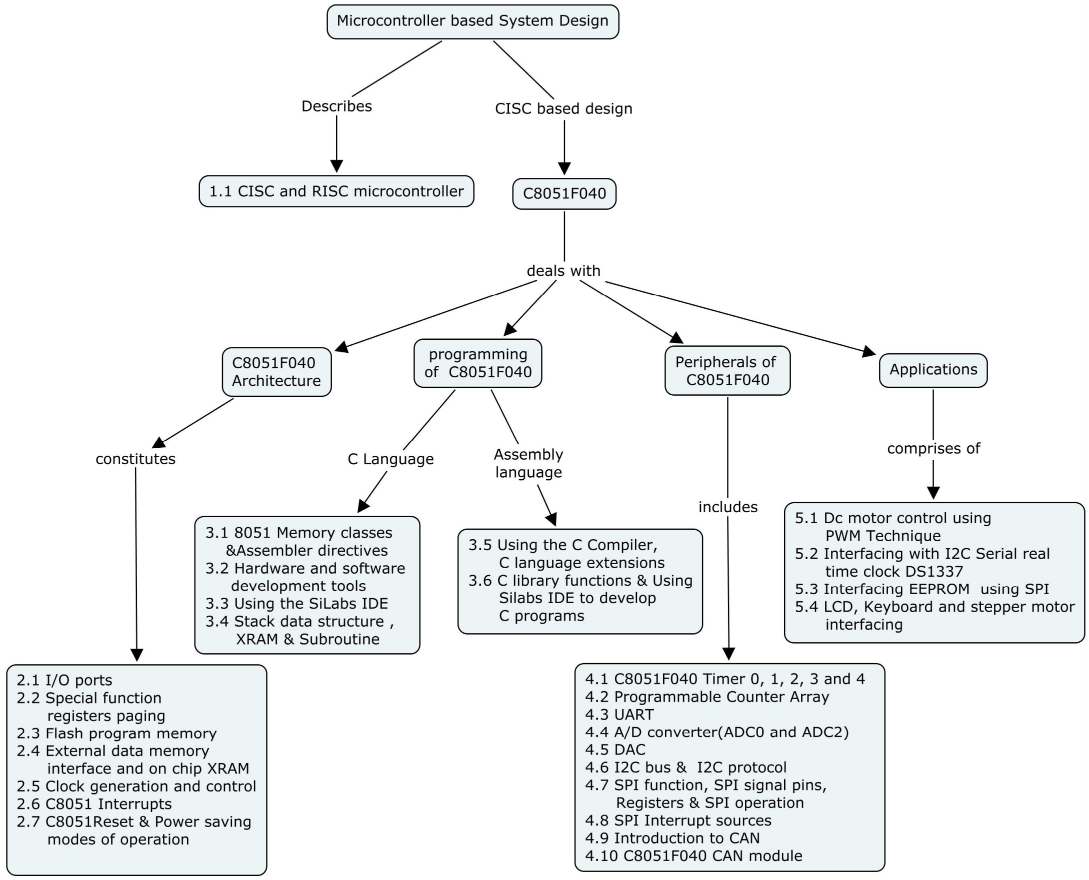
Understand

1. What is prescaling and postscaling in trimer 2? What is the advantage in using post scaling?
2. Write an instruction sequence to output the value of input Port P5 of the C8051F040.
3. What kind of interaction is there between CCP modules ? How is it take care of ?
4. Explain how SPI bus can be used for I/O port expansion.
5. How to decide the clock source and the reference voltages for 16F877 AD module operation ?
6. Write a program to generate a square waveform with a 50 percent duty cycle and a frequency that alternates between 1 kHz and 2 kHz every four seconds.
7. Write a program to add the 16-bit numbers stored at internal data-memory locations 0x34 ~ 0x35 and 0x36 ~ 0x37, respectively, and save the sum at 0x40~0x41.
8. Write a program to add the 16-bit numbers stored at internal data-memory locations 0x40 ~ 0x41 and 0x42 ~ 0x43, respectively, and save the sum at 0x50~0x51.
9. Why it is more efficient to use interrupts to handle inputs and outputs.
10. Write a C program to swap the first column of a matrix to last column.

Apply

1. Write a subroutine that can create a time delay that is a multiple of 10 ms. The multiple is passed in register R0.
2. Write a program to generate a 100-Hz square waveform with a 50 percent duty cycle from the P5.0 pin.
3. Write a program to use Timer 2 of the C8051F040 to create a time delay of 20 ms, assuming that the C8051F040 is running with a 24-MHz external oscillator.
4. Write a program to generate a 500-kHz digital waveform with a 50 percentage duty cycle from the T2 pin of a C8051F040 running with a 24-MHz crystal oscillator.
5. Write a C program to create a time delay that is a multiple of 10ms.
6. Design a 16F877 program to write a byte in to the program memory.

Concept Map



Syllabus

Introduction

CISC and RISC microcontroller

C8051F040 Architecture

I/O ports- Special function registers paging- Flash program memory- External data memory interface and on chip XRAM- Clock generation and control-C8051 Interrupts- C8051Reset- Power saving modes of operation

Assembly and C programming of C8051F040

8051 memory classes- 8051 assembly directives- Hardware and software development tools- Using the SiLabs IDE- Stack data structure- XRAM- Subroutine- Using the C Compiler- C language extensions- C library functions -Using SiLabs IDE to develop C programs

Peripherals of C8051F040

C8051F040 Timer 0, 1, 2, 3 and 4- Programmable Counter Array-UART-A/D converter(ADC0 and ADC2)- DAC- I2C bus- I^2C protocol- SPI function – SPI signal pins – Registers- SPIoperation – Interrupt sources-Introduction to CAN-C8051F040 CAN module

Applications of C8051F040

Dc motor control using PWM Technique- Interfacing with I^2C Serial real time clock DS1337- Interfacing EEPROM using SPI-LCD, Keyboard and stepper motor interfacing

Reference Books

1. Han-Way Huang – Embedded System Design using C8051-Cengage Learning India Private Limited, New Delhi, 2009.
2. Ajay V Deshmukh-Microcontrollers-Theory and Applications-Tata McGraw-Hill Publishing Company Limited, New Delhi, 2005.
3. WWW.Silabs.com

Course Contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1.0	**Introduction**	
1.1	CISC and RISC microcontroller	1
2.0	**C8051F040 Architecture**	
2.1	I/O ports	1
2.2	Special function registers paging	1
2.3	Flash program memory	2
2.4	External data memory interface and on chip XRAM	1
2.5	Clock generation and control	1
2.6	C8051 Interrupts	2
2.7	C8051 Reset & Power saving modes of operation	1
3.0	**Assembly and C programming of C8051F040**	
3.1	8051 Memory classes & Assembler directives	2
3.2	Hardware and software development tools	2
3.3	Using the SiLabs IDE	1
3.4	Stack data structure ,XRAM & Subroutine	1
3.5	Using the C Compiler, C language extensions	2
3.6	C library functions & Using Silabs IDE to develop C programs	2
4.0	**Peripherals of C8051F040**	
4.1	C8051F040 Timer 0, 1, 2, 3 and 4	2
4.2	Programmable Counter Array	2
4.3	UART	2
4.4	A/D converter(ADC0 and ADC2)	2
4.5	DAC	1
4.6	I^2C bus & I^2C protocol	2
4.7	SPI function, SPI signal pins, Registers & SPI operation	2
4.8	SPI Interrupt sources	1
4.9	Introduction to CAN	2
4.10	C8051F040 CAN module	2
5.0	**Applications of C8051F040**	
5.1	Dc motor control using PWM Technique	1
5.2	Interfacing with I^2C Serial real time clock DS1337	2
5.3	Interfacing EEPROM using SPI	1
5.4	LCD, Keyboard and stepper motor interfacing	2
	Total No. Of Lectures	**45**

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Sub Code	Lectures	Tutorial	Practical	Credit
CN16	3	1	-	4

CN16 Advanced Digital Signal Processing 3:1

Preamble

Signals play major role in our life. In general, a signal can be a function of time, distance, position, temperature, pressure etc., and represents some variable of interest associated with system. A signal carries information and objective of signal processing is to extract this information. Signal processing is concerned with representing the signal in mathematical terms and extracting the information by carrying out the algorithmic operations on the signal.

Digital processing of a signal has major advantage over analog techniques. With digital filters, linear phase characteristics can be achieved; filters can be made to work over a wide range of frequencies. Storage of digital data is very easy. Digital processing is more suited for low frequency signals like seismic signals, bio-signals.

Competencies

The student, at the end of the course, should be able to:

1. Gain the knowledge discrete time signal and systems
2. Apply DTFT, DFT, FFT on the given functions.
3. design and realization of digital filters
4. understand the concepts of multi rate signal processing and wavelet transforms
5. know about the features of TMS320f240 digital signal processor
6. write programs on digital signal processor

Assessment pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	20	20	20
2	Understand	20	20	20
3	Apply	40	40	30
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	20	20	30

Course level Learning Objectives

Remember

1. Define odd and even signal
2. Give the properties of CWT.
3. Give Hamming window function.
4. State Shannon's sampling theorem.
5. State and prove circular frequency shift property of DFT.
6. Define and give the properties of DWT.

7. Define DTFT and IDTFT

Understand

1. What is warping effect?
2. What is meant by radix – 2 FFT?
3. Write the different types of error due to quantization of coefficients and number.
4. Explain the digital signal processing system with necessary sketches and give its merits and demerits.
5. Explain impulse and magnitude responses of the four level trees of Haar Wavelets.
6. What is known as aliasing?
7. Explain the basic architecture of TMS320f240 Digital signal processor.

Apply

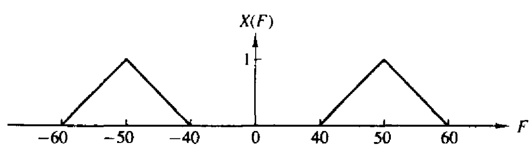
1. Find circular convolution of the given sequences and compare with linear convolution.

   $x_1(n) = \{2, 3,-1,2\}$ & $x_2(n)=\{-1,2,-1,2\}$

2. Determine 8 point DFT of the sequence $x(n) = \{1,1,1,1,1,1,0,0\}$.

3. An 8- point sequence is given by $x(n) = \{2,2,2,2,1,1,1,1\}$ compute DFT of x(n) using radix 2 DIT FFT.

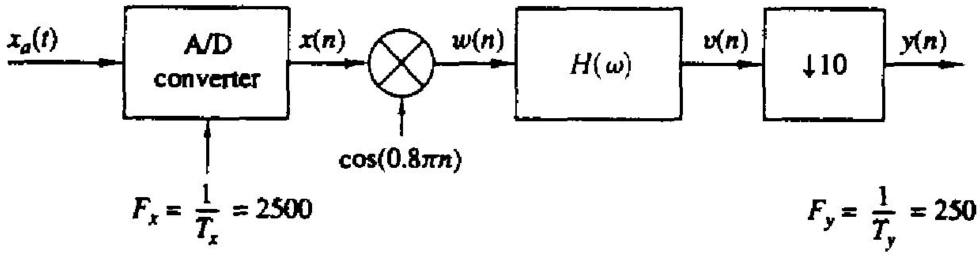
4. Consider the sampling of band pass signal whose spectrum is given in the figure. Determine minimum sampling rate to avoid aliasing.



5. Determine IDFT of the Sequence $X(k) = \{1,1,1,1,0,0,0,0\}$.

6. Find correlation of given the sequences, $x= \{1, 2, 0, 4\}$ and $y= \{2, 0, 3, 1\}$

7. An analog signal Xa(t)is band limited to the range $900 \le F \le 1100$Hz. It is used as an input to the system shown in the figure. In this system H(w) is an ideal LPF with cutoff frequency Fc= 125Hz.



a) Determine and sketch the spectra for the signals x(n),w(n),v(n)and y(n).

b) Show that it is possible to obtain y(n) by sampling Xa(t) with period T= 4msecs.

8. How the data compression can be obtained as an application of Wavelet transform.

Create

1. Using a rectangular window technique design a LPF with passband gain of unity, cutoff frequency of 1000Hz and working sampling frequency of 5kHz. The length of impulse be 7.
2. Design a Chebyshev filter for the following specification using bilinear transformation

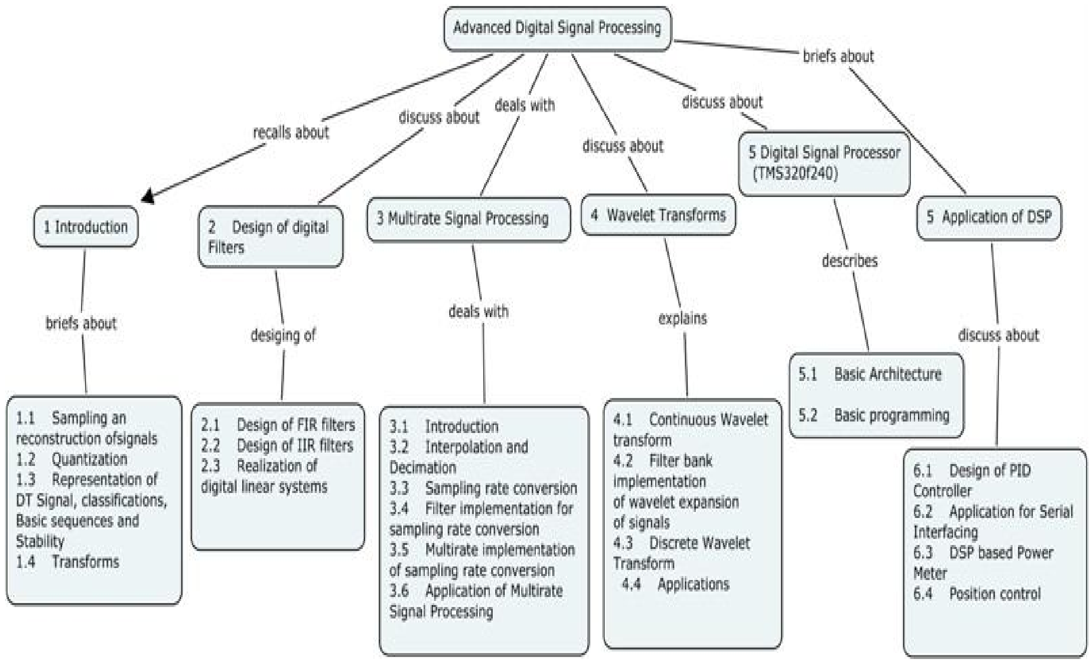
   $0.8 \leq |He^{j\omega}| \leq 1 \qquad 0 \leq \omega \leq 0.2\pi$

   $|He^{j\omega}| \leq 0.2 \qquad 0.6\pi \leq \omega \leq \pi$
3. obtain the cascade and parallel realization of the system described by y(n)= -0.1y(n-1)+0.2y(n-2)+3x(n)+3.6x(n-1)+0.6x(n-2).
4. Design a digital Butterworth filter satisfying the following constraints with T=1sec.using Bilinear transformation. (12)

   $0.9 =< |He^{j\omega}| =< 1 \qquad \text{for } 0 \leq \omega \leq \pi/2$

   $|He^{j\omega}| =< 0.2 \qquad \text{for } 3\pi/4 \leq \omega \leq \pi$
5. Design and also realize a high pass FIR filter with a cutoff frequency of 1.3 rad/sec and N=9.
6. Design an analog BPF to satisfy the following specifications:
   i) 3dB upper and lower cutoff frequencies are 100 Hz and 3.8kHz
   ii) Stop attenuation of 20dB at 20Hz and 8Hz
   iii) No ripple with passband and stopband
7. Write assembly language program to generate Pulse Width modulated signal with fixed duty cycle for TMS320f240 Digital signal processor.(data sheet will be provided)

Concept Map



Syllabus

Introduction
Sampling and reconstruction of signals, Quantization. Representation of DT Signal, classifications, Basic sequences and Stability, Transforms-DTFT & its properties, Discrete Fourier Transform and its properties, Convolution and correlation, efficient computation of DFT by Fast Fourier Transform. Design of digital Filters- Design of FIR filters - design of linear phase FIR filters using Windows, Design of IIR Filters- Design of IIR Filters using Impulse Invariant method and Bilinear transformation method, Butterworth filters and Chebychev filters, Realization of digital linear systems - realization of FIR systems realization of IIR systems.

Multirate Signal Processing
Introduction, Interpolation and Decimation, sampling rate conversion, Filter implementation for sampling rate conversion, multirate implementation of sampling rate conversion, Application of Multirate Signal Processing.
Wavelet Transforms: Continuous Wavelet transform, filter bank implementation of wavelet expansion of signals, Discrete Wavelet Transform -Wavelets, orthogonal Wavelets and biorthogonal Wavelets, Applications.

Digital Signal Processor (TMS320f240)
Basic Architecture – Computational building blocks, MAC, Bus Architecture and memory, Data Addressing, Parallelism and pipelining, Parallel I/O interface, Memory Interface, Interrupt, DMA. Basic programming – Arithmetic Operations, Convolution and Correlation, Filter Design, PWM generation

Application of DSP
Design of Decimation and Interpolation Filter, FFT Algorithm, PID Controller, Application for Serial Interfacing, DSP based Power Meter, Position control.

Reference BOOKS

1. John G.Proakis, Dimitris G.Manolakis, "Digital Signal Processing: Principles, Algorithms and Applications", PHI.
2. A.V. Oppenheim and R.W.Schafer, Englewood "Digital Signal Processing", Prentice Hall, Inc, 1975.
3. S.Salivahanan, A.Vallavaraj and C.Gnanapriya "Digital Signal Processing, TMH, 2000.
4. P.Ramesh Babu – Digital signal processing, Scitech publications of India, 2001.
5. Lonnie C.Ludeman, 'Fundamentals of DSP' John Wiley & Sons, Singapore.
6. S.Mallet, 'A Wavelet tour of signal processing', Academic Press 1998
7. Raguveer m Rao & Ajith S. Bopardikar, 'Wavelet transforms – Introduction to theory and applications', Addison Wesley, 1998
8. www.alldatasheet.com

Course contents and Lecture Schedule

S. No.	Topics	No of lectures
1	**Introduction**	
1.1	Sampling and reconstruction of signals	1
1.2	Quantization	1
1.3	Representation of DT Signal, classifications, Basic sequences and Stability	1
1.4	Transforms	
1.4.1	DTFT & its properties	1
1.4.2	Discrete Fourier Transform and its properties	1
1.4.3	Convolution and correlation	1
1.4.4	Efficient computation of DFT by Fast Fourier Transform	2
2	**Design of digital Filters**	
2.1	Design of FIR filters	
2.1.1	Design of linear-phase FIR filters using Windows	2
2.2	Design of IIR Filters	
2.2.1	Design of IIR Filters using Impulse Invariant method,	1
2.2.2	Bilinear transformation method	1
2.2.3	Butterworth filters, Chebychev filters	1
2.3	Realization of digital linear systems	
2.3.1	Realization of IIR systems	1
2.3.2	Realization of FIR systems	1
3	**Multirate Signal Processing**	
3.1	Introduction	1
3.2	Interpolation and Decimation	2
3.3	Sampling rate conversion	1
3.4	Filter implementation for sampling rate conversion	2
3.5	Multirate implementation of sampling rate conversion	2
3.6	Application of Multirate Signal Processing	1
4	**Wavelet Transforms**	
4.1	Continuous Wavelet transform	1
4.2	Filter bank implementation of wavelet expansion of signals	2
4.3	Discrete Wavelet Transform	1
4.3.1	Wavelets	1
4.3.2	Orthogonal Wavelets	1
4.3.3	Biorthogonal Wavelets	1

4.4	Applications	1
5	**Digital Signal Processor (TMS320f240)**	
5.1	Basic Architecture	1
5.1.1	Computational building blocks	1
5.1.2	MAC, Bus Architecture and memory	1
5.1.3	Data Addressing, Parallelism and pipelining	1
5.1.4	Parallel I/O interface, Memory Interface	1
5.1.5	Interrupt, DMA	1
5.2	Basic programming	
5.2.1	Arithmetic Operations	1
5.2.2	Convolution and Correlation	1
5.2.3	Filter Design	1
5.2.4	PWM generation	1
6	**Application of DSP**	
6.1	Design of PID Controller	1
6.2	Application for Serial Interfacing	1
6.3	DSP based Power Meter	1
6.4	Position control	1
	Total	45

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CN17	-	-	3	1

CN17 Control and Instrumentation Laboratory 0:1

Objective

The Instrumentation and Control Lab aims at training the students in the field of Process control and Instrumentation. Experiments have been designed to demonstrate the time response and frequency response of control systems, performance criteria for optimizing the transient response.

List of Experiments

Control system

1. Characteristics of Control valve, I/P to P/I converters
2. Level control loop using digital controller
3. Cascade control loop using digital controller
4. Temperature control loop using digital controller
5. PLC based automation of industrial processes
6. Design of Fuzzy logic controller using MATLAB fuzzy logic tool box.
7. Simulation of MIMO process using MATLAB/SciLab

Instrumentation

8. Linearization of thermocouple
9. Data acquisition through virtual instrumentation
10. Verification of Nyquist theorem using LABVIEW software.
11. Study the effects of compensator (lag/lead) networks.
12. Calibration of LVDT and Strain gauge.
13. Study of Digital storage Oscilloscope.
14. Design of Current to voltage converter and voltage to current converter.
15. Microprocessor based measurement controlsystem (temperature, position)

Outcome

Upon completing the above laboratory course the students are able to simultaneously work out the solution on the PCs using MATLAB and see exactly how the theoretical and practical observation differ. The students are able design the control schemes for various problems based on constraints independently.

Course designer

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M.Tech. DEGREE (Control and Instrumentation) PROGRAM

CURRICULUM AND

DETAILED SYLLABI FOR SECOND SEMESTER SUBJECTS

&

ELECTIVE SUBJECTS

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2011-2012

THIAGARAJAR COLLEGE OF ENGINEERING
(A Govt. Aided ISO 9001-2008 certified Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU
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Passed in BOS meeting held on 08.10.2011 Approved in 43rd AC meeting held on 12.11.2011

Department of Electrical and Electronics Engineering

Graduating Students of M.Tech. program of Control and Instrumentation will be able to:

1. Specify, architect, design and analyze systems that efficiently measure, control and automation of a plant
2. Specify, design, prototype and test modern control systems that perform analog and digital processing functions.
3. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering, Madurai-625015

Department of Electrical and Electronics Engineering

Scheduling of Courses

Sem	Theory Courses						Practical / Project
4th (12)							CN41 Project 0:12
3rd (16)	CN31 System Identification and adaptive control 3:1	CN EX Elective V 3:1	CN EX Elective VI 3:1				CN34 Project 0:4
2nd (24)	CN21 Advanced Instrumentation system 3:0	CN22 Digital Control system 3:1	CN EX Elective I 3:1	CN EX Elective II 3:1	CN EX Elective III 3:1	CN EX Elective IV 3:1	CN 27 Advanced Control and Instrumentation Laboratory 0:1
1st (24)	CN11 Applied Mathematics for Electrical Engineers 3:1	CN12 Systems Theory 3:1	CN13 Transducer Engineering 3:1	CN14 Process Control and Instrumentation 3:1	CN15 Microcontroller based system Design 3:0	CN16 Advanced Digital Signal Processing 3:1	CN17 Control and Instrumentation Laboratory 0:1

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.Tech. DEGREE (Control and Instrumentation) PROGRAM

SUBJECTS OF STUDY
(For the candidates admitted from 2011-2012 onwards)

FIRST SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
CN11	Applied Mathematics for Electrical Engineers	BS	3	1	-	4
CN12	Systems Theory	DC	3	1	-	4
CN13	Transducer Engineering	DC	3	1	-	4
CN14	Process Control Instrumentation	DC	3	1	-	4
CN15	Microcontroller based system Design	DC	3	-	-	3
CN16	Advanced Digital Signal Processing	DC	3	1	-	4
PRACTICAL						
CN17	Control and Instrumentation Laboratory	DC	-	-	3	1
Total			**18**	**5**	**3**	**24**

SECOND SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
CN21	Advanced Instrumentation system	DC	3	-	-	3
CN22	Digital Control System	DC	3	1	-	4
CNEx	Elective-I	DC	3	1	-	4
CNEx	Elective-II	DC	3	1	-	4
CNEx	Elective-III	DC	3	1	-	4
CNEx	Elective-IV	DC	3	1	-	4
PRACTICAL						
CN27	Advanced Control and Instrumentation Laboratory	DC	-	-	3	1
Total			**18**	**5**	**3**	**24**

BS : Basic Science
DC : Department Core
DE : Departmental Elective

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.Tech. DEGREE (Control and Instrumentation) PROGRAM

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2011-2012 onwards)

FIRST SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	CN 11	Applied Mathematics for Electrical Engineers	3	50	50	100	25	50
2	CN 12	Systems theory	3	50	50	100	25	50
3	CN 13	Transducer Engineering	3	50	50	100	25	50
4	CN 14	Process Control Instrumentation	3	50	50	100	25	50
5	CN 15	Microcontroller based system Design	3	50	50	100	25	50
6	CN 16	Advanced Digital Signal Processing	3	50	50	100	25	50
PRACTICAL								
7	CN 17	Control and Instrumentation Laboratory	3	50	50	100	25	50

SECOND SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	CN21	Advanced Instrumentation system	3	50	50	100	25	50
2	CN22	Digital Control System	3	50	50	100	25	50
3	CNEx	Elective-I	3	50	50	100	25	50
4	CNEx	Elective-II	3	50	50	100	25	50
5	CNEx	Elective-III	3	50	50	100	25	50
6	CNEx	Elective-IV	3	50	50	100	25	50
PRACTICAL								
7	CN27	Advanced Control and Instrumentation Laboratory	3	50	50	100	25	50

* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

List of Elective Subjects – M.Tech. Control and Instrumentation

Departmental Electives			
Sub. Code (CN Ex)	Subject Name	Pre/Co requisites	Credits
A/KEI	Control of Electric Drives	Electrical Machines, Power Electronics	4
B	Bio-Medical Instrumentation	--	4
C	Digital System Design using PLDs	Digital systems	4
D	Advanced Industrial Controllers	Control systems	4
E	Intelligent Controllers	Control systems	4
F	Optimal Control And Filtering	Control systems	4
G	Robust Control	Control systems, system theory	4
H/KEB	Power Plant Instrumentation and Control	Measurements and Instrumentation	4
I/KET	Real Time Operating System	Microprocessor/ Microcontrollers	4
J	MEMS Based Instrumentation	Measurements and Instrumentation	4
K	Robotics And Automation	Control system Microprocessor/ Microcontrollers	4
L	Multi-Sensor Data Fusion	Measurements and Instrumentation	4
M	Data Communication for controllers	Digital systems, Computer Networks	4
N	Embedded System Design	Digital systems	4
O/KEU	SCADA	Microprocessors, Instrumentation, DSP	4

Sub Code	Lectures	Tutorial	Practical	Credit
CN 21	3	0	-	3

CN21 Advanced Instrumentation System 3:0

Preamble

PC has become the most widely used platform for data acquisition and control. The main reasons for the popularity of PC-based technology are low costs, flexibility and ease of use. Data acquisition with a PC enables one to display, log and control a wide variety of real world signals such as pressure, flow, and temperature. This ability coupled with that of easy interface with various stand-alone instruments makes the systems ever more desirable. Today's sophisticated software-based operator interfaces make the PC an increasingly attractive option typical applications like Laboratory data acquisition and control, Automatic test equipment (ATE) for inspection of components , Medical instrumentation and monitoring , Process control of plants and factories, Environmental monitoring and control , Machine vision and inspection . The key to the effective application of PC-based data acquisition is the careful matching of real world requirements with appropriate hardware and software. This course gives solid grasp of the principles and practical implementation of interfacing the PC and stand-alone instruments with real world signals.

Program Outcomes Addressed

b. An ability to design and conduct experiments, as well as to analyze and interpret data
c. An ability to design a system or component, or process to meet stated specifications
d. An ability to identify, formulate and solve engineering problems
e. An ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints

Competencies

At the end of the course students should be able to:

1. Understand the fundamentals of PC-based data acquisition systems.
2. Specify data acquisition systems quickly.
3. Configure data acquisition systems effectively.
4. Develop data acquisition systems for measuring temperature, pressure, level.

Assessment Pattern

Sl.No	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	20	20	10
2	Understand	60	60	60
3	Apply	20	20	30
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. What is aliasing?
2. Mention the types of popular ADCs.
3. What is the maximum data transfer rate in GPIB?
4. List a few buses for PC Expansion.
5. What are the compensations needed while measuring temperature using thermocouple?

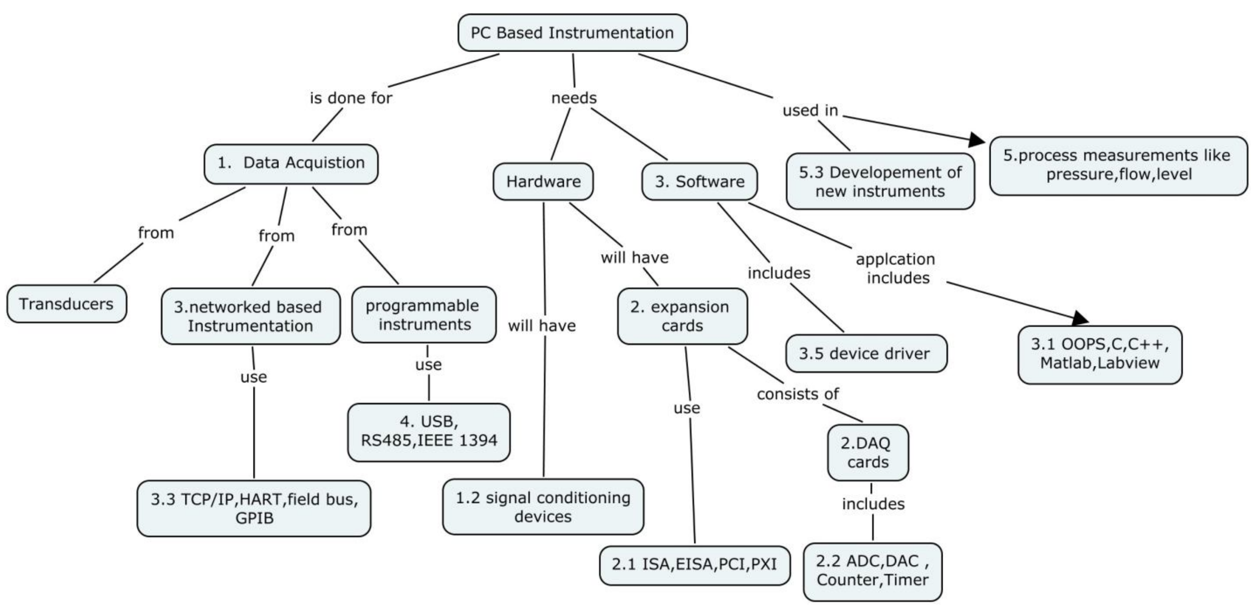
Understand

1. Name a sensor that can be interfaced with a PC for measurement of vibration.
2. Distinguish traditional instruments and PC based instruments.
3. List few software used for development of PC based instruments.
4. What is device driver software?
5. Elaborate on the Electrical Characteristics of the PC bus design Analyze

Apply

1. Describe PC based data acquisition system with associated circuitry for measurement of strain using a full bridge.
2. Describe with schematic diagram showing the key elements in a PC based data acquisition system.
3. With necessary diagrams, describe the general purpose interface bus architecture and explain how multiple devices can be connected to it?
4. Describe the necessary hardware & software for building a PC based instrument.
5. Develop a Temperature measuring instrument using a PC based system.

Concept map



Syllabus

Data Acquisition
Definition of data acquisition and control, Fundamentals of data acquisition, Data acquisition and control system configuration: **Signal Conditioning** types of signal conditioning, Classes of signal conditioning, Field wiring and signal measurement, Noise and interference Minimizing noise, Shielded and twisted-pair cable.
PC Expansion Cards
Operation of interrupts, Operation of direct memory access (DMA) Expansion bus standards (ISA, EISA, PCI, and PXI bus): **Plug-in data acquisition boards**: A/D Boards, Single ended vs differential signals, Resolution, dynamic range and accuracy of A/D boards, Speed vs throughput, D/A boards, Digital I/O boards, Interfacing digital inputs/outputs.
Network based Instrumentation & **Distributed and stand-alone loggers/controllers**
Methods of operation, Stand-alone logger/controller hardware, Communications hardware interface, Host software, Application Software like C, C++, Matlab, LABview ,Considerations in using standalone logger/controllers, Stand-alone logger/controllers vs internal systems, HART Communication protocol -Communication modes , HART networks , control system interface , HART commands : **GPIB**: Electrical and mechanical characteristics, Physical connection configurations, Device types, Bus structure, Device communication, **Ethernet and field buses for data acquisition**: Introduction to Foundation Field bus.
Serial Data Communications
Serial interface standards, comparison of the RS-232 and RS-485 standards, IEEE 1394: **The universal serial bus (USB):** USB overall structure, the physical layer, Data link layer, Application layer (user layer): Wireless technologies: Wireless LANs (WLANs).
PC based Data Acquisition applications
Ultrasonic Measurement system, Electrocardiogram measurement system, Commercial equipments using embedded PCs, Laboratory furnace temperature control, industrial process measurements flow, pressure and level, Future trends in PC based data acquisition.

Reference Books

1. John Park, Steve Mackay, “Practical Data Acquisition for Instrumentation and Control Systems” ELSEVIER , 2005
2. Deon Reynders , Steve Mackay, Edwin Wright “Practical Industrial Data Communications Best Practice Techniques”, ELSEVIER , 2005
3. Howard Austerlitz, “Data acquisition techniques using PC” ACADEMIC PRESS, second edition 2003
4. Mike Tooley, ”PC Based Instrumentation and Control,” ELSEVIER , 2005
5. N.Mathivanan,”PC Based Instrumentation Concepts and Practice”, PHI ,2007
6. Kevin James,”PC Interfacing and Data Acquisition :Techniques for measurements, Instrumentation and Control “,Newnes 2000

Course contents and lecture schedule

Sl.No.	Topic	No. of Lectures
1	**Data Acquisition**: Definition of data acquisition and control	1
1.1	Fundamentals of data acquisition, Data acquisition and control system configuration	2

1.2	**Signal Conditioning**: types of signal conditioning	1
1.3	Classes of signal conditioning, Field wiring and signal measurement,	2
1.4	Noise and interference Minimizing noise, Shielded and twisted-pair cable	1
2	**PC Expansion Cards**: Operation of interrupts	1
2.1	Operation of direct memory access (DMA) Expansion bus standards (ISA, EISA, PCI, and PXI bus)	2
2.2	**Plug-in data acquisition boards**: A/D Boards, Single ended vs differential signals,	2
2.3	Resolution, dynamic range and accuracy of A/D boards, Speed vs throughput,	2
2.4	D/A boards, Digital I/O boards, Interfacing digital inputs/outputs	2
3	**Network based Instrumentation** & **Distributed and stand-alone loggers/controllers**: Methods of operation, Stand-alone logger/controller hardware,	2
3.1	Communications hardware interface, Host software, Application Software like C,C++,Matlab,LABview Considerations in using standalone logger/controllers,	2
3.2	Stand-alone logger/controllers vs internal systems,	2
3.3	HART Communication protocol -Communication modes , HART networks	2
3.4	control system interface , HART commands : **GPIB**: Electrical and mechanical characteristics,	2
3.5.	Physical connection configurations, Device types, Bus structure, Device communication,	1
3.6	**Ethernet and field buses for data acquisition**: Introduction to Foundation Field bus	1
4	**Serial Data Communications**: serial interface standards,	1
4.1	comparison of the RS-232 and RS-485 standards, IEEE 1394:	2
4.2	**The universal serial bus (USB):** USB overall structure, the physical layer, Data link layer, Application layer (user layer):	2
4.3	Wireless technologies: Wireless LANs (WLANs)	1
5	**PC based Data Acquisition applications**: Ultrasonic Measurement system, Electrocardiogram measurement system,	1
5.1	Commercial equipments using embedded PCs, Laboratory furnace temperature control,	2
5.2	industrial process measurements flow, pressure and level	2
5.3	Future trends in PC based data acquisition	1
	Total	40

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CN 22	**3**	**1**	**-**	**4**

CN 22 Digital Control System 3: 1

Preamble

Modern embedded solutions allow for better performance and lower costs of dynamic systems such as servomechanisms, chemical processes, and vehicles that move over water, land, air, or space. Digital control theory is here an enabling factor as it can exploit steadily increasing computational capabilities to shift emphasis from hardware to software and thus to take full advantage of modern embedded solutions. This course illustrates the main issues related to digital control theory. The aim is to provide basic notions required for the design and implementation of a digital control system. This knowledge is necessary for the selection of an appropriate microprocessor/DSP or for the correct design of a dedicated component.

Program outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics and science
b. An ability to design and conduct experiments, as well as to analyze and interpret data
c. An ability to identify, formulate and solve engineering problems
d. An ability to use techniques, skills and modern engineering tools to implement and organize engineering works under given constraints

Competencies

At the end of the course the students should be able to:

1. Represent sampled-data systems using difference equations, transfer functions, all-delay block diagrams and state-space models.
2. Analyze digital control systems using transform techniques and state-space methods .
3. Design, digital control systems using transform techniques and state-space methods .

Assessment Pattern

Sl.No.	Bloom's Category	Test 1	Test 2	Test 3/End semester examination
1	Remember	20	20	20
2	Understand	40	40	20
3	Apply	0	0	0
4	Analyze	40	40	60
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. What is zero-order hold circuit in sampled data control system?
2. List the methods of discritezation technique.
3. Define observability and controllability of a system.
4. What is meant by dead beat control?
5. What is aliasing?
6. What is state feedback controller?
7. What is reduced order observer?
8. What is meant by sampled data control system?
9. Define pulse transfer function with respect to sampled data control system.

Understand

1. Write the condition of the sampling period for a signal to be reconstructed faithfully.
2. Discuss the effects of sampling?
3. What is purpose of hold circuit in sample data control system?
4. What are the effects of adding an observer on a closed loop system?
5. What is aliasing phenomena and how it can be corrected?
6. List the different types of digital control systems.
7. Compare between transform technique and frequency response method.
8. What are the problems encountered in the practical hold circuit?
9. State the necessary condition to be stable for a sampled data control system.
10. List the methods for analyzing the sampled data control system.

Analyze

1. Design a suitable state feedback controller such that system will have the closed loop response at Z=0.5+0.5j, Z=0.5-0.5j.

2. Consider plant given by the state space equation, x(k+1)=Gx(k)+Hu(k), y(k)=Cx(k) Where

$$G=\begin{pmatrix}1 & T\\ 0 & 1\end{pmatrix} \quad H=\begin{pmatrix}0\\ 1\end{pmatrix} \quad C=\begin{pmatrix}1\\ 0\end{pmatrix}$$

T=1 sec sampling period.

Design a suitable state observer. It is desired that the error vector exhibit deadbeat response.

3. Solve the following difference equation using z-transform method;

C(k+2)-1.5c(k+1)+c(k)=2u(k) where c(0)=0 and c(1)=1

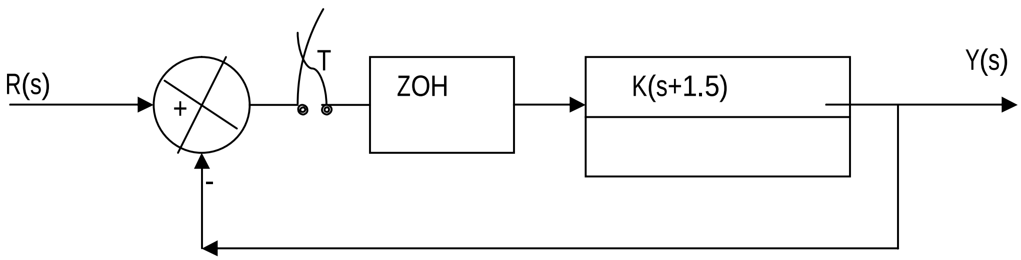
4. The characteristic equation of a digital system is

$2Jz^2+(2k_rT-4J_v+T^2K_p)z+(2J_v-2K_rT+T^2K_p)=0$

$T=0.264s$, $J_v=41822$ and $K_p=1.65*10^6$

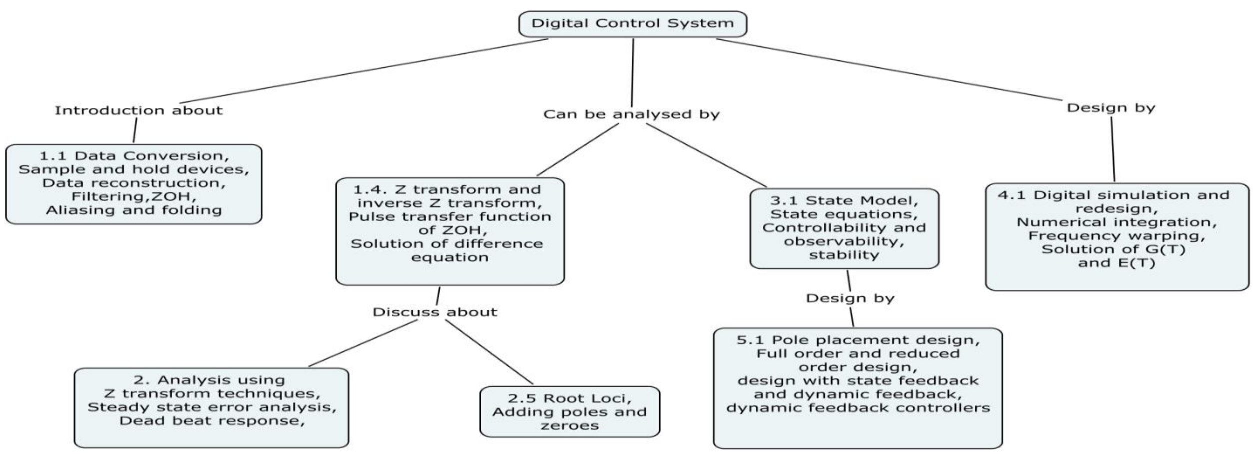
(a) Sketch the root loci of the characteristic equation for $0<K_R<\infty$.
(b) Find the range of K_R so that the system is stable.

5. The block diagram shown below represents a discrete-data model of a continuous-data system by the insertion of sample and hold device in the forward path.



Find the region of stability in the K-versus-T plane .

Concept Map



Syllabus

Introduction to digital control systems and Z- Transform Techniques

Basic elements, data conversion and quantization, sample and Hold devices, mathematical modeling of the sampling process, data reconstruction and filtering of sampled signals, zero-order hold, the first-order hold, aliasing and folding, choice of the sampling period - Z-transform, Inverse Z-transform, pulse transfer and z-transfer function, pulse transfer function of the ZOH, solution of difference equation, response of discrete-data control system.

Analysis using Z- Transform Techniques

Comparison of time responses of continuous data and discrete data systems, steady state error analysis of digital control systems, correlation between time response and root locations in the s-plane and the z-plane, constant damping factor and constant damping ratio loci, dead beat response at the sampling instants, root loci for digital control systems, effect of adding poles and zeroes to the open-loop transfer function.

Discrete-time state model

State equations of discrete-data systems with sample and hold devices, state equations of digital systems with all digital elements, different state variable models, digital simulation and approximation, state transition equations, state diagrams of digital systems, Decomposition of discrete data transfer functions, Controllability and observability of discrete data systems, relation between observability, controllability and transfer functions, Controllability and observability versus sampling period, stability.

Digital simulation and Digital redesign

Digital modeling of sample and Hold devices, Digital simulation of state variable model, Digital simulation- Numerical integration, Frequency warping and prewarping, Digital redesign- closed form solution for G(T), Partial matching of states, solution of feedback matrix by series expansion, Exact solution of E(T), solution of E(T) by series expansion.

Controller Design using Discrete-time state model

Pole placement design by state feedback: single input and multiple input, Full order and reduced order observer design, design of digital control systems with state feedback and dynamic output feedback, realization of state feedback by dynamic controllers.

Reference books

1. Benjamin C. Kuo, Digital control systems, Second edition (Indian),2007, Oxford University Press.
2. R. J. Vacaro, Digital Control: A State Space Approach, McGraw-Hill Higher Education, 1995
3. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill Publication Limited, 2008
4. Ogata, Discrete-time Control Systems, Prentice hall, Second edition, 2005.
5. M. Gopal, Digital Control Engineering New Age International,2006.
6. Franklin, Powell, Workman, Digital Control of Dynamic Systems, Pearson Education Third, 2006.

Course contents and lecture schedule

Sl.No.	Topic	No of Lectures
1	**Introduction to digital control systems and Z- Transform Techniques**	

1.1	Basic elements, data conversion and quantization, sample and Hold devices	1
1.2	Mathematical modeling of the sampling process, data reconstruction and filtering of sampled signals	2
1.3	Zero-order hold, the first-order hold, aliasing and folding, choice of the sampling period	2
1.4	Z-transform, Inverse Z-transform, pulse transfer and z-transfer function	2
1.5	Pulse transfer function of the ZOH, solution of difference equation	2
1.6	Response of discrete-data control system.	1
2	**Analysis using Z- Transform Techniques**	
2.1	Comparison of time responses of continuous data and discrete data systems	1
2.2	Steady state error analysis of digital control systems	2
2.3	Correlation between time response and root locations in the s-plane and the z-plane, constant damping factor and constant damping ratio loci.	1
2.4	Dead beat response at the sampling instants	1
2.5	Root loci for digital control systems	1
2.6	Effect of adding poles and zeroes to the open-loop transfer function.	1
3	**Discrete-time state model**	
3.1	State equations of discrete-data systems with sample and hold devices, state equations of digital systems with all digital elements	2
3.2	Different state variable models, digital simulation and approximation	1
3.3	State transition equations, state diagrams of digital systems	1
3.4	Decomposition of discrete data transfer functions	1
3.5	Controllability and observability of discrete data systems, relation between observability, controllability and transfer functions	1
3.6	Controllability and observability versus sampling period, stability.	2
4	**Digital simulation and Digital redesign**	
4.1	Digital modeling of sample and Hold devices	1
4.2	Digital simulation of state variable model	1

4.3	Digital simulation- Numerical integration	1
4.4	Frequency warping and prewarping	1
4.5	Digital redesign- closed form solution for G(T), Partial matching of states	1
4.6	Solution of feedback matrix by series expansion, Exact solution of E(T)	2
4.7	Solution of E(T) by series expansion.	1
5	**Controller Design using Discrete-time state model**	
5.1	Pole placement design by state feedback: single input and multiple input	2
5.2	Full order and reduced order observer design	2
5.3	Design of digital control systems with state feedback and dynamic output feedback	2
5.4	Realization of state feedback by dynamic controllers	1
Total		40

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CN 27	-	-	**3**	**1**

CN 27 Advanced Control and Instrumentation Laboratory 0 :1

Objective

The advanced Control and Instrumentation Laboratory aims at training the students in the recent developments in the field of Process control and Instrumentation. Experiments have been designed to demonstrate the performance of intelligent tools in modeling and control, LabView and dSPACE based real time data acquisition and control, PLC based process automation.

List of Experiments

1. System modeling using Neural Network and ANFIS using MATLAB
2. Fuzzy logic controller using Fuzzy logic Toolbox
3. Labview based measurement of strain using strain gauge module
4. Labview based buffered data acquisition
5. Experimental determination of transfer function of Quanser Servo plant using dSPACE
6. Real time control of magnetic ball suspension system using dSPACE
7. DSP based closed loop Induction motor control
8. DC servo motor control
9. PLC based process automation
10. Optimal tuning of PID controller for various processes using MATLAB
11. DC motor control using PLC Drive

Outcome

Upon completing the above laboratory course the students know the application of intelligent tools in modeling and control, LabView and dSPACE based real time data acquisition and control, PLC based process automation.

Course designers

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Sub code	Lectures	Tutorial	Practical	Credit
CN EA / KEI	**3**	**1**	**-**	**4**

CN EA / KEI Control of Electric drives 3:1

(Common to M.E Power System Engineering)

Preamble

Electrical drives play an important role as electromechanical energy converters in transportation, material handling and most production processes. The ease of controlling electrical drives is an important aspect for meeting the increasing demands by the user with respect to flexibility and precision, needed by technological progress in industry as well as the need for energy conservation. A drive may require a control of torque, acceleration, speed or Position. The field of controlled electrical drives has undergone a rapid expansion mainly due to the advances of semiconductors in the form of power electronics as well as analogue and digital signal electronics. The introduction of electronically switched solid-state power converters has created new and difficult control problems to the electric drives.

Program Outcomes addressed

a) An ability to apply knowledge of engineering, information technology, mathematics and science
c) An ability to design a system or component, or process to meet stated specifications
d) An ability to identify, formulate and solve engineering problems.
e) An ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints

Competencies

At end of the course the graduates will be able to:

1. Analyze and characterize various control strategies for DC & AC motor Drives.
2. Analyze the role of power electronic converters in drives.
3. Classify the choice of electrical drives for practical applications.
4. Able to design the controller for an application.
5. Able to build an efficient drive system to meet the increasing demands in industry.

Assessment pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3 /End-semester examination
1	Remember	20	20	20
2	Understand	20	20	20
3	Apply	30	30	30
4	Analyze	30	30	30
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. Name the various blocks in closed loop drives.
2. What is meant by v/f control?
3. List the advantages of variable frequency drives.
4. Name the types of stepper motor drive.
5. List the advantages of load commutated inverter fed BLDC drive.
6. Identify the blocks in digital position control.

Understand

1. With the neat block diagram explain the operation of closed loop speed control with inner current loop and field weakening.
2. Explain how four quadrant operation is achieved by dual converters, each of 3-phase full wave configuration, for a dc motor.
3. With neat block diagram explain the operation of closed loop variable frequency drive using current controlled PWM inverter.
4. Describe the operation of wound field BLDC motor drive with constant margin angle control.
5. Explain the operation of speed controlled PMBLDCM drive scheme.
6. Discuss limits of analog implementation on the closed-loop performance.

Apply:

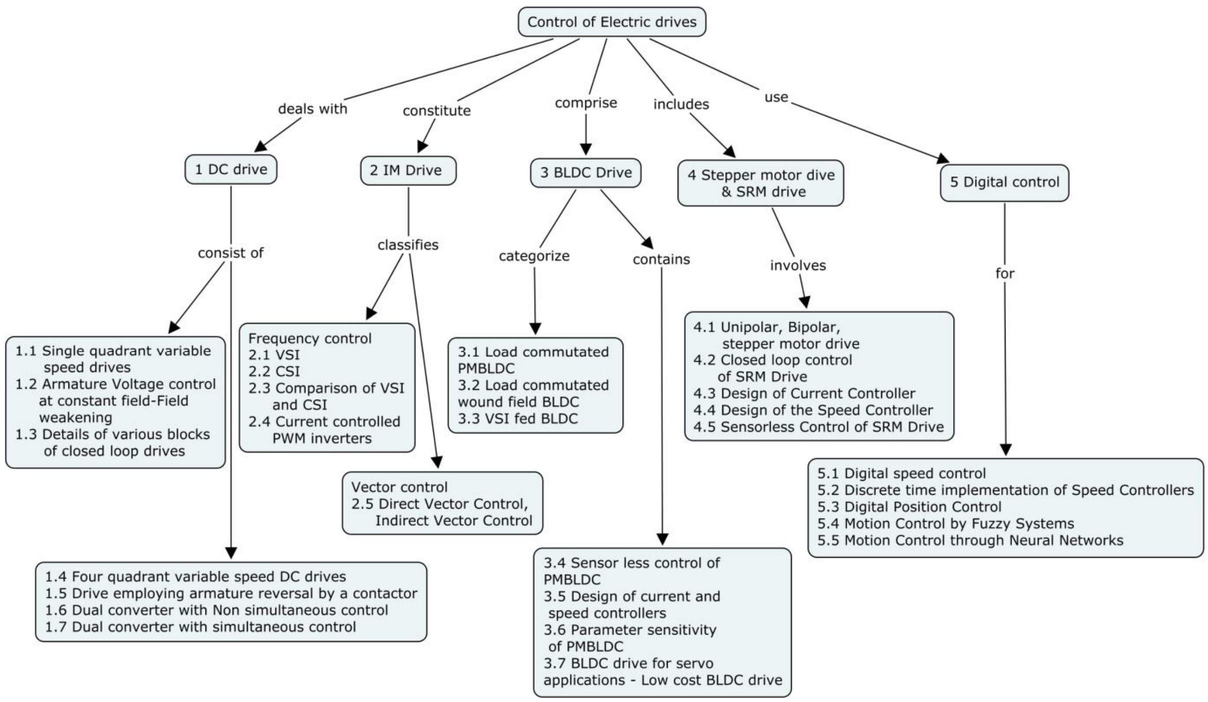
1. A 3-phase, 50KW, 1470rpm, 400V, 50Hz, 4 pole Y-connected induction motor has the following data : R_s =0.42 Ω, R_r =0.23Ω, X_s =0.95 Ω, X_r =0.85 Ω and X_m =28Ω, all the quantities being referred to the stator side. The motor is operated with frequency control. If the slip for maximum torque at the given supply frequency 0.12, determine a) supply frequency b) breakdown torque c) The speed at maximum torque.
2. Draw a simple circuit of speed control by current limit control to illustrate the closed loop performance of dc drive.
3. Construct a current controller for a BLDC motor drive system.
4. A 460 V, 60Hz, 6 pole, 1180 rpm, Y-connected squirrel cage induction motor has the following parameters per phase referred to the stator: R_s =0.19 Ω, R_r’ =0.07Ω, X_s =0.75 Ω, X_r’ =0.67 Ω and X_m =20Ω. The motor is fed by a 6-step inverter, which in turn is fed by a 6-pulse fully controlled rectifier and the motor is operated at constant v/f ratio , calculate the inverter frequency and the stator current at half the rated torque and 500 rpm. Neglect derating due to harmonics.
5. Illustrate the effects of slip speed controlled PWM inverter drive with regenerative braking.
6. Implement the digital speed controllers in a closed loop operation of drive system.

Analyze

1. Differentiate between single quadrant and four quadrant drives.
2. Compare and contrast CSI and VSI fed induction motor drives.

3. Devise a control scheme to maximize the efficiency of the induction motor drive operating with a vector control strategy.
4. Analyze the issues related to sensor less control of PMBLDC drive scheme.
5. Organize the steps involved in closed loop speed control of SRM drive.
6. Inspect the role of the digital controller within a speed control system.

Concept map



Syllabus

CONTROL OF DC DRIVES

Single quadrant variable speed drives-Armature Voltage control at constant field- Field weakening- Details of various blocks of closed-loop drives - Four quadrant variable speed DC drives- Drive employing armature reversal by a contactor, Drive employing a Dual converter with Non simultaneous control, Drive employing a Dual converter with simultaneous control.

CONTROL OF INDUCTION MOTOR DRIVES

Voltage Source Inverter fed Variable frequency drives - Current Source Inverter fed Variable frequency drives – Comparison of Voltage source and Current source inverter drives-Closed loop variable frequency drive using Current controlled PWM inverters - Vector controlled Induction Motor drives- Direct Vector Control, Indirect Vector Control.

CONTROL OF BLDC DRIVES

Load commutated Permanent Magnet brushless dc motor drive- Load commutated wound field brushless dc motor drive - Voltage source inverter fed BLDC motor drive- Sensor less control of PMBLDC drive- Design of current and speed controllers - Parameter sensitivity of PMBLDC drive – BLDC drive for servo applications - Low cost BLDC drive.

STEPPER MOTOR DRIVE AND SRM DRIVE

Stepper Motor Drive- Unipolar drive, Bipolar drive - Control of SRM Drive - Closed-Loop, Speed Controlled SRM Drive - Design of Current Controller - Design of the Speed Controller-Sensorless Control of SRM Drive.

DIGITAL CONTROL OF DRIVES

Digital Speed Control- Discrete time implementation of Speed Controllers- Digital Position Control- Motion Control by Fuzzy Systems- Motion Control through Neural Networks.

Reference Books

1. G.K. Dubey, 'Power Semiconductor Controlled Drives', Prentice Hall, N. Jersey, 1989.
2. R.Krishnan, ‘Electric Motor Drives’, PHI Learning Pvt. Ltd., 2001.
3. G.K. Dubey, 'Fundamentals of Electrical Drives', Narosa Publishing House, Second Edition, 2001.
4. Slobodan N. Vukosavic, ‘Digital Control of Electrical Drives’, Springer, 2007.
5. Ion Boldea, Syed A. Nasar, ‘Electric Drives’, Second Edition, CRC Press, 1999
6. R. Krishnan ‘Switched Reluctance Motor drives’, CRC Press , 2001.
7. Jacek F Gieras , ‘Permanent Magnet Motor Technology Design and Applications’, Third Edition,CRC Press, 2010.

Course content and Lecture Schedule

S.No.	Topic	No. of Lectures
1	**CONTROL OF DC DRIVES**	
1.1	Single quadrant variable speed drives	2
1.2	Armature Voltage control at constant field-Field weakening	2
1.3	Details of various blocks of closed-loop drives	2
1.4	Four quadrant variable speed DC drives	1
1.5	Drive employing armature reversal by a contactor	1
1.6	Drive employing a Dual converter with Non simultaneous control	1
1.7	Drive employing a Dual converter with simultaneous control	1
2	**CONTROL OF INDUCTION MOTOR DRIVES**	
2.1	Voltage Source Inverter fed Variable frequency drives	1
2.2	Current Source Inverter fed Variable frequency drives	1
2.3	Comparison of Voltage source and Current source inverter drives	1
2.4	Closed loop variable frequency drive using Current controlled PWM inverters	2
2.5	Vector controlled Induction Motor drives- Direct Vector Control, Indirect Vector Control	2
3	**CONTROL OF BLDC DRIVES**	

3.1	Load commutated Permanent Magnet brushless dc motor drive	1
3.2	Load commutated wound field brushless dc motor drive	1
3.3	Voltage source inverter fed BLDC motor drive	1
3.4	Sensor less control of PMBLDC drive	2
3.5	Design of current and speed controllers	1
3.6	Parameter sensitivity of PMBLDC drive	1
3.7	BLDC drive for servo applications - Low cost BLDC drive	2
4	**STEPPER MOTOR DRIVE AND SRM DRIVE**	
4.1	Stepper Motor Drive- Unipolar drive, Bipolar drive	2
4.2	Control of SRM Drive - Closed-Loop, Speed Controlled SRM Drive	2
4.3	Design of Current Controller	1
4.4	Design of the Speed Controller	1
4.5	Sensorless Control of SRM Drive	1
5	**DIGITAL CONTROL OF DRIVES**	
5.1	Digital Speed Control	1
5.2	Discrete time implementation of Speed Controllers	1
5.3	Digital Position Control	1
5.4	Motion Control by Fuzzy Systems	2
5.5	Motion Control through Neural Networks	2
	Total	40

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CN EB	**3**	**1**	**-**	**4**

CN EB Bio-Medical Instrumentation 3:1

Preamble

Biomedical instrumentation is the application of engineering principles and design concepts to medicine and biology. This field seeks to close the gap between engineering and medicine: It combines the design and problem solving skills of engineering with medical and biological sciences to improve healthcare diagnosis, monitoring and therapy. Recent advances in medical field have been fuelled by the instruments developed by the Electronics and Instrumentation Engineers. Pacemakers, Ultrasound Machine CAT, Medical diagnostic systems are few names which have been contributed by engineers. Now health care industry uses many instruments which are to be looked after by instrumentation engineers. This subject will enable the students to learn the basic principles of different instruments/equipment used in the health care industry.

Program Outcomes Selected

b. Graduates will demonstrate knowledge of mathematics, science and engineering.
c. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
d. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.
e. Graduates will demonstrate skills to use modern engineering tools, softwares and equipment to analyze problems.

Competencies

At the end of the course, the students should be able to :

1. Understand the principles of biomedical measurement systems.
2. Understand the origin of biopotentials and various bioelectric signals.
3. Describe the signal amplification and processing that is common to many medical instruments design.
4. Design the bio signal amplifiers that is common to many medical instruments.
5. Apply principles of sensors to convert physiological events to electric signals in a number of medical instruments.
6. Identify the parameters constraining the resolution of the medical image.

Assessment pattern

Sl.No.	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	20	20	10
2	Understand	40	40	50
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning Objectives

Remember

1. Define accuracy and precision. Define macro and micro shock.
2. What is meant by over potential and give its types.
3. Give the merits and merits of electro magnetic blood flow meter.
4. What are the frequency range of ECG, EEG and EMG waves?

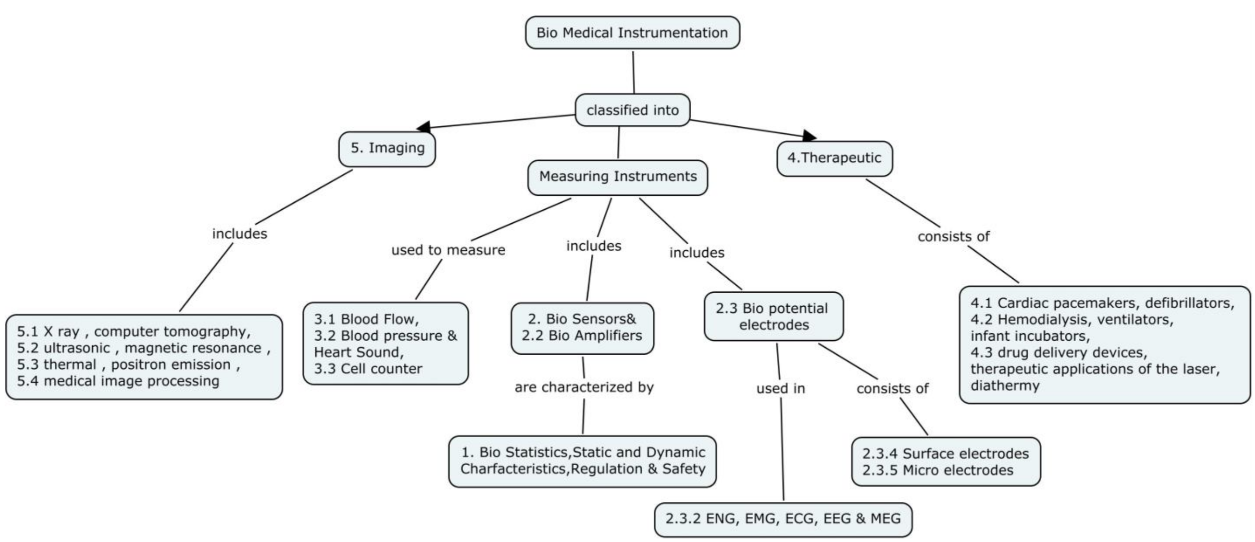
Understand

1. Explain electrical activity of Excitable cells with necessary sketch.
2. Explain different temperature transducers and give two applications in the field of Biomedical Engineering.
3. Explain EEG and 10-20 electrode system used in EEG recording systems.
4. List out the therapeutic applications of laser.
5. Explain the principles of Magnetic Resonance imaging systems and gives its advantages.

Apply

1. Calculate the cardiac ouput for given data: spirometer O_2 consumption 250ml/min, arterial O_2 content 0.20ml/ml, venous O_2 content 0.15ml/ml.
2. Calculate the half cell potential drop from the aluminium to the silver assuming that both the metals are immersed in an electrolyte and separated by a large distance. Half cell potential of Al and Ag is -1.7V and +0.8V respectively at 25degree Centigrade.
3. Construct the instrumentation amplifier with the gain of 10 and CMRR is 10dB.
4. A pulsed Doppler flow meter has fr=15kHz, fo=8MHz and θ=45 degree. Calculate Rm and u_m
5. Develop the electrode of the smallest area that has an impedance of 10Ω at 100Hz.

Concept Map



Syllabus

BASIC CONCEPTS OF BIO MEDICAL INSTRUMENTATION
Terminology – Generalised medical instrumentation system – Measurement constrains – Classification – Interfacing and modifying inputs – Bio statistics – Static and dynamic characteristic – Regulation of medical devices – Electrical safety in medical environment.

BIO SENSORS AND BIOELECTRIC AMPLIFIERS
Ion exchange membrane electrodes, enzyme electrode, glucose sensors, immunosensors. Basic principles of MOSFET biosensors & BIOMEMS. Special features of bioelectric amplifiers, safety requirements, realization of bioelectric amplifiers, current amplifiers, chopper amplifiers, phase sensitive detector, isolation amplifiers, and instrumentation amplifiers.

BIO POTENTIALS AND MEASUREMENTS
Electric activity and excitable cells – Functional organization of peripheral nervous system. ENG, EMG, ECG, EEG & MEG and recording systems – Bio-potential electrodes – Electrolyte interface. Polarization – Body surface recording electrodes -microelectrodes– Electrodes for electric simulation of tissues – Practical hints for using electrodes.

BLOOD FLOW, PRESSURE, SOUND, CELL COUNTERS MEASUREMENT
Blood Flow- Electromagnetic blood flow meter, ultrasonic blood flow meter, Doppler blood flow meter, NMR blood flow meter, cardiac output measurement – indicator dilution methods and impedance technique. **Blood pressure and heart sound measurement**: Measurement of blood pressure using sphygmomanometer instrument based on Korotkoff sound, indirect measurement of blood pressure, automated indirect measurement, and specific direct measurement techniques. Heart sound measurement – stethoscope, phonocardiograph. **Blood cell counters**: Different methods for cell counting, Coulter Counters, automatic recognition and differential counting of cells.

THERAPEUTIC AND PROSTHETIC DEVICES
Cardiac pacemakers, defibrillators, Hemodialysis, ventilators, infant incubators, drug delivery devices, therapeutic applications of the laser, diathermy

MEDICAL IMAGING SYSTEMS
X ray machine, computer tomography, ultrasonic imaging system, magnetic resonance imaging system, thermal imaging system, positron emission tomography , medical image processing

Reference Books

1. R. S. Khandpur "Handbook of Bio-Medical Instrumentation", second edition Tata McGraw Hill 2005.
2. J.Webster, "Medical Instrumentation application and design", third edition Wiley & Sons 2001.
3. Carr & Brown, "Introduction to Biomedical Equipment Technology" Pearson Education, Asia.
4. Leslie Cromwell, " Biomedical Instrumentation and Measurements"

Course content and Lecture Schedule

SL. No.	Topics	No of lectures
1	**BASIC CONCEPTS OF BIO MEDICAL INSTRUMENTATION**	
1.1	Terminology, Generalized medical instrumentation system	1
1.2	Measurement constrains &Classification	1
1.3	Interfacing and modifying inputs & Bio statistics	1
1.4	Static and dynamic characteristic	1
1.5	Regulation of medical devices & Electrical safety in medical environment	2
2	**BIO SENSORS AND BIOELECTRIC AMPLIFIERS**	
2.1	**BIO SENSORS**	
2.1.1	Ion exchange membrane electrodes, enzyme electrode,	1
2.1.2	Glucose sensors, immune sensors. Basic principles of MOSFET biosensors & BIOMEMS.	2
2.2	Special features of bioelectric amplifiers & safety requirements	1
2.2.1	Realization of bioelectric amplifiers & current amplifiers	2
2.2.2	Chopper amplifiers & phase sensitive detector	1
2.2.3	Isolation amplifiers and instrumentation amplifiers	1
2.3	**Bio Potentials and Measurements**	
2.3.1	Electric activity and excitable cells – Functional organization of peripheral nervous system	2
2.3.2	ENG, EMG, ECG	2
2.3.3	EEG & MEG and recording systems – Bio-potential electrodes – Practical hints for using electrodes	2
2.3.4	Electrolyte interface. Polarization – Body surface recording electrodes	1
2.3.5	Microelectrodes, Electrodes for electric simulation of tissues	1
3	**Blood Flow**	
3.1	Electromagnetic blood flow meter, ultrasonic blood flow meter.	1
3.1.2	Doppler blood flow meter, NMR blood flow meter.	1
3.1.3	Cardiac output measurement – indicator dilution methods and impedance technique	1
3.2	**Blood pressure and heart sound measurement**	
3.2.1	Measurement of blood pressure using sphygmomanometer instrument based on Korotkoff sound	1
3.2.2	Indirect measurement of blood pressure, automated indirect measurement, and specific direct measurement techniques.	2
3.2.3	Heart sound measurement – stethoscope, phonocardiograph.	1
3.3	**Blood cell counters**	
3.3.1	Different methods for cell counting, Coulter Counters,	1
3.3.2	Automatic recognition and differential counting of cells.	1
4	**THERAPEUTIC AND PROSTHETIC DEVICES**	
4.1	Cardiac pacemakers, defibrillators	1
4.2	Hemodialysis, ventilators, infant incubators	2
4.3	Drug delivery devices, therapeutic applications of the laser, diathermy	1

5	**MEDICAL IMAGING SYSTEMS**	
5.1	X ray machine, computer tomography	1
5.2	Ultrasonic imaging system, magnetic resonance imaging system	2
5.3	Thermal imaging system, positron emission tomography	1
5.4	Medical image processing	1
Total		40

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CN EC	**3**	**1**	**-**	**4**

CN EC Digital System Design using PLDs 3:1

Preamble

A decade back SSI, and MSI circuits were used largely to build digital systems. With advent of VLSI devices most of the designs moved to ASIC domain. Also, at the same time Filed Programmable devices started to evolve. As time progressed these devices has taken up the space of SSI and MSI devices and started to even replace ASICs at lowest end. Presently Field programmable devices are able to match the functional complexity of ASIC Devices such as PROM, PLDs(PLAs, PALs). PALs were widely used for glue logic and replaced SSI and MSI devices. Complex PLD's are hierarchical PLD's that connects smaller PLD's through a central programmable interconnect to enable the implementation of medium complexity digital circuits. Main feature of CPLDs are the wide decoding, but has a low register to logic ratio. CPLD's architecture is not scalable, due to the central switch used in connecting small PLD structures. Digital designs once built in custom silicon are increasingly implemented in field programmable gate arrays (FPGAs), but effective FPGA system design requires a understanding of new techniques developed for FPGAs. This course deals FPGA fabrics, introduces essential FPGA concepts, and compares multiple approaches to solving basic problems in programmable logic.

Program Outcomes addressed

a) Students will reveal an ability to identify, formulate and solve digital engineering problems.

b) Graduates will demonstrate knowledge of mathematics, science and engineering.
c) Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
d) Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.
e) Graduate will demonstrate skills to use modern engineering tools, softwares and equipment to analyze problems.
f) Graduate who can participate and succeed in competitive examinations.

Competencies

At the end of the course, the students should be able to:

1. Describe the architecture of SPLDs and CPLDs
2. Construct the digital circuits using SPLDs and CPLDs.
3. Describes the architecture of FPGAs based sytem.
4. Understand the FPGA Fabrics technology.
5. Design a digital system using FPGAs
6. Do modeling a digital system using Hardware Description Language (Verilog).

Assessment pattern

Sl.No.	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	20	20	10
2	Understand	30	30	30
3	Apply	30	30	30
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	20	20	30

Course level Learning Objectives

Remember

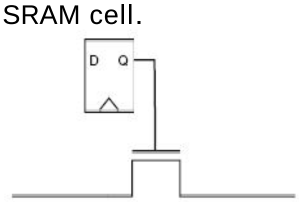
1. Explain the architecture of PLA.
2. Gives the Goals of FPGAs based system.
3. Define Clock Skew.
4. Define Design Abstraction of FPGAs.
5. Define One-Hot State Encoding .
6. Explain the type of packages used in CPLDs

Understand

1. Which technology is used for CPLD Programmable elements?
2. Explain the programmable AND, fixed OR structure of SPLD.
3. Explain the Methodology for evaluating FPGA fabrics.
4. How the antifuses can be programmed?
5. Explain the Logic Implementation methods for FPGAs.
6. What is meant by Antifuses?

Apply

1. Draw the internal architecture of a PLA device.
2. Show the logic arrangement of both a PROM and a PLA required implementing a binary full adder.
3. How many two-input LUTs would be required to implement a four-bit ripple-carry adder?
4. Draw a transistor-level schematic diagram for the programmable interconnection point shown in Figure. The interconnection point should be controlled by a five-transistor SRAM cell.

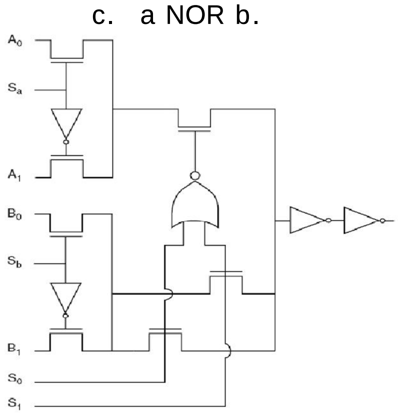


5. Show how to program this logic element to perform:
   a. a + b + c (arithmetic, sum only not carry).
   b. a - b (arithmetic, difference only not borrow).

6. Draw a transistor-level schematic for a programmable interconnection point implemented using a three-state buffer.
7. Draw a schematic of a switch logic network using transmission gates for a three input multiplexer

Create

1. Design each of these functions using a tree of multiplexers:
    a. a | ~b.
    b. a & (b | c).
    c. (a & ~b) | (c & d).
2. Write Verilog/VHDL code to introduce glitch control to the inputs of an adder.The adder receives an additional chg that is 1 when the adder's inputs are changing.
3. Design a four-input multiplexer that uses a combination of pass transistors and static gates. The first stage of multiplexing should be performed by pass transistors while the remaining multiplexing should be performed by static gates.
4. Program the logic element of shown Figure to perform these functions:
    a. a & b.
    b. a | b.
    c. a NOR b.

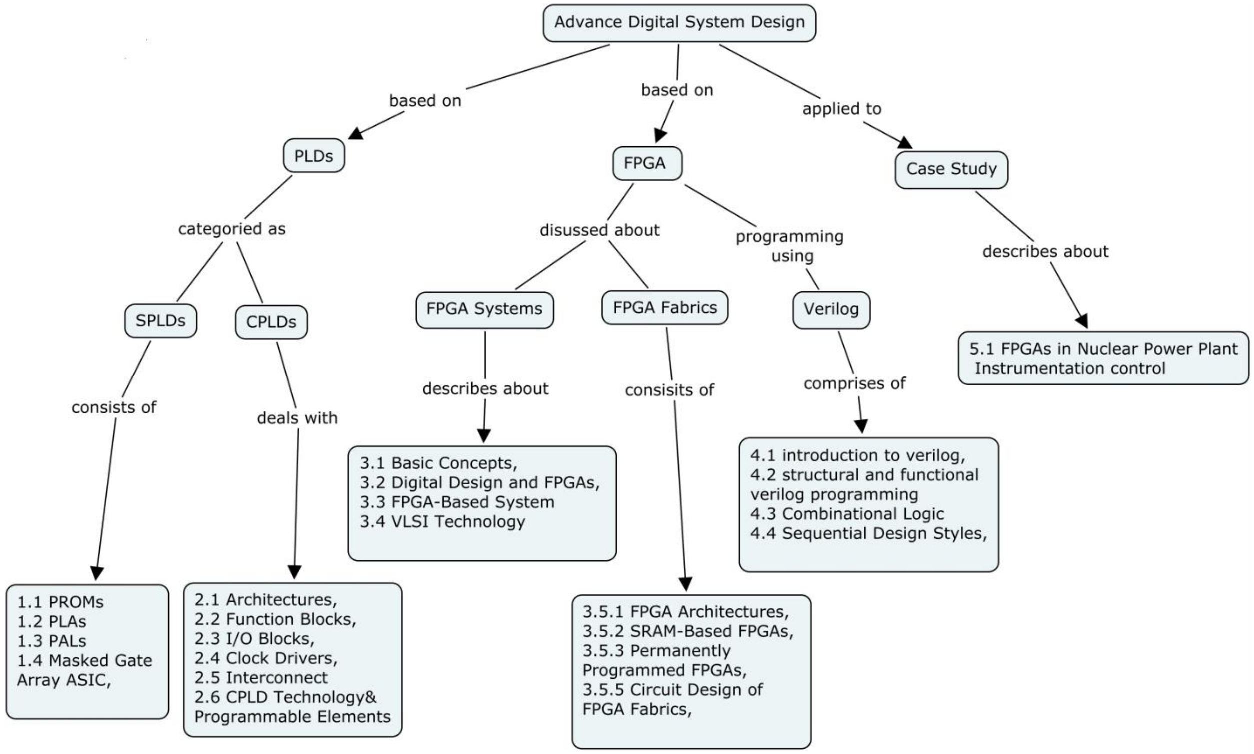


5. Populate the array of logic elements in inter connect with wires and programmable interconnection points. Each wiring channel should have two wires. Assume that each logic element has two inputs and one output; each logic element should be able to connect its inputs to the channel on its left and its output to the channel on its right. When two wiring.
6. Implement the following two Boolean functions with a PLA:

   F1(A, B, C) = $\sum$(O,1,2,4)

   F2(A, B, C) = $\sum$(0,5,6,7).

Concept map



Syllabus

Programmable Logic to ASICs

Programmable Read Only Memories (PROMs), Programmable Logic Arrays (PLAs), Programmable Array Logic (PALs), the Masked Gate Array ASIC, CPLDs and FPGAs.

Complex Programmable Logic Devices

CPLD Architectures, Function Blocks, I/O Blocks, Clock Drivers, Interconnect CPLD Technology and Programmable Elements.

FPGA Systems

Basic Concepts, Digital Design and FPGAs, FPGA-Based System, **VLSI Technology-** Manufacturing Processes, Transistor Characteristics, CMOS logic gates, Wires, Registers and RAM, Packages and Pads, **FPGA Fabrics-** FPGA Architectures, SRAM-Based FPGAs, Permanently Programmed FPGAs, Chip I/O, Circuit Design of FPGA Fabrics, Architecture of FPGA Fabrics

Hardware Description Language VERILOG

Introduction to verilog, structural, functional verilog programming, **Combinational Logic-** Combinational Network Delay, Power and Energy Optimization, Arithmetic Logic, Logic Implementation for FPGAs, Physical Design for FPGAs, **Sequential Machines** -Sequential Design Styles, Rules for Clocking, Performance Analysis, Power Optimization.

Case Study

FPGAs in lift control and Power Plant Instrumentation control.

Reference Books

1. Wayne Wolf “FPGA –Based System Design” Pearson Education, 2004.
2. Bob Zeidman, “Designing with FPGAs and CPLDs”, Elsevier, CMP Books, 2002.
3. M. Morris Mano and Michael D. Ciletti, “Digital Design”, PHI, fourth edition, 2008
4. R.F.Tinder: Engineering Digital Design, (2/e), Academic Press, 2000
5. Digital Electronics Principles, Devices and Applications Anil K. Maini – Wiley 2007
6. Samir Palnitkar, ”Verilog HDL”, Pearson Education, 2nd Edition, 2004.
7. Stephen Brown Zvonko Vranesic “Fundamentals of Digital Logic with VHDL Design” Tata McGraw- Hill Edition.
8. www.xilinx.com
9. www.acctel.com

Course Contents and Lecture Schedule

Sl.No.	Topic	No. of Lectures
1	**Programmable Logic to ASICs**	
1.1	Programmable Read Only Memories (PROMs).	1
1.2	Programmable Logic Arrays (PLAs)	1
1.3	Programmable Array Logic (PALs)	2
1.4	The Masked Gate Array ASIC	1
1.5	CPLDs and FPGAs	1
2	**Complex Programmable Logic Devices (CPLDs)**	
2.1	CPLD Architectures	1
2.2	Function Blocks.	1
2.3	I/O Blocks	1
2.4	Clock Drivers	1
2.5	Interconnect	1
2.6	CPLD Technology and Programmable Elements	2
3	**FPGA Systems**	
3.1	Basic Concepts(Boolean Algebra and karnaugh map)	1

3.2	Digital Design and FPGAs.	1
3.3	FPGA-Based System Design	1
3.4	**VLSI Technology**	
3.4.1	Manufacturing Processes	1
3.4.2	Transistor Characteristics	1
3.4.3	CMOS logic gatesand Wires	1
3.4.4	Registers and RAM	1
3.4.5	Packages and Pads	1
3.5	**FPGA Fabrics**	
3.5.1	FPGA Architectures	1
3.5.2	SRAM-Based FPGAs	1
3.5.3	Permanently Programmed FPGAs	1
3.5.4	Chip I/O,	1
3.5.5	Circuit Design of FPGA Fabrics	1
3.5.6	Architecture of FPGA Fabrics	1
4	**Hardware Description Language VERILOG:**	
4.1	Introduction to verilog	1
4.2	structural, functional verilog programming	1
4.3	**Combinational Logic-**Combinational Network Delay	1
4.3.1	Power and Energy Optimization	1
4.3.2	Arithmetic Logic	1
4.3.3	Logic Implementation for FPGAs	1
4.3.4	Physical Design for FPGAs	1
4.4	**Sequential Machines** -Sequential Design Styles	1
4.4.1	Rules for Clocking	1

4.4.2	Performance Analysis	1
4.4.3	Power Optimization	1
5	**Case Study:** FPGAs in lift control and Power Plant Instrumentation control	2
	Total	40

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CN ED	**3**	**1**	**-**	**4**

CN ED Advanced Industrial Controllers 3:1

Preamble

This course is designed to impart the knowledge of industrial controllers and their implementation, and design procedures. Emphasis is also given to distributed, programmable controllers and model- free controllers.

Programme Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.
c. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.
e. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Competencies

At the end of the course the students should be able to:

1. Demonstrate about various processes and the controllers
2. Explain the components of programmable logic controller
3. Implement PLC for real time industrial needs
4. Explain the commercial controllers
5. Apply the distributed and programmable controllers for industrial requirements
6. Identify the various intelligent controllers for different processes

Assessment Pattern

Sl.No	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	20	20	20
2	Understand	40	40	40
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. What is meant by DDC?
2. Draw the flowchart for derivative mode.
3. Draw the basic blocks and mention the different parts of PLC.
4. Mention any four application of PLC.

5. Write a PLC ladder program to start and stop a motor using two push buttons.
6. Write short notes on International Field bus standards
7. What is field bus?
8. Define model based controllers
9. List the name of membership functions used in fuzzy applications?
10. What is the need for Neuro-fuzzy controller?

Understand

1. Compare various types of digital controller modes.
2. Explain the operation of SCADA with neat diagram.
3. Explain the EXAMINE ON & EXAMINE OFF instructions used in PLC programming.
4. Write short notes on Temperature and pressure switches.
5. Compare neural and fuzzy controllers.
6. What is the need for model-free controllers?
7. Explain the operation of ON delay retentive timer.

Apply

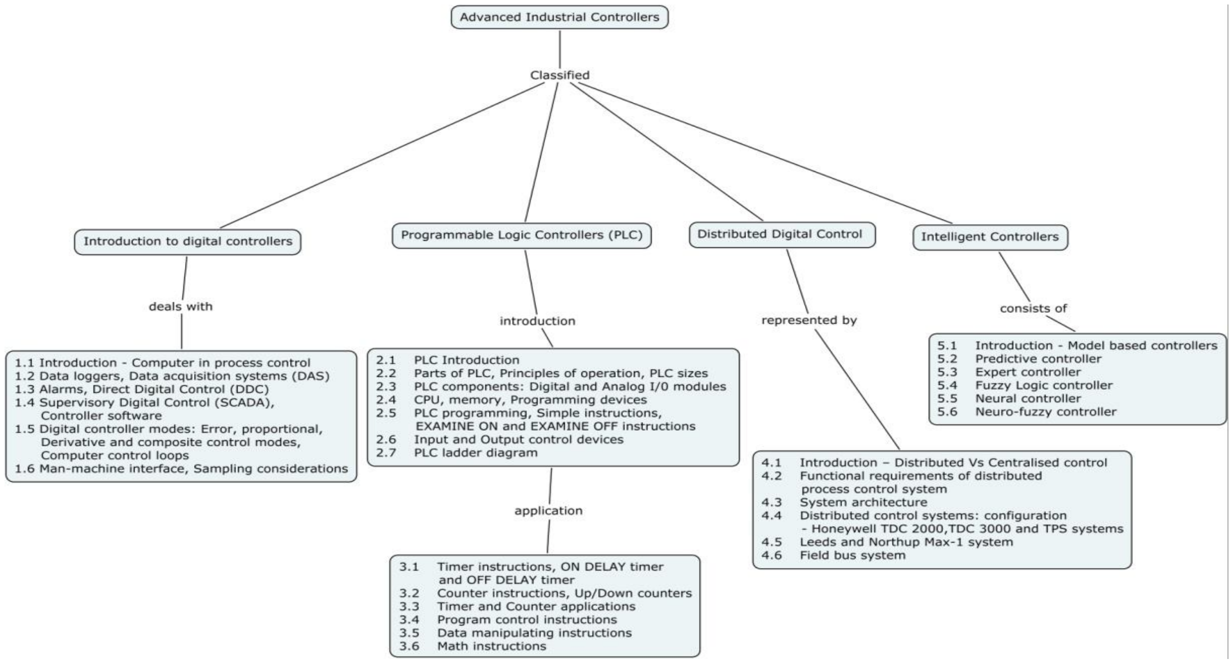
1. Develop a PLC ladder logic program for parts counting process
   i) Count the parts coming off from an assembly line conveyer
   ii) After 100 counts the parts are packaged
   iii) Count the total number of packages for a day
   iv) Reset all the counters at the end of the day using a mater reset NO push button.
2. Three motors can be started by a single push button when the push button is released, switching of motors should be at 20 Secs intervals each. Develop a PLC ladder diagram for the above process.
3. Develop a PLC ladder logic program using Data manipulation instructions for the below process
   i) Solenoid A is energized immediately when start pushbutton is pressed.

   ii) Solenoid B is energized 5s later than solenoid A.

   iii) Solenoid C is energized 15s later than solenoid A.

   iv) Solenoid D is energized 25s later than solenoid A.
4. Design fuzzy based tank level control model and explain the procedure in detail.
5. Design the neuro-fuzzy controller for Steam Turbine plant and explain the procedure in detail.

Concept map



Syllabus

Introduction to digital controllers

Introduction - Computer in process control - Data loggers, Data acquisition systems (DAS) - Alarms, Direct Digital Control (DDC), Supervisory Digital Control (SCADA) - Controller software - Digital controller modes: Error, proportional, derivative and composite control modes - Computer control loops – man-machine interface - Sampling considerations.

Programmable Logic Controllers (PLC)

PLC Introduction – Parts of PLC - Principles of operation, PLC sizes - PLC components: Digital and Analog I/0 modules - CPU – memory - Programming devices - PLC programming - Simple instructions - EXAMINE ON and EXAMINE OFF instructions – Input and Output control devices - PLC ladder diagram.

PLC Advanced Instructions

Timer instructions - ON DELAY timer and OFF DELAY timer - Counter instructions - Up/Down counters - Timer and Counter applications - program control instructions - Data manipulating instructions - math instructions.

Distributed Digital Control

Introduction – Distributed Vs Centralised control – Functional requirements of distributed process control system – system architecture – distributed control systems: configuration – typical DCS - Leeds and Northup Max-1 system – Field bus system.

Intelligent Controllers

Introduction - Model based controllers – Predictive controller - Expert controller - Fuzzy Logic controller - Neural controller - Neuro-fuzzy controller.

Reference Books

1. Krishna kant, "Computer based industrial control", PHI, second edition, 2010.
2. Frank D. Petruzella "Programmable Logic Controllers", TMH, Third Edition, 2010.
3. M.Chidambaram, "Computer Control of Processors" Narosa Publications, 2001.
4. Sivanandham S.N, Deepa,S.N., "Principles of Soft Computing", Wiley Publications,2011.
5. John W Webb, Ronald A Reis, "Programmable Logic Controllers - Principles and Applications", Third Edition, PHI, 1995.
6. Krishna kant, "Digital control systems", ISTE learning materials centre, First edition 2001.

Course content and Lecture schedule

Sl.No.	Topic	No. of Lectures
1.0	**Introduction to digital controllers**	
1.1	Introduction - Computer in process control	1
1.2	Data loggers, Data acquisition systems (DAS)	1
1.3	Alarms, Direct Digital Control (DDC)	1
1.4	Supervisory Digital Control (SCADA), Controller software	1
1.5	Digital controller modes: Error, proportional, derivative and composite control modes, Computer control loops	1
1.6	Man-machine interface, Sampling considerations	1
2.0	**Programmable Logic Controllers (PLC)**	
2.1	PLC Introduction	1
2.2	Parts of PLC, Principles of operation, PLC sizes	1
2.3	PLC components: Digital and Analog I/0 modules	2
2.4	CPU, memory, Programming devices	1
2.5	PLC programming, Simple instructions, EXAMINE ON and EXAMINE OFF instructions	2
2.6	Input and Output control devices	2
2.7	PLC ladder diagram	1
3.0	**PLC Advanced Instructions**	
3.1	Timer instructions, ON DELAY timer and OFF DELAY timer	1
3.2	Counter instructions, Up/Down counters	2
3.3	Timer and Counter applications	2
3.4	Program control instructions	1
3.5	Data manipulating instructions	1
3.6	Math instructions	1
4.0	**Distributed Digital Control**	
4.1	Introduction – Distributed Vs Centralised control	1
4.2	Functional requirements of distributed process control system	2
4.3	System architecture	1

4.4	Distributed control systems: configuration - typical DCS	2
4.5	Leeds and Northup Max-1 system	1
4.6	Field bus system	2
5.0	**Intelligent Controllers**	
5.1	Introduction - Model based controllers	1
5.2	Predictive controller	1
5.3	Expert controller	1
5.4	Fuzzy Logic controller	1
5.5	Neural controller	2
5.6	Neuro-fuzzy controller	1
	Total	40

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CN EE	**3**	**1**	**-**	**4**

CN EE Intelligent Controllers 3:1

Preamble

Intelligent control achieves automation via the emulation of biological intelligence. It either seeks to replace a human who performs a control task (e.g., a chemical process operator) or it borrows ideas from how biological systems solve problems and applies them to the solution of control problems. This course provides an overview of several techniques used for intelligent control and discusses challenging industrial application domains where these methods may provide particularly useful solutions. The subject begins with a brief overview of the main areas in intelligent control, which are fuzzy control and neural networks.

Program Outcomes Selected

a. An ability to apply knowledge of engineering, information technology, mathematics and science
b. An ability to design and conduct experiments, as well as to analyze and interpret data
c. An ability to design a system or component, or process to meet stated specifications
d. An ability to identify, formulate and solve engineering problems
e. An ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints
g. An ability to function on multidisciplinary teams
i. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context.

Competencies

At the end of the course the students should be able to:

1. Understand the role of Artificial intelligence in industrial controllers.
2. Understand the concept of fuzzy and neural based controllers.
3. Model the controller using fuzzy and neural systems
4. Identify and control the system using fuzzy and neural systems
5. Design the controllers based on fuzzy and neural for industrial applications.

Assessment pattern

Sl.No	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	30	30	20
2	Understand	30	30	20
3	Apply	40	40	40
4	Analyze	0	0	20
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. What are the types of learning?
2. Mention the linear and non-linear activation functions used in ANN.
3. What is perceptron?
4. What is feed forward networks? Give example
5. Give some common applications of fuzzy logic?
6. What are the different methods of De-fuzzification?
7. What are the parameters to be considered for the design of membership function?

Understand

1. Explain multilayer perceptron with its architecture. How is it used to solve XOR Problem?
2. What do you mean by supervised and unsupervised learning?
3. Explain back propagation algorithm in detail.
4. Describe the learning expressions in the back propagation network.
5. Explain Sugeno type fuzzy model
6. Explain the construction of fuzzy model for a nonlinear equation
7. Explain the basic idea behind SVM with suitable illustrations

Apply

1. Compute the centroid defuzzifier for
   $\overline{A}=\left\{\frac{0.9}{-3},\frac{0.7}{-2},\frac{0}{-1},\frac{0.3}{1},\frac{1}{2},\frac{0.2}{3}\right\}$

2. Let $X=\{0,1,2,3,4,5\}$ and $\overline{A}=\left\{\frac{0.9}{-3},\frac{0.7}{-2},\frac{0}{-1},\frac{0.3}{1},\frac{1}{2},\frac{0.2}{3}\right\}$, $\overline{B}=\left\{\frac{0.9}{-3},\frac{0.7}{-2},\frac{0}{-1},\frac{0.3}{1},\frac{1}{2},\frac{0.2}{3}\right\}$

   Find the fuzzy max and fuzzy min of $\overline{A}$ and $\overline{B}$

3. For the following data set, develop a suitable simple feed forward neuron model

```
OriginalData = {{1, 20}, {2, 12}, {3, 9}, {4, 6},
  {5, 5}, {6, 4}, {7, 5}, {8, 6}, {9, 9}, {10, 12}, {11, 20}};
```

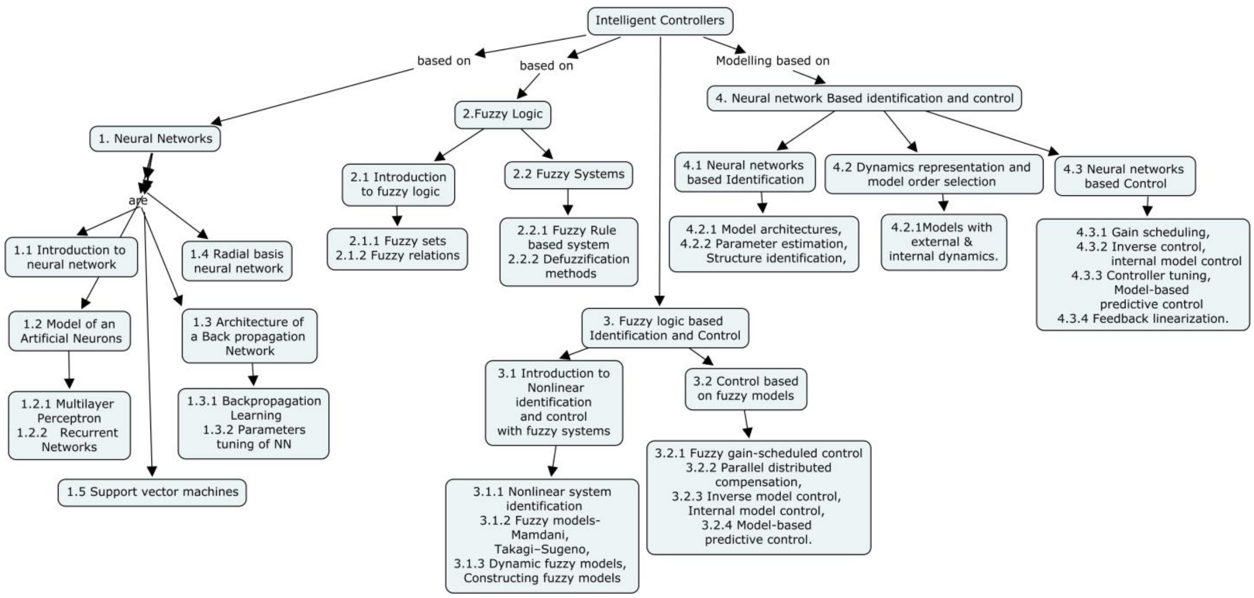
4. Develop a fuzzy based gain scheduling for a nonlinear process

5. With suitable illustration, explain how neural network is used for nonlinear system identification.

Analyze

1. Analyze the performance of the controller using fuzzy logic system and neural network for armature controlled DC motor seed control
2. Analyze the performance of neural network and fuzzy logic system for system identification
3. What is the reason for better generalization capability of SVM as compared to Neural network?
4. Analyze the performance of fuzzy based gain scheduling control
5. Explain the selection of activation function in neural network.

Concept Map



Syllabus

Neural Networks

Introduction to neural network - Model of an Artificial Neurons -Multilayer Perceptron, , Recurrent Networks , Architecture of a Back propagation Network, Backpropagation Learning, Parameters tuning of the Back propagation Neural Network, Radial basis neural network, support vector machines.

Fuzzy Logic

Introduction to fuzzy logic, Fuzzy versus Crisp, Fuzzy sets, Fuzzy relations, Fuzzy Systems: Fuzzy logic- universe discourse, membership function, Quantifiers, Inference, Fuzzy Rule based system, Defuzzification methods, Nero-Fuzzy system, ANFIS.

Fuzzy logic based Identification and Control

Introduction to Nonlinear identification and control with fuzzy systems, Nonlinear system identification, Fuzzy models- Mamdani, Takagi–Sugeno, Dynamic fuzzy models. Constructing fuzzy models, Control based on fuzzy models - Fuzzy gain-scheduled control, Parallel distributed compensation, Inverse model control, Internal model control, Model-based predictive control.

Neural network Based identification and control

Neural networks based Identification: Model architectures, Parameter estimation, Structure identification, Dynamics representation and model order selection - Models with external & internal dynamics. ANFIS based model identification.

Neural networks based C*ontrol:* Gain scheduling, inverse control, internal model control, Controller tuning, Model-based predictive control, Feedback linearization.

Reference Books

1. A.E. Ruano, 'Intelligent Control Systems using computational Intelligence technique', IET, 2008.
2. Simon Haykin, 'Neural Networks', Pearson Education, 2003.
3. John Yen Timothy J. Ross, 'Fuzzy Logic with Engineering Applications', Tata McGraw Hill, 1997.
4. John Yen and Reza Langari, 'Fuzzy Logic – Intelligence Control & Information', Pearson Education, New Delhi, 2003
5. S.Rajasekaran, G.A. Vijayalakshmi pai, 'Neural Networks, Fuzzy logic and Genetic Algorithms synthesis and Applications', Prentice Hall, 2003.

Course Contents and lecture Schedule

Sl.No.	Topic	No.of Lectures
1.	**Neural Networks**	
1.1	Introduction to neural network	1
1.2	Model of an Artificial Neurons	1
1.2.1	Multilayer Perceptron	1
1.2.2	Recurrent Networks	1
1.3	Architecture of a Back propagation Network	1
1.3.1	Backpropagation Learning	1
1.3.2	Parameters tuning of the Back propagation Neural Network	1
1.4	Radial basis neural network	1
1.5	Support vector machines	1
2.	**Fuzzy Logic**	
2.1	Introduction to fuzzy logic: Fuzzy versus Crisp	1
2.1.1	Fuzzy sets	1

2.1.2	Fuzzy relations	1
2.2	Fuzzy Systems: Fuzzy logic- Quantifiers, Inference	1
2.2.1	Fuzzy Rule based system	1
2.2.2	Defuzzification methods	1
2.2.3	Nero-Fuzzy system, ANFIS	1
3.	**Fuzzy logic based Identification and Control**	
3.1	Introduction to Nonlinear identification and control with fuzzy systems	1
3.1.1	Nonlinear system identification,	1
3.1.2	Fuzzy models- Mamdani, Takagi–Sugeno,	1
3.1.3	Dynamic fuzzy models, Constructing fuzzy models	2
3.2	Control based on fuzzy models	1
3.2.1	Fuzzy gain-scheduled control	1
3.2.2	Parallel distributed compensation	1
3.2.3	Inverse model control, Internal model control,	2
3.2.4	Model-based predictive control.	1
4.	**Neural network Based identification and control**	
4.1	Neural networks based Identification	1
4.1.1	Model architectures,	1
4.1.2	Parameter estimation, Structure identification,	1
4.2	Dynamics representation and model order selection	1
4.2.1	Models with external & internal dynamics.	1
4.2.2	ANFIS based model identification	1
4.3	Neural networks based Control	1
4.3.1	Gain scheduling,	1
4.3.2	Inverse control, internal model control	2
4.3.3	Controller tuning, Model-based predictive control	2
4.3.4	Feedback linearization	1
Total		40

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CN EF	**3**	**1**	**-**	**4**

CN EF Optimal Control and filtering 3:1

Preamble

Optimal control theory, which is playing an increasingly important role in the design of modern systems, has maximizing the returns while minimizing the operational efforts as its objectives. Often the optimal control is described by a feedback law. Such a law determines the optimal control. This subject deals with deriving optimal control laws for control systems, as functions of time, and decisions that must be made as time proceeds.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
d. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.
f. Graduate will demonstrate skills to use modern engineering tools, softwares and equipment to analyze problems.

k. Graduate who can participate and succeed in competitive examinations.

Competencies

At the end of the course the students should be able to:

1. formulate the optimal control problem.
2. analyze given a process model and select the optimal path.
3. design a optimal regulator.
4. apply optimal principles on various control problems.
5. estimate the various types of noise and making smooth filtration

Assessment Pattern

Sl.No.	Bloom's Category	Test 1	Test 2	Test 3/ End-semester examination
1	Remember	10	10	20
2	Understand	10	10	20
3	Apply	30	30	60
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. State Pontryagin's minimum principle.
2. Define minimum Time problem.
3. Write the performance measure for minimum control –effort problem.
4. What is meant by SNR?
5. What are the advantages of– Recursive estimation over Least square estimation?

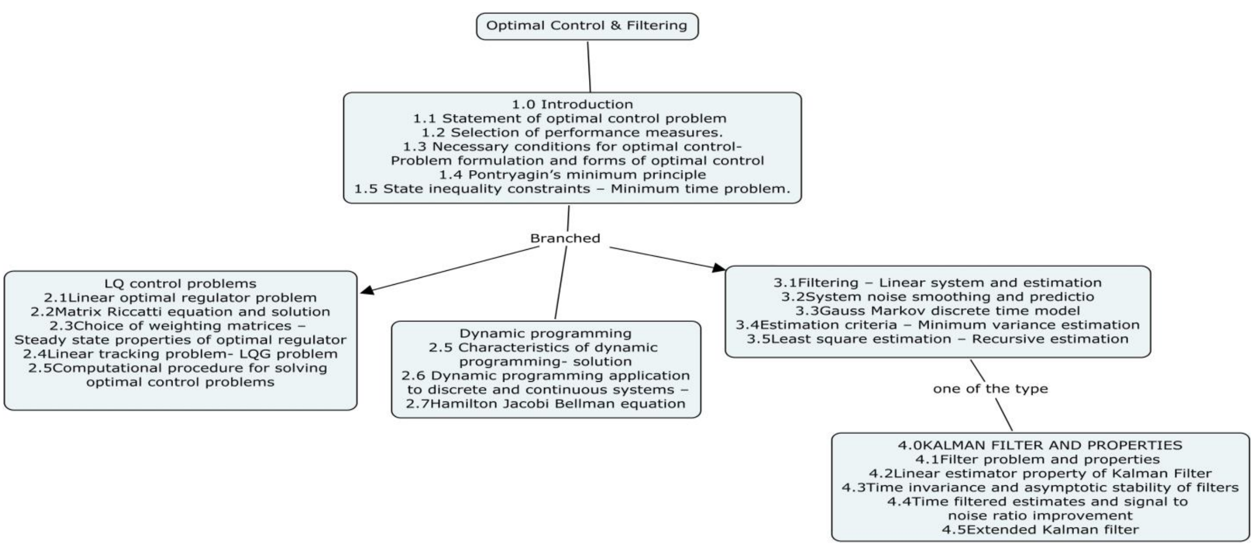
Understand

1. Using simple diagram, state the condition for optimality for dynamic programming.
2. What is linear tracking problem?
3. State any two properties of optimal solution.
4. Write the HJB equation and the conditions for optimality?
5. State the properties of Kalman filter?

Apply

1. Using dynamic programming, find the control law for the performance measure to be minimized for the equation $X(k+1)=-0.5\ X(k+1)+u\ (k)$,$J=1/2/^{o}{}_{\infty}(x^2+u^2)$with limits zero to infinity.
2. Derive the Pontryagin's minimum principle for a first order system.
3. Derive the HJB equation for a boundary value problem.
4. Derive the Least square estimation for a first order ARMA process .
5. Explain the Kalman filter and extended Kalman filter and prove how they effectively reduces SNR?

Concept Map



Syllabus

Introduction

Statement of optimal control problem – Problem formulation and forms of optimal control – Selection of performance measures. Necessary conditions for optimal control – Pontryagin's minimum principle – State inequality constraints – Minimum time problem.

LQ Control Problems And Dynamic Programming

Linear optimal regulator problem – Matrix Riccatti equation and solution method – Choice of weighting matrices – Steady state properties of optimal regulator – Linear tracking problem – LQG 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.

Filtering and estimation

Filtering – Linear system and estimation – System noise smoothing and prediction – Gauss Markov discrete time model – Estimation criteria – Minimum variance estimation – Least square estimation – Recursive estimation.

KALMAN Filter and properties

Filter problem and properties – Linear estimator property of Kalman Filter – Time invariance and asymptotic stability of filters – Time filtered estimates and signal to noise ratio improvement – Extended Kalman filter.

Reference Books

1. Kirk D.E., 'Optimal Control Theory – An introduction', Dover Publications, 2004.
2. S.M. Bozic, "Digital and Kalman Filtering", Edward Arnould, London, 1994.
3. B. D. O. Anderson and J. B. Moore. Linear Optimal Control., Dover Publications, New York, 2005
4. K. J. AStrom, *Introduction to Stochastic Control Theory*. Dover, New York, 2006.
   Sage, A.P., 'Optimum System Control', Prentice Hall N.H., 1968.
5. C.K. Chui and G. Chen. *Kalman Filtering with Real-Time Applications*. Springer Ser. Info. Sci., Vol. 17. Springer, Berlin, Heidelberg, 1987.
6. A.V.Bala Krishnan ,Kalman filtering Theory , Springer; 1 edition, 28, 1984

Course content and Lecture Schedule

Sl.No.	Topic	No. of Lectures
1	**INTRODUCTION**	
1.1	Statement of optimal control problem	1
1.2	Selection of performance measures.	1
1.3	Necessary conditions for optimal control- Problem formulation and forms of optimal control	2
1.4	Pontryagin's minimum principle	2
1.5	State inequality constraints – Minimum time problem.	2
2.	**LQ CONTROL PROBLEMS AND DYNAMIC PROGRAMMING**	
2.1	Linear optimal regulator problem	2

2.2	Matrix Riccatti equation and solution	2
2.3	Choice of weighting matrices – Steady state properties of optimal regulator	2
2.2	Linear tracking problem- LQG problem	3
2.4	Computational procedure for solving optimal control problems	2
2.5	Characteristics of dynamic programming- solution	1
2.6	Dynamic programming application to discrete and continuous systems	3
2.7	Hamilton Jacobi Bellman equation	2
3.	**FILTERING AND ESTIMATION**	
3.1	Filtering – Linear system and estimation	1
3.2	System noise smoothing and prediction	1
3.3	Gauss Markov discrete time model	1
3.4	Estimation criteria – Minimum variance estimation	2
3.5	Least square estimation – Recursive estimation	2
4.	**KALMAN FILTER AND PROPERTIES**	
4.1	Filter problem and properties	2
4.2	Linear estimator property of Kalman Filter	1
4.3	Time invariance and asymptotic stability of filters	2
4.4	Time filtered estimates and signal to noise ratio improvement	2
4.5	Extended Kalman filter	1
	Total	40

Course Designers

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Sub code	Lectures	Tutorial	Practical	Credit
CN EM	**3**	**1**	**-**	**4**

CN EM Data Communication for Controllers 3:1

Preamble

Industrial process control and production automation requires proficient and reliable data communication. This is achieved by linking equipment such as PCs, PLCs, SCADA, distributed control systems and simple instrument together with data communications systems that are correctly designed and implemented. This course highlights the industrial protocols, industrial networks, and communication requirements for smart instrumentation.

Program Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics and science.
d. An ability to identify, formulate and solve engineering problems.
e. An ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints.
g. An ability to function on multidisciplinary teams.
i. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context.
j. An ability to consider issues from global and multilateral views.

Competencies

At end of the course the students should be able to:

1. Analyze and specify the industrial data communications systems for instrumentation and control.
2. Determine the performance of a industrial network.
3. Design services based on industrial networks.
4. Build efficient industrial network for all modern requirement.
5. Select, install and maintain the industrial protocols in most cost-effective manner for the plant.

Assessment pattern

S.No.	Bloom's category	Test1	Test2	Test3 / end semester Examination
1	Remember	20	20	20
2	Understand	20	20	20
3	Apply	30	30	30
4	Analyze	30	30	30
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level learning objectives

Remember

1. What are the major elements of RS-232?
2. What are the disadvantages of ASCII based protocols?
3. Mention the benefits of HART protocol.
4. List the classes of Fieldbus networks.
5. Define factory information protocol.
6. What is the need of IEEE 802.2 LLC?

Understand

1. With neat diagram explain the architecture of USB.
2. Explain the HART application layer implementations.
3. Describe the master slave Working Principle of Actuator Sensor interface.
4. Describe about the CAN bus packet format.
5. Discuss about the accessing method of standard Ethernet.
6. Discuss about the Profibus protocol architecture.

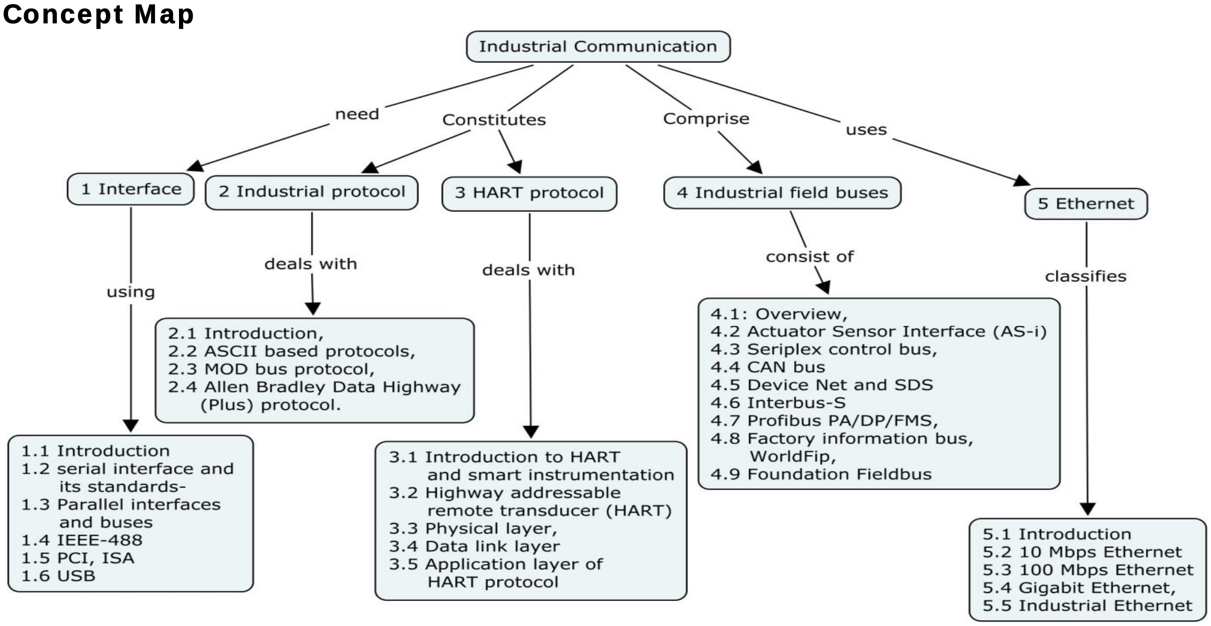
Apply

1. Illustrate about IEEE-488 to connect and control programmable instruments.
2. Demonstrate the features of Full-duplex data link layer of Allen Bradley Data Highway (Plus) protocol.
3. Illustrate the data link frame format of HART protocol.
4. Demonstrate the overall architecture of a Profibus system.
5. Implement the upgrades associated with standard Ethernet to be suitable for industrial automation architecture.
6. Demonstrate the passage of information packets to the physical layer by user layer in the Foundation Fieldbus protocol stack.

Analyze

1. Analyze the structure of Modbus protocol.
2. Compare and contrast RS-232 and RS-485 standards.
3. Inspect the DeviceNet system to interconnect lower level devices (sensors and actuators) with higher-level devices (controllers).
4. Inspect the features of the Interbus-S network and protocol.
5. Organize the steps involved in communication through Foundation Field bus for the process control industry.
6. Analyze MAC frame format and implementations of 10 Mbps Ethernet.

Concept Map



Syllabus

Interfaces

Introduction - serial interface and its standards- RS-232 and RS-485; Parallel interfaces and buses - AGP and Parallel Ports, IEEE-488, PCI, ISA, USB.

Industrial protocols

Introduction - ASCII based protocols - MOD bus protocol - Data Highway (Plus) protocol.

HART protocol

Introduction to HART and smart instrumentation - Highway addressable remote transducer (HART) - Physical layer, Data link layer and Application layer of HART protocol.

Industrial field buses

Overview - Actuator Sensor Interface (AS-i) - Seriplex control bus - CAN bus - Device Net and SDS - Interbus-S - Profibus PA/DP/FMS - Factory information bus, WorldFip - Foundation Fieldbus.

Industrial ethernet

Introduction - 10 Mbps Ethernet - 100 Mbps Ethernet - Gigabit Ethernet - Industrial Ethernet.

Reference Books

1. John park, Steve Mackay, Edwin wright, "Practical Data Communications for Instrumentation and Control", Newnes imprint of Elsevier, 2003.

2. Peng Zhang, "Industrial Control technology", William Andrew Inc, 2008.

3. Deon Reynders, Steve Mackay, Edwin Wright, "Practical industrial data communications-best practice techniques", Newnes imprint of Elsevier, 2005.

Course content and Lecture Schedule

Sl.No.	Topic	No. of Lectures
1	**Interface**	
1.1	Introduction	1
1.2	serial interface and its standards- RS-232 and RS-485	2
1.3	Parallel interfaces- AGP and Parallel Ports	1
1.4	IEEE-488	2
1.5	Buses- PCI, ISA	1
1.6	USB	2
2	**Industrial protocols**	
2.1	Introduction	1
2.2	ASCII based protocols	2
2.3	MOD bus protocol	2
2.4	Data Highway (Plus) protocol	2
3	**HART protocol**	
3.1	Introduction to HART and smart instrumentation	1
3.2	Highway addressable remote transducer (HART)	1
3.3	Physical layer	1
3.4	Data link layer	1
3.5	Application layer	1
4	**Industrial field buses**	
4.1	Overview	1
4.2	Actuator Sensor Interface (AS-i)	2
4.3	Seriplex control bus	1
4.4	CAN bus	2
4.5	Device Net and SDS	2
4.6	Interbus-S	1
4.7	Profibus PA/DP/FMS	2
4.8	Factory information bus, WorldFip	1
4.9	Foundation Fieldbus	2
5	**Industrial Ethernet**	
5.1	Introduction	1
5.2	10 Mbps Ethernet	1
5.3	100 Mbps Ethernet	1
5.4	Gigabit Ethernet	1
5.5	Industrial Ethernet	2
	Total	40

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Passed in BOS meeting held on 08.10.2011 Approved in 43rd AC meeting held on 12.11.2011

Sub Code	Lectures	Tutorial	Practical	Credit
CN EN	**3**	**1**	**-**	**4**

CN EN Embedded System Design 3:1

Preamble

This course provides a broad introduction to embedded system design. It explores the hardware and software aspects of embedded systems. Details about ARM microprocessor is dealt in detail. Embedded ARM Applications are also discussed.

Program Outcomes Selected

f. An ability to apply knowledge of engineering, information technology, mathematics and science.
g. An ability to design and conduct experiments, as well as to analyze and interpret data.
h. An ability to design a system or component, or process to meet stated specifications.

e) An ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints

Competencies

At the end of the course the students should be able to:

1. Gain the knowledge of ARM microprocessor and its instruction set.
2. Gain the knowledge about System Development and Operating System support by ARM processors.
3. Gain the knowledge about ARM applications in embedded system design.

Assessment pattern

Sl.No.	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	10	10	10
2	Understand	20	20	20
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	30	30	30

Course level Learning Objectives

Remember

1. Define CPSR.

2. What is ARMulator?
3. What is pre-indexed addressing mode?
4. Define SPSR.
5. Draw the block diagram of a typical Bluetooth system.

Understand

1. Describe the principle features of ARM architecture.
2. Explain in detail about Cache memory of ARM processor.
3. Explain the ARM shift operations.
4. Discuss in detail about Exceptions in ARM programming.
5. Explain about ARM7500 system organization.

Apply

1. Explain the ARM Programmer's model.
2. Estimate the die area of a 128-entry inverted page table compared with a 64 entry TLB, assuming that one bit of CAM requires twice the area of one bit of RAM.
3. Write a subprogram which copies a string of bytes from one memory location to another. The start of the source string will be passed in r1, the length (in bytes) in r2 and the start of the destination string in r3.
4. Estimate the power saving that results from using the on-chip RAM. (Assume that on-chip accesses cost 2 nJ and off-chip accesses 10 nJ.)
5. If the ARM had no SWAP instruction, devise a hardware peripheral that could be used to support synchronization.

Create

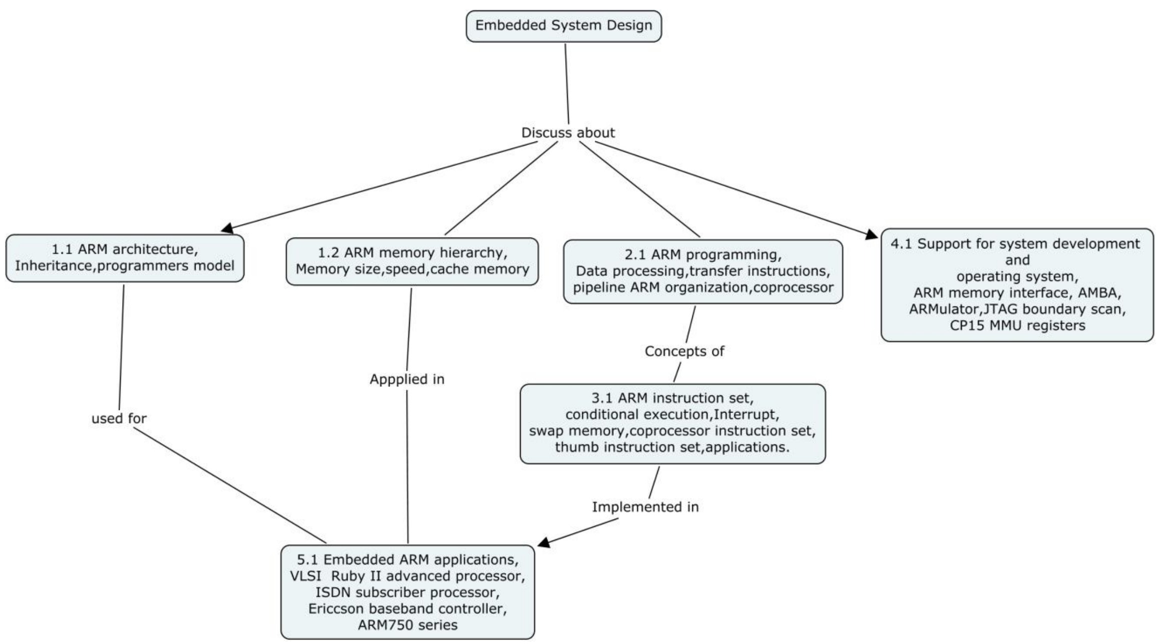
1. Design a cache memory for ARM processor.

2. Print out r1 in hexadecimal**.** Modify the program to output r1 in binary format. For the value loaded into r1 in the example program you should get:

00010010001101000101011001111000

3. Estimate the performance improvement which results from running a critical DSP routine in zero wait state on-chip RAM instead of two wait state off-chip RAM.
4. Use TCC to generate Thumb code from C source programs (starting, as usual, with a 'Hello World' program). Look at the assembly code generated by the C compiler (using the '-s' option). Compare the code size and the execution time with the same programs compiled into ARM code.
5. Estimate the proportion of the number of test vectors required to test an ARM core via the JTAG and AMBA interfaces

Concept Map



Syllabus

The ARM Architecture and Memory Hierarchy : The Acorn RISC Machine - Architectural inheritance - The ARM -programmer's model - ARM development tools - Memory size and speed- On-chip memory- Caches-Cache design - an example- Memory management

ARM Assembly Language Programming : Data processing instructions - Data transfer instructions - Control flow instructions - Writing simple assembly language programs - ARM Organization and Implementation- 3-stage pipeline ARM organization -5-stage pipeline ARM organization - ARM instruction execution - ARM implementation- The ARM coprocessor interface

The ARM Instruction Set: Introduction - Exceptions - Conditional execution - Branch and Branch with Link (B, BL) - Branch, Branch with Link and eXchange (BX, BLX) - Software Interrupt (SWI)- Data processing instructions - Multiply instructions - Count leading zeros (CLZ - architecture v5T only)- Single word and unsigned byte data transfer instructions - Half-word and signed byte data transfer instructions - Multiple register transfer instructions - Swap memory and register instructions (SWP) - Status register to general register transfer instructions - General register to status register transfer instructions - Coprocessor instructions - Coprocessor data operations - Coprocessor data transfers - Coprocessor register transfers - Breakpoint instruction (BRK - architecture v5T only)- Unused instruction space -Memory faults - ARM architecture variants-The Thumb Instruction Set- The Thumb bit in the CPSR - The Thumb programmer's model - Thumb branch instructions - Thumb software interrupt instruction - Thumb data processing instructions - Thumb single register data transfer instructions - Thumb multiple register data transfer instructions - Thumb breakpoint instruction - Thumb implementation - Thumb applications

Architectural Support for System Development and Operating Systems: The ARM memory interface - The Advanced Microcontroller Bus Architecture (AMBA) - The ARM reference peripheral specification - Hardware system prototyping tools- The ARMulator - The JTAG boundary scan test architecture - The ARM debug architecture - Embedded Trace - Signal processing support -An introduction to operating systems- The ARM system control coprocessor- CP15 protection unit registers- ARM protection unit- CP15 MMU registers- ARM MMU architecture- Synchronization- Context switching- Input/Output

Embedded ARM Applications: The VLSI Ruby II Advanced Communication Processor- The VLSI ISDN Subscriber Processor- The OneC™ VWS22100 GSM chip- The Ericsson-VLSI Bluetooth Baseband Controller- The ARM7500 and ARM7500FE- The ARM7100 - The SA-1100.

Reference Books

1. ARM System-on-Chip Architecture (2nd Edition) by Steve Furber, Publisher: Addison-Wesley Professional, 2000.

2. ARM Architecture Reference Manual, ARM Limited, Issue E, June 2000.

3. Wayne Wolf, Computers as Components: Principles of Embedded Computing System Design, Morgan Kaufman Publishers, Second Edition, 2008.

4. Frank Vahid and Tony Givargis, 'Embedded System Design: A Unified Hardware/Software Introduction', John Wiley & Sons, Inc. 2002.

5. Raj Kamal, Embedded Systems: Architecture, Programming and Design, Tata McGraw-Hill, 2006.

Course Contents and lecture Schedule

SNo.	Topic	Lectures
1	**The ARM Architecture and Memory Hierarchy**	
1.1	The Acorn RISC Machine- Architectural inheritance	1
1.2	The ARM -programmer's model - ARM development tools	2
1.3	Memory size and speed- On-chip memory	1
1.4	Caches-Cache design - an example	1
1.5	Memory management	1
2	**ARM Assembly Language Programming**	
2.1	Data processing instructions	1
2.2	Data transfer instructions	1
2.3	Control flow instructions	1
2.4	Writing simple assembly language programs	1
2.5	ARM Organization and Implementation- 3-stage pipeline ARM organization -5-stage pipeline ARM organization	2
2.6	ARM instruction execution - ARM implementation	1
2.7	The ARM coprocessor interface	1
3	**The ARM Instruction Set**	
3.1	Introduction - Exceptions - Conditional execution - Branch and Branch with Link (B, BL) - Branch, Branch with Link and eXchange (BX, BLX) - Software Interrupt (SWI)	2
3.2	Data processing instructions - Multiply instructions - Count leading zeros (CLZ - architecture v5T only)- Single word and unsigned byte	2

	data transfer instructions - Half-word and signed byte data transfer instructions - Multiple register transfer instructions	
3.3	Swap memory and register instructions (SWP) - Status register to general register transfer instructions - General register to status register transfer instructions	2
3.4	Coprocessor instructions - Coprocessor data operations - Coprocessor data transfers - Coprocessor register transfers	1
3.5	Breakpoint instruction (BRK - architecture v5T only)- Unused instruction space -Memory faults - ARM architecture variants	2
3.6	The Thumb Instruction Set- The Thumb bit in the CPSR - The Thumb programmer's model	1
3.7	Thumb branch instructions - Thumb software interrupt instruction - Thumb data processing instructions	1
3.8	Thumb single register data transfer instructions - Thumb multiple register data transfer instructions	1
3.9	Thumb breakpoint instruction - Thumb implementation - Thumb applications	1
4	**Architectural Support for System Development and Operating Systems**	
4.1	The ARM memory interface - The Advanced Microcontroller Bus Architecture (AMBA)	1
4.2	The ARM reference peripheral specification - Hardware system prototyping tools	1
4.3	The ARMulator - The JTAG boundary scan test architecture - The ARM debug architecture	1
4.4	Embedded Trace - Signal processing support	1
4.5	An introduction to operating systems- The ARM system control coprocessor	1
4.6	CP15 protection unit registers- ARM protection unit	1
4.7	CP15 MMU registers- ARM MMU architecture	1
4.8	Synchronization- Context switching- Input / Output	1
5	**Embedded ARM Applications**	

5.1	The VLSI Ruby II Advanced Communication Processor	1
5.2	The VLSI ISDN Subscriber Processor	1
5.3	The OneC™ VWS22100 GSM chip	1
5.4	The Ericsson-VLSI Bluetooth Baseband Controller-	1
5.5	The ARM7500 and ARM7500FE- The ARM7100- The SA-1100	1
Total		40

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CN EO / KEU	**3**	**1**	**-**	**4**

CN EO / KEU SCADA 3:1

(Common to M.E Power system Engineering)

Preamble

Knowledge of basic control theory is essential for studying this course. This course is designed to impart the knowledge of industrial SCADA system implementation. Emphasis is also given to modems and trouble shooting.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
c. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.
d. Graduate will demonstrate skills to use modern engineering tools, softwares and equipment to analyze problems.
e. Graduate who can participate and succeed in competitive examinations.

Competencies

At the end of the course the students should be able to:

1. Demonstrate about various LANs.
2. Explain the design of SCADA systems.
3. Apply the distributed and programmable controllers for industrial requirements
4. Identify the problems in practical installation of SCADA systems.

Assessment Pattern

Sl.No.	Bloom's Category	Test 1	Test 2	Test 3/ End-semester examination
1	Remember	10	10	20
2	Understand	20	20	40
3	Apply	20	20	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. Draw the typical RTU hardware structure.
2. List the components of analog input module.
3. What are the specifications of A/D converter?
4. Name some high speed Ethernet systems.
5. What is the principle of Huff man encoding?
6. What are the different trivial alarms?

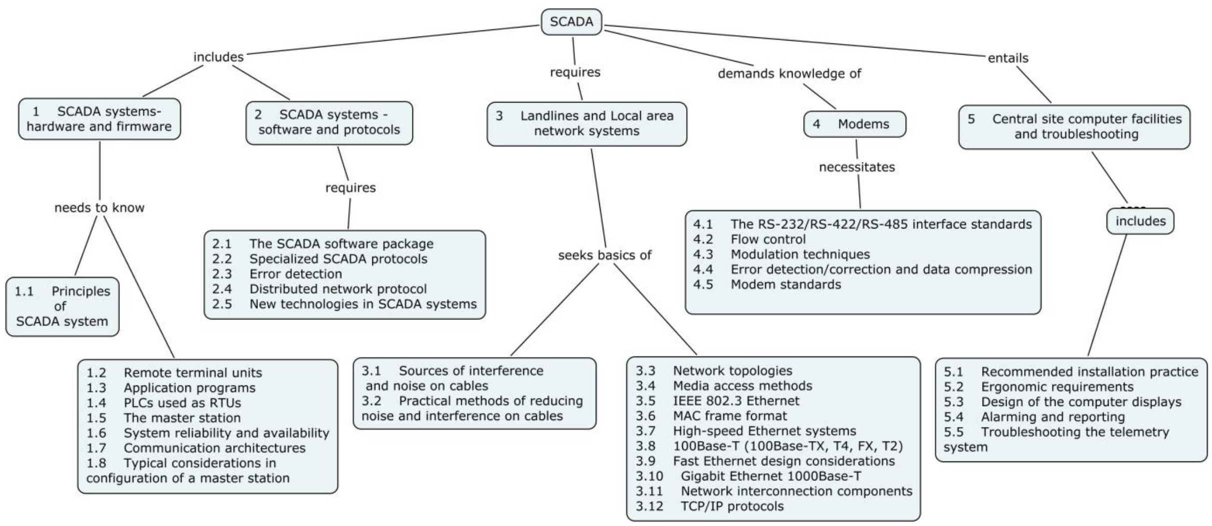
Understand

1. Why mixed digital and analog modules are used?
2. What are the requirements of RTU system?
3. What are the ways of transferring control of the ladder logic program?
4. Discuss the communication architecture of SCADA.
5. How noises and interferences are reduced by shielding and twisting wires?
6. How IP messages are routed?
7. What are the various distributed system protocols?

Apply

1. Develop PLC ladder program for ON/OFF control.
2. How SCADA system can be designed for a power industry?
3. Select a modem for a particular telemetry application. Justify the selection.
4. Design a simple SCADA system for a tank filling device.
5. How to troubleshoot the system if CPU module is not running?
6. Compare the performance of different Ethernet systems.

Concept Map



Syllabus

SCADA systems- hardware and firmware
Principles of SCADA system - Remote terminal units - Application programs- PLCs used as RTUs - The master station - System reliability and availability - Communication architectures - Typical considerations in configuration of a master station

SCADA systems - software and protocols
The SCADA software package - Specialized SCADA protocols - Error detection - Distributed network protocol - New technologies in SCADA systems

Landlines and Local area network systems
Sources of interference and noise on cables - Practical methods of reducing noise and interference on cables - Network topologies - Media access methods - IEEE 802.3 Ethernet - MAC frame format - High-speed Ethernet systems - 100Base-T (100Base-TX, T4, FX, T2) -

Fast Ethernet design considerations - Gigabit Ethernet 1000Base-T - Network interconnection components - TCP/IP protocols

Modems
The RS-232/RS-422/RS-485 interface standards - Flow control - Modulation techniques - Error detection/correction and data compression - Modem standards

Central site computer facilities and troubleshooting
Recommended installation practice - Ergonomic requirements - Design of the computer displays - Alarming and reporting - Troubleshooting the telemetry system

Reference Books

1. David Bailey, Edwin Wright, "Practical SCADA for Industry", Newnes, An imprint of Elsevier 2006.

2. Gordon Clarke, Deon Reynders, Edwin Wright "Practical Modern SCADA Protocols:DNP3, 60870.5 and Related Systems", Newnes, An imprint of Elsevier 2004.

Course contents and Lecture Schedule

Sl.No.	Topic	No. Of Lectures
1	**SCADA systems- hardware and firmware**	
1.1	Principles of SCADA system	1
1.2	Remote terminal units	1
1.3	Application programs	1
1.4	PLCs used as RTUs	2
1.5	The master station	1
1.6	System reliability and availability	1
1.7	Communication architectures	2
1.8	Typical considerations in configuration of a master station	1
2	**SCADA systems - software and protocols**	
2.1	The SCADA software package	1
2.2	Specialized SCADA protocols	2
2.3	Error detection	2
2.4	Distributed network protocol	1
2.5	New technologies in SCADA systems	1

3	**Landlines and Local area network systems**	
3.1	Sources of interference and noise on cables	1
3.2	Practical methods of reducing noise and interference on cables	1
3.3	Network topologies	2
3.4	Media access methods	1
3.5	IEEE 802.3 Ethernet	1
3.6	MAC frame format	1
3.7	High-speed Ethernet systems	1
3.8	100Base-T (100Base-TX, T4, FX, T2)	1
3.9	Fast Ethernet design considerations	1
3.10	Gigabit Ethernet 1000Base-T	1
3.11	Network interconnection components	1
3.12	TCP/IP protocols	1
4	**Modems**	
4.1	The RS-232/RS-422/RS-485 interface standards	1
4.2	Flow control	1
4.3	Modulation techniques	1
4.4	Error detection/correction and data compression	1
4.5	Modem standards	1
5	**Central site computer facilities and troubleshooting**	
5.1	Recommended installation practice	1
5.2	Ergonomic requirements	1
5.3	Design of the computer displays	1
5.4	Alarming and reporting	1
5.5	Troubleshooting the telemetry system	1
	Total	40

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CN EH / KEB	**4**	**-**	**-**	**4**

CNEH / KEB Power Plant Instrumentation and Control 4:0
(Common to M.E. Power System Engg.)

Preamble
This course aims to give the fundamental concepts and practical aspects of power plant instrumentation and control. A power station is a complex entity. It involves a wide range of engineering disciplines. The basic principles of steam and water cycles, fuel, air and flue gas circuits are discussed. Also the steam generator, boiler drum and circulation, water treatment and various types of controls in a steam power plant has been discussed. It includes compression and draught control, feed water control, steam temperature control and control equipment have been discussed. The updated information on combined cycle generation is also provided.

Programme Outcomes addressed
a. Graduates will demonstrate knowledge of power plant instrumentation and control engineering.
b. Graduates will have an ability to identify, formulate and solve power plant instrumentation and control engineering problems.
c. Graduates will have an ability to use the techniques, skills and modern instrumentation and control for power plants.
d. Graduates can participate and succeed in competitive examinations.

Competencies
At the end of the course the student should be able to:

1. Explain the basic principles of power system instrumentation and control.
2. Explain and determine the different types of instrumentation and control systems used for power plants.
3. Determine the performance of various power plant instrumentation and control systems.
4. Choose from currently commercially available power plant instrumentation and control systems for a given application.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	20	20	20
2	Understand	40	40	20
3	Apply	20	20	40
4	Analyze	20	20	20
5	Evaluate	0	0	0
6	Create	0	0	0

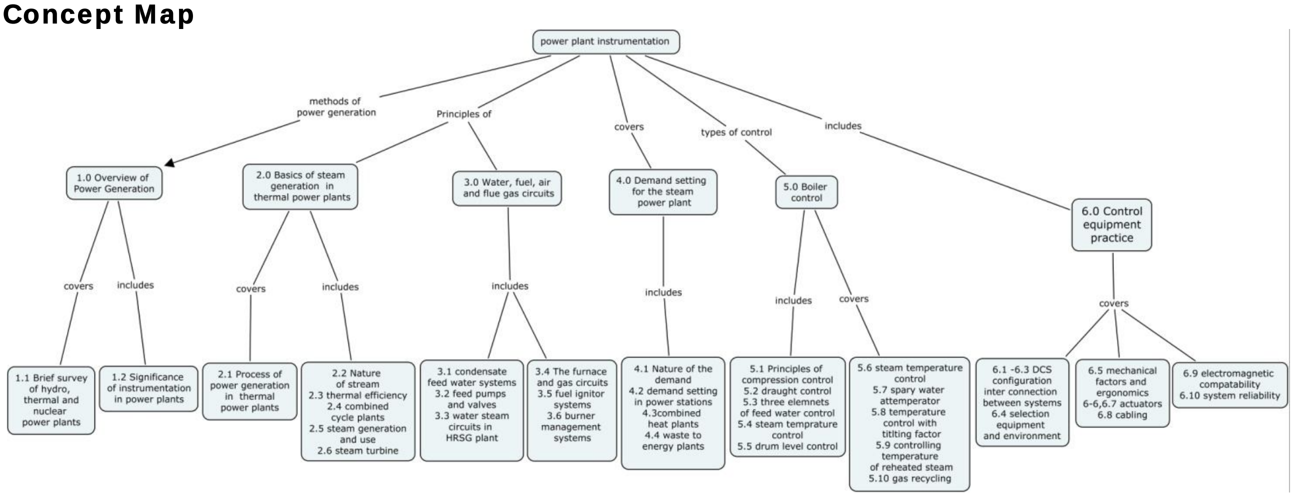
Course Level Learning Objectives
Remember
1. Name the different methods of conventional power generation.
2. State the importance of instrumentation.
3. Define the term thermal efficiency.
4. Name the different types of feed water control.
5. What is meant by dearreator?

6. What is meant by combined heatened power plant?
7. List any two types of attemperator.
8. List the different modules of boiler control mechanism.
9. What is meant by DCS?
10. State any two advantages of electrical actuators.

Understand
1. Explain the nature of steam and the uses of steam.
2. Describe how the demand setting in power station is done.
3. Discuss briefly about waste to energy plants.
4. Explain how temperature is controlled with tilting burners.

Analyse
1. Compare the operation of two element and three element control used for feed water pumping.
2. Differentiate the operation of different methods of draught control in a power plant.
3. Organise the steps involved in compression control.
4. Compare and contrast between an oxygen analyser and a flue gas analyser.

Concept Map



Syllabus

Overview of Power Generating Stations: Brief survey of different methods of conventional power generation (hydro, thermal and nuclear)-Importance of instrumentation in power generating stations.
Basics of steam generation in thermal power plants: Process of power generation in coal-fired and oil fired in thermal power plants-Nature of steam-Thermal efficiency-Gas turbine and combined cycle plants-Steam turbine and use-Steam turbine
Water, fuel, air and flue gas circuits: The condensate and feed water system
Feed pumps and valves-The water and steam circuits in HRSC plant
Setting the demand for the steam generator: Nature of the demand-Setting the demand in power stations applications-Master demand in power station applications-Load demand in combined heat and power plants-Waste to energy plants
Boiler control: The principles of compression control-Draught control-The principles of feed water control-One, two and three elements feed water control
Drum level control-Steam temperature control-Spray-water attemperator-Temperature control with tilting burners-controlling temperature of reheated steam-Gas Recycling

Control Equipment Practice: DCS configuration in power plant-A Typical DCS configuration-Interconnections between systems-Equipment selection and environment-Mechanical factors and ergonomics-Electrical actuators-Hydraulic actuators-Cabling-Electromagnetic compatibility-Reliability of systems

Reference Books

1. David Lindsley, "Power Plant Control & Instrumentation ",IEE Publications, London, UK (2001).
2. Sam G.Dukelow, The control of Boilers, Instrument Society of America, 1991.
3. Elonka, S.M. and Kohal A.L.Standard Boiler Operations, McGraw Hill, NewDelhi, 1994.
4. R.K.Jain, Mechanical and Industrial Measurements, Khanna Publishers, New Delhi, 1995.
5. P.K.Nag, "Power Plant Engineering" Tata McGraw-Hill, NewDelhi, 2005.
6. A.K.Mahalanbias-"Power System Instrumentation"-Tata McGraw Hill.

Course Contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1.0	**OVERVIEW OF POWER GENERATING STATIONS**	
1.1	Brief survey of different methods of conventional power generation (hydro, thermal and nuclear)	1
1.2	Importance of instrumentation in power generating stations	1
2.0	**Basics of steam generation in thermal power plants**	
2.1	Process of power generation in coal-fired and oil fired in thermal power plants	1
2.2	Nature of steam	1
2.3	Thermal efficiency	1
2.4	Gas turbine and combined cycle plants	1
2.5	Steam generation and use	1
2.6	Steam turbine	1
3.0	**Water, fuel, air and flue gas circuits**	
3.1	The condensate and feed water system	1
3.2	Feed pumps and valves	1
3.3	The water and steam circuits in HRSG plant	1
3.4	The air and gas circuits	1
3.5	Fuel and Igniter systems	1
3.6	Burner- management systems	1
4.0	**Setting the demand for the steam generator**	
4.1	Nature of the demand	1
4.2	Setting the demand in power station applications	1
4.3	Master demand in power station applications	1
4.5	Load demand in combined heat and power plants	1
4.6	Waste to energy plants	1
5.0	**Boiler control**	
5.1	The principles of compression control	1
5.2	Draught control	1
5.3	The principles of feed water control	1
5.4	One, two and three elements feed water control	1
5.5	Drum level control	2
5.6	Steam temperature control	1
5.7	Spray-water attemperator	1
5.8	Temperature control with tilting burners,	1
5.9	controlling temperature of reheated steam	1

5.10	Gas Recycling	1
6.0	**CONTROL EQUIPMENT PRACTICE**	
6.1	DCS configuration in power plant	1
6.2	A Typical DCS configuration	1
6.3	Interconnections between systems,	1
6.4	Equipment selection and environment	1
6.5	mechanical factors and ergonomics	1
6.6	Electrical actuators	1
6.7	Hydraulic actuators	1
6.8	Cabling,	1
6.9	Electromagnetic compatibility	1
6.10	Reliability of systems	1
	TOTAL	40

Course Designer

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M.Tech. DEGREE (Control and Instrumentation) PROGRAM

CURRICULUM AND

DETAILED SYLLABI FOR III & IV SEMESTER SUBJECTS

&

ELECTIVE SUBJECTS

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2011-2012

THIAGARAJAR COLLEGE OF ENGINEERING
(A Govt. Aided ISO 9001-2008 certified Autonomous Institution affiliated to Anna University)

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Passed in BOS meeting held on 07.04.2012 Approved in 44th Academic Council meeting on 9th June 2012

Department of Electrical and Electronics Engineering

Graduating Students of M.Tech. program of Control and Instrumentation will be able to:

1. Specify, architect, design and analyze systems that efficiently measure, control and automation of a plant
2. Specify, design, prototype and test modern control systems that perform analog and digital processing functions.
3. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering, Madurai-625015

Department of Electrical and Electronics Engineering

Scheduling of Courses

Sem	Theory Courses						Practical / Project
4th (12)							CN41 Project 0:12
3rd (16)	CN31 System Identification and adaptive control 3:1	CN EX Elective V 3:1	CN EX Elective VI 3:1				CN34 Project 0:4
2nd (24)	CN21 Advanced Instrumentation system 3:0	CN22 Digital Control system 3:1	CN EX Elective I 3:1	CN EX Elective II 3:1	CN EX Elective III 3:1	CN EX Elective IV 3:1	CN 27 Advanced Control and Instrumentation Laboratory 0:1
1st (24)	CN11 Applied Mathematics for Electrical Engineers 3:1	CN12 Systems Theory 3:1	CN13 Transducer Engineering 3:1	CN14 Process Control and Instrumentation 3:1	CN15 Microcontroller based system Design 3:0	CN16 Advanced Digital Signal Processing 3:1	CN17 Control and Instrumentation Laboratory 0:1

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.Tech. DEGREE (Control and Instrumentation) PROGRAM

SUBJECTS OF STUDY
(For the candidates admitted from 2011-2012 onwards)

FIRST SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
CN11	Applied Mathematics for Electrical Engineers	BS	3	1	-	4
CN12	Systems Theory	DC	3	1	-	4
CN13	Transducer Engineering	DC	3	1	-	4
CN14	Process Control Instrumentation	DC	3	1	-	4
CN15	Microcontroller based system Design	DC	3	-	-	3
CN16	Advanced Digital Signal Processing	DC	3	1	-	4
PRACTICAL						
CN17	Control and Instrumentation Laboratory	DC	-	-	3	1
Total			**18**	**5**	**3**	**24**

SECOND SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
CN21	Advanced Instrumentation system	DC	3	-	-	3
CN22	Digital Control System	DC	3	1	-	4
CNEx	Elective-I	DE	3	1	-	4
CNEx	Elective-II	DE	3	1	-	4
CNEx	Elective-III	DE	3	1	-	4
CNEx	Elective-IV	DE	3	1	-	4
PRACTICAL						
CN27	Advanced Control and Instrumentation Laboratory	DC	-	-	3	1
Total			**18**	**5**	**3**	**24**

THIRD SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
CN31	System Identification and adaptive control	DC	3	1	-	4
CNEx	Elective-V	DE	3	1	-	4
CNEx	Elective-VI	DE	3	1	-	4
PRACTICAL						
CN34	Project	DC	-	-	12	4
Total			**9**	**3**	**12**	**16**

FOURTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
PRACTICAL						
CN41	Project	DC	-	-	36	12
Total			**-**	**-**	**36**	**12**

Total credits: 76

BS : Basic Science
DC : Department Core
DE : Departmental Elective

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.Tech. DEGREE (Control and Instrumentation) PROGRAM

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2011-2012 onwards)

FIRST SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	CN 11	Applied Mathematics for Electrical Engineers	3	50	50	100	25	50
2	CN 12	Systems theory	3	50	50	100	25	50
3	CN 13	Transducer Engineering	3	50	50	100	25	50
4	CN 14	Process Control Instrumentation	3	50	50	100	25	50
5	CN 15	Microcontroller based system Design	3	50	50	100	25	50
6	CN 16	Advanced Digital Signal Processing	3	50	50	100	25	50
PRACTICAL								
7	CN 17	Control and Instrumentation Laboratory	3	50	50	100	25	50

SECOND SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	CN21	Advanced Instrumentation system	3	50	50	100	25	50
2	CN22	Digital Control System	3	50	50	100	25	50
3	CNEx	Elective-I	3	50	50	100	25	50
4	CNEx	Elective-II	3	50	50	100	25	50
5	CNEx	Elective-III	3	50	50	100	25	50
6	CNEx	Elective-IV	3	50	50	100	25	50
PRACTICAL								
7	CN27	Advanced Control and Instrumentation Laboratory	3	50	50	100	25	50

THIRD SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	CN31	System Identification and adaptive control	3	50	50	100	25	50
2	CNEx	Elective-V	3	50	50	100	25	50
3	CNEx	Elective-VI	3	50	50	100	25	50
PRACTICAL								
7	CN34	Project	-	150	150	300	75	150

FOURTH SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
PRACTICAL								
1	CN41	Project	-	150	150	300	75	150

* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100/300 and subsequently be reduced to 50/150 marks for the award of terminal examination marks

List of Elective Subjects – M.Tech. Control and Instrumentation

Departmental Electives			
Sub. Code (CN Ex)	Subject Name	Pre/Co requisites	Credits
A/KEI	Control of Electric Drives	Electrical Machines, Power Electronics	4
B	Bio-Medical Instrumentation	--	4
C	Digital System Design using PLDs	Digital systems	4
D	Advanced Industrial Controllers	Control systems	4
E	Intelligent Controllers	Control systems	4
F	Optimal Control And Filtering	Control systems	4
G	Robust Control	Control systems, system theory	4
H/KEB	Power Plant Instrumentation and Control	Measurements and Instrumentation	4
J	Analytical Instrumentation		
K	MEMS	Measurements and Instrumentation	4
L	Multi sensor data fusion	Control system Microprocessor/ Microcontrollers	4
M	Data Communication for controllers	Digital systems, Computer Networks	4
N	Embedded System Design	Digital systems	4
O/KEU	SCADA	Microprocessors, Instrumentation, DSP	4
P/KES	Real Time Operating System	Microprocessor/ Microcontrollers	4
Q	Non linear control	Control system	4
R	Image Processing and Computer vision	--	4
S	State Estimation	Control System	4

Sub Code	Lectures	Tutorial	Practical	Credit
CN31	**3**	**1**	**0**	**4**

CN31 System Identification and Adaptive Control 3:1

Preamble

The area of adaptive control has grown to be one of the richest in terms of algorithms, design techniques, analytical tools, and modifications. The purpose of this course is to alleviate some of the confusion and difficulty in understanding the design, analysis, and robustness of a wide class of adaptive control for continuous-time plants. The system identification methods and several adaptive control techniques are discussed with mathematical models. The course also gives exposure to implementation of adaptive controller for industrial applications.

Competencies

At the end of the course, the student will be able to:

1. Acquire knowledge about system identification methods and several adaptive control techniques.
2. Get familiar with modelling and control of dynamic system.
3. Acquire an active knowledge of key approaches and a good sense of implementing adaptive techniques
4. Identify when adaptive techniques can be used and when other methods are suitable.
5. Apply adaptive control techniques and design a stochastic models

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3 / End-semester examination
1	Remember	30	20	20
2	Understand	30	20	20
3	Apply	20	30	30
4	Analyze	20	30	30
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1) What is an Adaptive control?
2) State the importance of Identification.
3) What are conventional techniques of Identification?
4) What is meant by prediction error?
5) What is the significance of Predictive control?
6) Draw the block diagram of adaptive control.

Understand

1) Explain the least square technique in detail.
2) What are drawbacks of Gain scheduling technique?
3) State the necessity of an observer.
4) What is the purpose of state and parameter estimation?
5) Explain about gain scheduling control.
6) Explain about Self tuning control technique.

Apply

1) With a suitable example explain about MRAC.
2) Describe the control algorithm for closed loop pole assignment.
3) Find descriptions of adaptive controller from some manufacturers and write a note about them.
4) Consider the system $G(s) = G_1(s)G_2(s)$
   Where
   $G_1(s) = \frac{b}{(s+a)}$ & $G_2(s) = \frac{c}{(s+a)}$
   Discuss how to make an MRAS based on the gradient approach.
5) Design an adaptive fuzzy logic for process control to improve the stability of the system.
6) For an automotive application apply adaptive neural control for improvement of efficiency.

Analyze

1) Make an assessment of the field of adaptive control by making a literature search.
2) Determine a state observer for the continuous-time system in state-space form

$$\begin{cases} \dot{x}(t) &= \begin{bmatrix} -1 & 0 \\ 1 & -1 \end{bmatrix} x(t) + \begin{bmatrix} 2 \\ 0 \end{bmatrix} u(t) \\ y(t) &= \begin{bmatrix} 0 & \frac{1}{2} \end{bmatrix} x(t) \end{cases}$$

   The desired Eigen values are -5, -5.

3) Consider data generated by the discrete-time system
   $$y(t) = b_0u(t) + b_1u(t-1) + e(t)$$
   Where $e(t)$ is a sequence of independent N(0,1) random variables. Assume that the parameter b of the model $y(t) = bu(t)$is determined by least squares. Determine the estimates obtained for large observation sets when the input u is a step.
4) Consider the system
   $$\frac{dx_1}{dt} = x_2 + \theta f(x_1)$$
   $$\frac{dx_2}{dt} = u$$
   where θ is an unknown parameter and f is a known differential function. Find the control law using the certainty equivalence principle.

5) For a system given below determine model reference adaptive controllers based on gradient and stability theory.

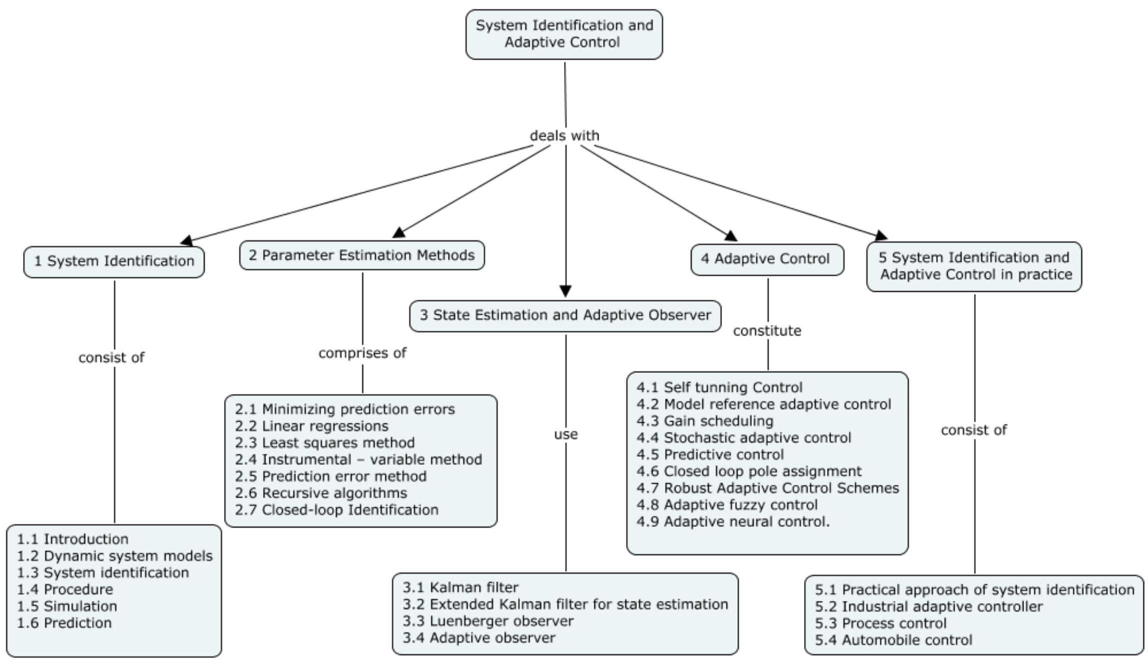
$$G(s) = \frac{k}{s(s+a)}$$

Analyse discrete-time direct and indirect self-tuning parameters for the partially know system.

6) Determine the performance parameters of the given system using continuous time parameter estimation.

$$\frac{k}{s(s+a)}$$

Concept map



Course Contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1	**System Identification**	
1.2	Introduction	1
1.3	Dynamic system models	2
1.4	System identification procedure	1
1.5	Simulation	1
1.6	prediction	1
2	**Parameter estimation methods**	
2.1	Minimizing prediction errors	1
2.2	Linear regressions	1
2.3	Least squares method	1
2.4	Instrumental – variable method	1

2.5	Prediction error method	1
2.6	Recursive algorithms	1
2.7	Closed-loop Identification	1
3	**State Estimation and adaptive observer**	
3.1	Kalman filter	2
3.2	Extended Kalman filter for state estimation	1
3.3	Luenberger observer	2
3.4	Adaptive observer	1
4	**Adaptive control**	
4.1	Self tuning Control	2
4.2	Model reference adaptive control	1
4.3	Gain scheduling	1
4.4	Stochastic adaptive control	2
4.5	Predictive control	2
4.6	Adaptive control algorithms for closed loop pole assignment,	2
4.7	Robust Adaptive Control Schemes	1
4.8	Adaptive fuzzy control	2
4.9	Adaptive neural control	2
5	**System Identification and adaptive control in practice**	
5.1	Practical approach of system identification	2
5.2	Industrial adaptive controller	2
5.3	Process control	1
5.4	Automobile control	1
	Total	40

Syllabus

System Identification

Introduction, dynamic system models, system identification procedure, simulation and prediction.

Parameter estimation methods
Minimizing prediction errors, linear regressions and Least squares method, Instrumental – variable method, prediction error method. Recursive algorithms, Closed-loop Identification.

State Estimation and adaptive observer

Kalman filter and extended Kalman filter for state estimation, Luenberger observer and adaptive observer.

Adaptive control

Self tuning Control, model reference adaptive control, Gain scheduling, stochastic adaptive control, Predictive control, Adaptive control algorithms for closed loop pole assignment, Robust Adaptive Control Schemes, adaptive fuzzy control, adaptive neural control.

System Identification and adaptive control in practice

Practical approach of system identification, Industrial adaptive controller, process control and automobile control

Reference books

1. Ljung.L, ‘System Identification: Theory for the user”, Prentice Hall, Englewood Cliffs,1987.
2. Astrom .K, “Adaptive Control”, Second Edition, Pearson Education Asia Pte Ltd, 2002.
3. Chang C. Hong, Tong H. Lee and Weng K. Ho, “Adaptive Control”, ISA press, Research Triangle Park, 1993.
4. Nelles. O, “Nonlinear System Identification’, Springer Verlag, Berlin, 2001.

Course Designers

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Sub code	Lectures	Tutorial	Practical	Credit
CN EG	3	1	-	4

CN EG Robust Control **3:1**

Preamble

Robust control deals with system analysis and control design for such imperfectly known process models. One of the main goals of feedback control is to maintain overall stability and system performance despite uncertainties in the plant. One of the most useful qualities of a properly designed feedback control system is robustness, i.e., the ability of the closed-loop system to continue performing satisfactorily despite large variations in the (open-loop) plant dynamics. This course will provide an introduction to the analysis and design of robust feedback control systems. The course enables the control engineer to be pioneered in designing control system. It also gives an attempt to thoroughly Analyze the system for performance & stability and design robust controller for various applications.

Competencies

1. Enhance the nominal controller to a robust controller in the presence of uncertainties.
2. Design the system robust stability and performance.
3. Apply and check robust performance and stability on various problems.
4. Analyze the system stability and performance using H2 and H-infinity norms.
5. Analyze the system stability and performance using frequency domain techniques.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	40	20	10
2	Understand	40	20	10
3	Apply	20	20	40
4	Analyze	0	40	40
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. Define robustness in stability.
2. List the types of uncertainties that affect the closed loop system.
3. State any two properties of LFT mapping.
4. Define internal stability.
5. State the condition for a system to be well posedness.
6. State kharitonov's theorem.

Understand

1. Draw and explain H_2 energy space.
2. Draw and explain H_∞ energy space.
3. Explain the various steps involved in μ synthesis.
4. Explain the quantitative feedback theory based on robust control.

5. Outline various robust control methods for parametric families.
6. Interpret between the loop shaping design procedure and LQG control scheme.

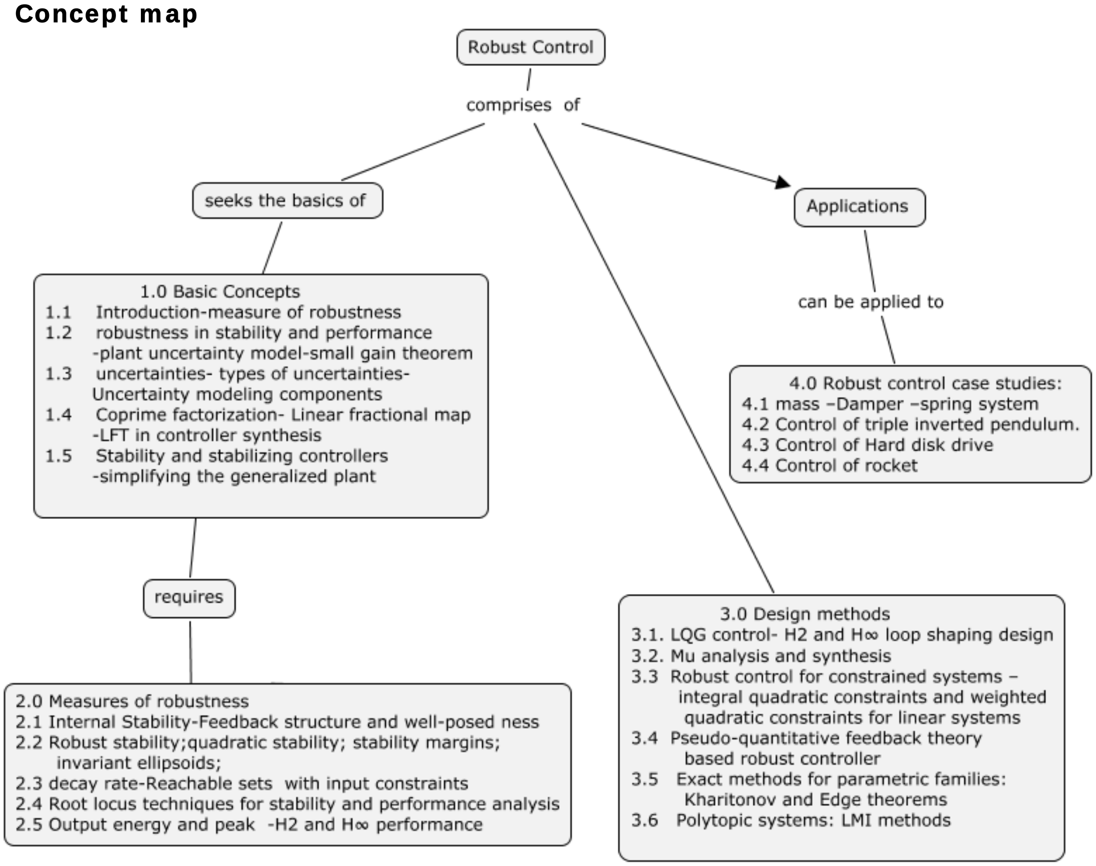
Apply

1. Construct a robust control scheme for mass damper spring system.
2. Make an attempt to design a robust controller for a hard disc drive.
3. Apply LFT mapping to simplify a generalized plant.
4. Show the various types of uncertainties affect the closed loop system and illustrate with an example.
5. Use small gain theorem to show that a feedback system is internally stable.
6. In LMI method explain the changing weights and adaptation done in loop shaping.

Analyze

1. Explain the steps involved in Mu analysis in sequence with an example.
2. Distinguish between the loop shaping design and Mu synthesis method with respect to control of rocket.
3. Sequence the various steps in LFT controller synthesis.
4. Deduce a robust controller for a triple inverted pendulum system with a suitable method.
5. Distinguish between QFT, quantitative feedback theory and LQG controller with a suitable example.

Concept map



Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.0	**Basic Concepts**	
1.1	Introduction-measure of robustness	1
1.2	robustness in stability and performance-plant uncertainty model-small gain theorem	2
1.3	uncertainties- types of uncertainties-Uncertainty modeling components	3
1.4	Co-prime factorization- Linear fractional map -LFT in controller synthesis	3
1.5	Stability and stabilizing controllers -simplifying the generalized plant	3
2.0	**Measures of robustness**	
2.1	Internal Stability- Feedback structure and well-posedness	2
2.2	Robust stability; quadratic stability; stability margins; invariant ellipsoids;	3
2.3	decay rate-Reachable sets with input constraints	2
2.4	Root locus techniques for stability and performance analysis	3
2.5	Output energy and peak -H_2 and H_∞ performance	2
3.0	**Various approaches of robust control design**	
3.1.	LQG control- H_2 and H_∞ loop shaping design	3
3.2.	Mu analysis and synthesis	2
3.3	Robust control for constrained systems –integral quadratic constraints and weighted quadratic constraints for linear systems	4
3.4	Pseudo-quantitative feedback theory based robust controller	2
3.5	Exact methods for parametric families: Kharitonov and Edge theorems	2
3.6	Polytopic systems: LMI methods	2
4.	**Applications using MATLAB**	
4.1	Robust control case studies: mass –Damper –spring system	2
4.2	Control of triple inverted pendulum.	1
4.3	control of Hard disk drive	1
4.4	Control of rocket	2
	Total	**45**

SYALLABUS

Basic Concepts

Introduction-measure of robustness –robustness in stability and performance-plant uncertainty model-small gain theorem- uncertainties- types of uncertainties-Uncertainty modeling components- Co-prime factorization- Linear fractional map- Stability and stabilizing controllers -LFT in controller synthesis –simplifying the generalized plant.

Measures of robustness

Internal Stability- Feedback structure and well-posedness - Robust stability; quadratic stability; stability margins; invariant ellipsoids; decay rate-Reachable sets with input constraints-Output energy and peak -H_2 and H_∞ performance.

Various approaches of robust control design

LQG control- H_2 and H_∞ loop shaping design-Mu analysis and synthesis. Robust control for constrained systems –integral quadratic constraints and weighted quadratic constraints for linear systems. Pseudo-quantitative feedback theory based robust controller- Exact methods for parametric families: Kharitonov and Edge theorems -Polytopic systems: LMI methods

Applications using MATLAB

Robust control case studies: mass –Damper –spring system, control of triple inverted pendulum, control of Hard disk drive, control of rocket.

Reference Books

1. Min Wu, Yong He, Jin-Hua She, Stability Analysis and Robust Control of Time- Delay Systems, Springer Press Beijing-2010.
2. Sigurd Skogestad, Ian Postlethwaite, Multivariable Feedback Control: Analysis and Design, Wiley-Interscience.2005.
3. Kemin Zhou, John C. Doyle, Essentials Of Robust Control, Published September, Prentice Hall 1998- ISBN 0-13-525833-2
4. Gu, Da-Wei, Petkov, Petko Hr., Konstantinov, Mihail M, *Robust Control Design with MATLAB* Springer-Verlag 2005.
5. S.P.Bhattacharyya, H.Chapellat and L.H.Keel, Robust Control (The Parametric approach), Prentice Hall, New Jersy, 1995.
6. J.Ackerman, Robust control systems with uncertain physical parameters, Springer –Verlag, London, 1993.

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CNEJ	**3**	**1**	**0**	**4**

CNEJ Analytical Instrumentation 3:1

Preamble

Analytical instruments are an exciting and fascinating part of chemical analysis that interacts with all areas of chemistry and with many other areas of applied science. An analytical instrument plays an important role in the production and evaluation of new products and also provides lower detection limits required to assure safe food, drugs, water and air. This course emphasizes the principles of analytical instruments and their applications in hospitals for routine clinical analysis, drugs, pharmaceutical laboratories and environmental pollution monitoring and control.

Competencies

At the end of the course, the student will be able to:

1. Understand provide various techniques and methods of analysis which occur in various regions of Electromagnetic spectrum
2. Understand the principles and components of analytical instruments
3. Understand the applications of analytical instruments in chemical, environmental and pollution monitoring.
4. Understand the important methods of analysis of industrial gases
5. Illustrate the methods of separating the mixture samples.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	20	20	20
2	Understand	50	50	50
3	Apply	30	30	30
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. Define ion selective electrode.
2. Give any two measuring and reference electrodes.
3. Define the working principle of thermal conductivity analyzer.
4. What are the different techniques to measure NO_2 in gases?
5. What is Gamma camera?

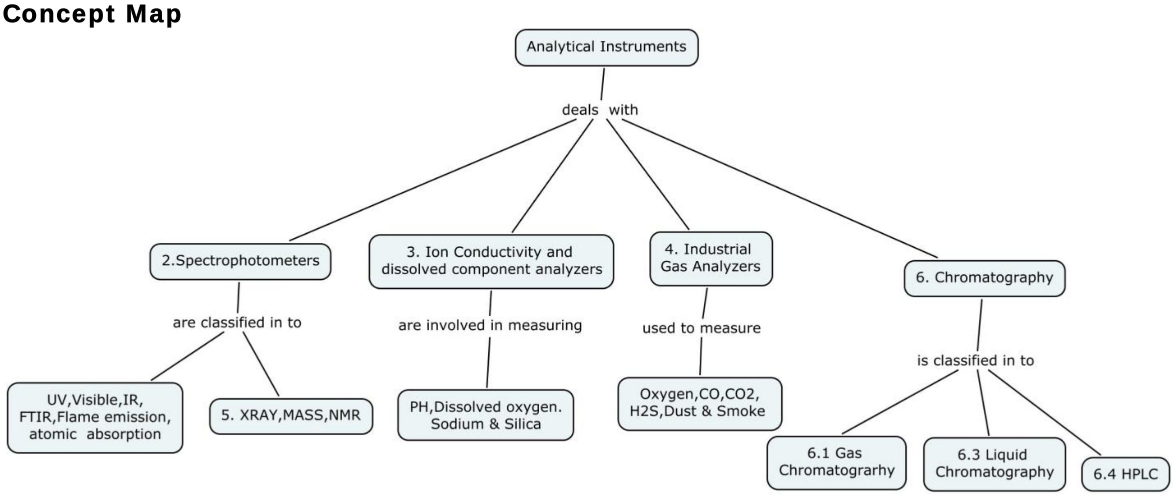
Understand

1. Explain O_2 measurement in gases with neat Sketch.
2. Explain dust and smoke measurement in gases with neat diagram
3. Describe the working principle of IR analyzers with neat diagram.
4. Enumerate the working principle of CO and H_2S analyzers
5. Illustrate the working of PH meter with neat diagram.
6. Explain silica analyzer in detail and mention its few applications

Apply

1. Assuming that the limits of the visible spectrum are approximately 380 and 70 mm. Find the angular range of the first-order visible spectrum produced by a plane grating that has 900 grooves/mm with the light normally on the grating.
2. With a certain filter photometer and using a 510 nm filter and 2.00 cm cuvettes the reading on a linear scale for Po was 85.4. With a 1.00* 10^{-4} M solution of a chromophore in the cuvette, the value of P was 20.3. Calculate the molar absorptivity.
3. Calculate the fraction of cesium atoms ionized in a flame at 2000 K when the total cesium concentration in the flame gases is 10^{-4} atm.,10^{-6} atm and 10^{-7} atm.
4. A water sample containing trace amounts of zinc is analyzed using an ICP with a photomultiplier tube detector. A calibration sample containing 1.4 ppm of zinc gives a signal of 124.5 units. If the background signal is 8.2 unitsa and the concentration equivalent of the background is .02 ppm. Calculate the concentration of zinc in a sample that gives signal response of 94.5 units.
5. Calculate the short-wavelength limit for a 60 kV X ray Tube. What is the atomic number of the element for which insufficient energy is available for excitation?
6. Consider a 50 cm column with a plate height of 1.5 mm that provides atheoretical plate number of 333 at a flow rate of 3 mL min^{-1},V_M=1.0 mL. Calculate the solute retention time and retention volume when k' is 1, 2, 5 and 10.

Concept Map



Course contents and Lecture schedule

Sl.No	Topic	No.of Lectures
1	**Introduction to Analytical Instruments**	1
1.1	Basic Components of Analytical Instruments & Intelligent analytical Instrumentation systems.	2
1.2	Performance requirements of Analytical Instruments.	1
1.3	Laws of photometry (Beer and Lambert's law).	1
2	**Spectrophotometers**	
2.1	UV Spectrophotometers, Visible Spectrophotometers, Infrared Spectrophotometers	2
2.2	Fourier transform infrared spectrometry, atomic absorption Spectrophotometers	2
2.3	Flame emission Spectrophotometers,	1
2.4	Sources and detectors used in spectrophotometers	1
2.4.1	**Case Study:** Analyzing the absorption characteristics of different solutions.	1
3	**Conductivity and dissolved component analyzer**	
3.1	Ion selective electrodes, pH meters	2
3.2	Conductivity meters, Dissolved oxygen analyzer,	2
3.3	Sodium analyzer, Silica Analyzer, Turbidity meter	2
4	**NMR,XRAY and MASS Spectrometric Techniques**	
4.1	NMR Spectroscopy Principle	1
4.2	NMR Detectors-GM Counters, Proportional Counters	2
4.3	X-ray spectrometry, Instrumentation for X-ray spectrometry,	1
4.4	X-ray diffractometer & X ray absorption meter,	2
4.5	Mass Spectrometer (MS): Principle,	1
4.6	Mass analyzer -magnetic deflection type, time of flight.	2
5	**Industrial Gas analyzers**	
5.1	paramagnetic gas analyzer, Infrared gas analyzer,	2
5.2	Environmental Pollution Monitoring Instruments-	1
5.3	Carbon monoxide-non dispersive infrared analyzer(NDIR),	1
5.4	Sulphur dioxide:flame photometric, coulometry, UV fluorescence ,	2
5.5	Hydrogen sulfide , Nitrous oxide	2
6	**Chromatography**	
6.1	Gas chromatography: principle, constructional	1
6.2	Gas chromatography detectors,	1
6.3	Liquid Chromatography principle, construction	1
6.4	High Performance Liquid Chromatography (HPLC): principle, construction details	1
6.4.1	**Case Study:** Design of column for analyzing different samples.	1
	Total	40

Syllabus

Introduction to Analytical instruments

Basic Components of Analytical Instruments, Intelligent analytical Instrumentation systems , Performance requirements of Analytical Instruments, Laws of photometry (Beer and Lambert's law),

Spectrophotometers

UV, Visible, Infrared, Fourier transform infrared spectrometry, atomic absorption, Flame emission Spectrophotometers, Sources and detectors used in spectrophotometers, **Case Study:** Analyzing the absorption characteristics of different solutions.

Conductivity and dissolved component analyzer

Ion selective electrodes, Conductivity meters, pH meters, Dissolved oxygen analyzer, Sodium analyzer, Silica Analyzer, Turbidity meter

NMR,XRAY and MASS Spectrometric Techniques

NMR Spectroscopy :Principle & Detection-GM Counters, Proportional Counters, X-ray spectrometry: Instrumentation for X-ray spectrometry, X-ray diffractometer , X ray absorption meter, Mass Spectrometer (MS): Principle, mass analyzer types - magnetic deflection type, time of flight.

Industrial Gas analyzers

paramagnetic gas analyzer, Infrared gas analyzer, Environmental Pollution Monitoring Instruments- Carbon monoxide: non dispersive infrared analyzer(NDIR), Sulphur dioxide-flame photometric, coulometry, UV fluorescence ,Hydrogen sulfide, Nitrousoxide

Chromatography

Gas chromatography: principle, constructional details, GC detectors, Liquid Chromatography, High Performance Liquid Chromatography (HPLC): principle, constructional details, **Case Study:** Design of column for analyzing different samples.

Reference books

1. Instrumental Methods of Analysis, Willard, Merritt, Dean, Settle, CBS Publishers & Distributors, New Delhi, Seventh edition.
2. Handbook of Analytical Instruments, R. S. Khandpur, Tata McGraw–Hill Publications, 3rd edition
3. Principles of Instrumental Analysis, Skoog, Holler, Nieman, Thomson books-cole publications, 5th edition.
4. Instrumental Methods of Chemical Analysis, Galen W. Ewing, McGraw-Hill Book Company, Fifth edition.
5. Introduction to Instrumental Analysis, Robert D. Braun, McGraw-Hill Book Company.

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CNEK	**3**	**1**	**0**	**4**

CNEK MEMS 3:1

Preamble

The technological advances of Microsystems engineering have been truly impressive in both pace of development and number of new applications. Microsystem engineering involves the design, manufacture and packaging of microelectromechnical systems (MEMS) and peripherals. Applications of Microsystems include aerospace, automotive, biotechnology, environmental protection, safety and healthcare, etc. The strong demand for MEMS and microsystems has generated strong interest as well as a need for engineering educators to offer a course on this subject.

Competencies

At the end of the course the student will be able to:

1. Explain the working principles of MEMS and Microsystems.
2. Apply engineering mechanics for MEMS and Microsystems design.
3. Understand scaling laws in miniaturization
4. Choose materials for MEMS and Microsystems
5. Explain microsystem fabrication process
6. Design microsystem sensor

Assessment Pattern

S.No	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	20	20	20
2	Understand	40	40	40
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. Explain the difference between MEMS and Microsystems.
2. Give at least four distinct advantages of miniaturization of machines and devices.
3. What are the advantages and disadvantages of using piezoresistors and capacitors as signal transducer?
4. What are the principle applications of microsensors, actuators and fluidics?
5. What are the principal sources of intrinsic stresses induced in the microstructures?
6. Explain the photolithography process with neat digarm.

Understand

1. Why can't traditional manufacturing technologies such as mechanical milling, drilling, and welding be used to produce Microsystems?
2. Why are electrostatic forces used to run micromotors rather than conventional electromagnetic forces? Explain why this actuation technique is not used in macrodevices and machines.
3. Why the change of the state of stress in a silicon diaphragm in a micro pressure sensor results in a change of its natural or resonant frequency?
4. Why is model analysis important in the design of Microsystems involving motion?
5. When to choose positive and negative resistors in photolithography?
6. Why silicon is preferred for MEMS applications?

Apply

1. Determine the capacitance of a parallel capacitor. The two plates have identical dimensions of L = W = 1mm with a gap d = 2 μm. Air is the dielectric medium between the plates.

2. Estimate the voltage output for the microthermopile if copper wires are used for the thermocouples with the hot junction temperature at 120^0C and while the cold junction temperature is maintained at 20^0C.

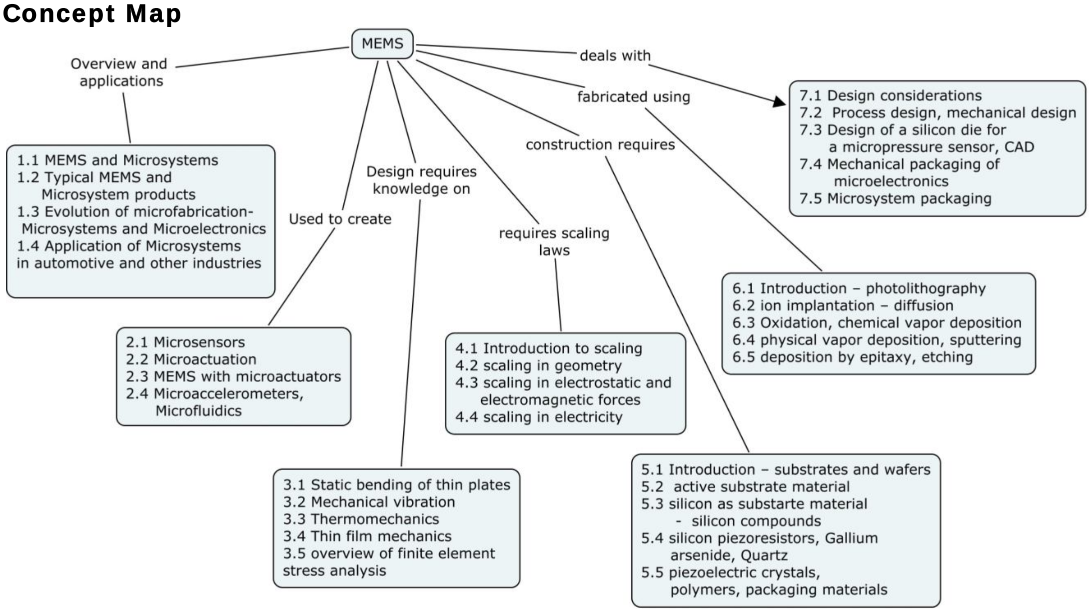
3. A parallel plate capacitor is made of two square plates with the dimensions L = W = 1 mm. Determine the normal electrostatic force if the gap between the plates is 2 μm and the applied voltage is 100V. The plates are separated by static air.

4. A square silicon diaphragm with 532 μm edge length is subjected to pressure loading of 20 MPa. The diaphram has thickness of 13.387 μm. Determine the maximum stress and deflection in the diaphragm under the applied pressure.

5. Determine the equivalent spring constant k and the natural frequency of the cantilever beam element in a microaccelerometer. The beam is made of silicon with a Young's modulus of 190,000 MPa.

6. A microactuator is made of a bilayer strip and an oxidized silicon beam. A resistance heating film is deposited on the top of the oxide. Estimate the interfacial force between the Si and SiO2 layers and the movement of the free end of the strip with a temperature rise $\Delta T = 10^0$C. Use the following material properties.
   Young's modulus: E(SiO2) = 385,000 MPa, E(Si) = 190,000 MPa
   CTE: α (SiO2) = $0.6 \times 10^{-6}/^0$C , α (Si) = $2.33 \times 10^{-6}/^0$C

Concept Map



Course contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1.0	**OVERVIEW OF MEMS AND MICROSYSTEMS**	
1.1	MEMS and Microsystems	1
1.2	Typical MEMS and Microsystem products	1
1.3	Evolution of microfabrication- Microsystems and Microelectronics	2
1.4	Application of Microsystems in automotive and other industries.	1
2.0	**WORKING PRINCIPLES OF MICROSYSTEMS**	
2.1	Microsensors	2
2.2	Microactuation	2
2.3	MEMS with microactuators	2
2.4	Microaccelerometers, Microfluidics	1
3.0	**ENGINEERING MECHANICS FOR MICROSYSTEMS DESIGN**	
3.1	Static bending of thin plates	1
3.2	Mechanical vibration	2
3.3	Thermomechanics	2
3.4	Thin film mechanics	1
3.5	Overview of finite element stress analysis	1
4.0	**SCALING LAWS IN MINIATURIZATION**	
4.1	Introduction to scaling	1
4.2	Scaling in geometry	1
4.3	Scaling in electrostatic and electromagnetic forces	2
4.4	Scaling in electricity	1
5.0	**MATERIAL FOR MEMS AND MICROSYSTEMS**	
5.1	Introduction – substrates and wafers	1
5.2	Active substrate material	1
5.3	Silicon as substarte material, silicon compounds	2
5.4	Silicon piezoresistors, Gallium arsenide, Quartz	2
5.5	Piezoelectric crystals, polymers, packaging materials	1
6.0	**MICROSYSTEM FABRICATION PROCESSES**	
6.1	Introduction – photolithography	1

6.2	Ion implantation, diffusion	1
6.3	Oxidation, chemical vapor deposition	1
6.4	Physical vapor deposition, sputtering	1
6.5	Deposition by epitaxy, etching	1
7.0.	**MICROSYSTEM DESIGN & MICROSYSTEM PACKAGING**	
7.1	Design considerations	2
7.2	Process design, mechanical design	2
7.3	Design of a silicon die for a micropressure sensor, CAD	2
7.4	Mechanical packaging of microelectronics	1
7.5	Microsystem packaging	2
	Total	45

Syllabus

OVERVIEW OF MEMS AND MICROSYSTEMS
MEMS and Microsystems - Typical MEMS and Microsystem products – Evolution of microfabrication- Microsystems and Microelectronics – Application of Microsystems in automotive and other industries.

WORKING PRINCIPLES OF MICROSYSTEMS – Microsensors – Microactuation-MEMS with microactuators-Microaccelerometers- Microfluidics

ENGINEERING MECHANICS FOR MICROSYSTEMS DESIGN –Static bending of thin plates-Mechanical vibration-Thermomechanics – Thin film mechanics – overview of finite element stress analysis

SCALING LAWS IN MINIATURIZATION - Introduction to scaling – scaling in geometry – scaling in electrostatic and electromagnetic forces – scaling in electricity

MATERIAL FOR MEMS AND MICROSYSTEMS – Introduction – substrates and wafers – active substrate material – silicon as substarte material - silicon compounds – silicon piezoresistors – Gallium arsenide – Quartz – piezoelectric crystals – polymers –packaging materials

MICROSYSTEM FABRICATION PROCESSES – Introduction – photolithography – ion implantation – diffusion – oxidation – chemical vapor deposition – physical vapor deposition – sputtering – deposition by epitaxy –etching

MICROSYSTEM DESIGN – Design considerations – process design – mechanical design – design of a silicon die for a micropressure sensor, CAD

MICROSYSTEM PACKAGING – Overview of mechanical packaging of microelectronics – Microsystem packaging

Reference Books

1. Tai –Ran Hsu, MEMS & MICROSYSTEMS Design and manufacture, TATA McGraw Hill, 2002
2. Thomas M.Adams, Richard A.Layton, Introductory MEMS –fabrication and applications, springer, 2010.
3. Mohamed Gad-El-Hak, MEMS: Design and fabrication, CRC/Taylor & Francis, 2006.

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CNEL	**3**	**1**	**0**	**4**

CNEL Multi Sensor Data Fusion 3:1

Preamble

Multi Sensor data fusion is a subset of information fusion and is generally defined as the use of techniques that combine data from multiple sources and gather that information into discrete, actionable items in order to achieve inferences, which will be more efficient and narrowly tailored than if they were achieved by means of disparate sources. In this course reference has been made about the algorithms for data fusion and estimation and advanced filtering of signals from sensors. It also includes designing of optimal sensor systems.The proposed course is offered as an elective. The subject requires the fundamental knowledge of sensors, control theory, digital signal processing and mathematical knowledge of probability theory, statistical estimation and linear algebra.

Competencies

At the end of the course the students will be able to:

1. Understand the various algorithms for data fusion
2. Estimate and filter the data from multi sensors
3. Design optimal sensor systems

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	40	20	20
2	Understand	60	40	40
3	Apply	0	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. Name the sensors available for data fusion.
2. Specify the different forms of output from sensor.
3. Mention the data fusion models.
4. Exemplify data sensor fusion with suitable applications.
5. List the benefits of data fusion.
6. State the limitations of data fusion.

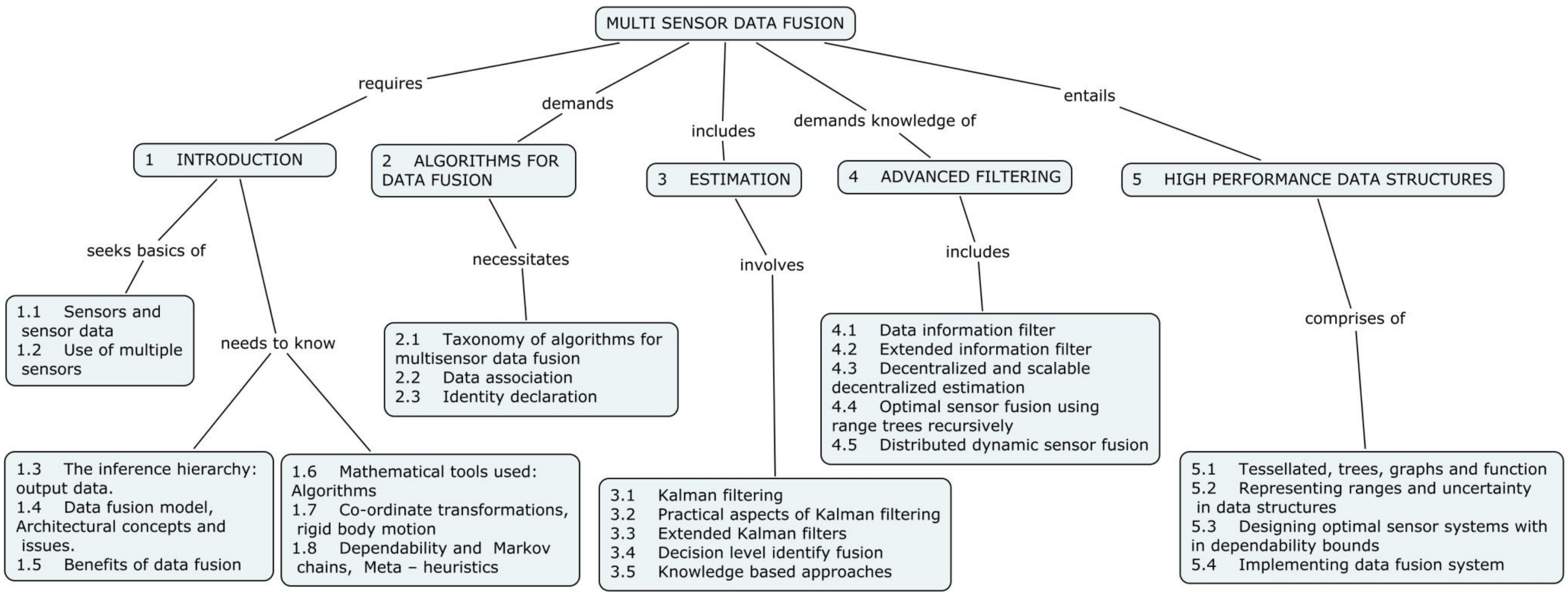
Understand

1. Compare the algorithms for data fusion.
2. Explain how kalman filter is used for estimation.
3. What are the practical aspects of kalman filtering?
4. Compare the knowledge based approaches for estimation.
5. Elaborate on the advanced filtering techniques for multi sensor data fusion.
6. Explain decision level identity fusion.

Apply

1. Design an extended kalman filter for estimation.
2. With suitable figures, elaborate the process of implementing data fusion systems.
3. Design optimal sensor system for a robot.
4. How uncertainity analysis can be applied to determine the error in inference during data fusion with multiple sensors.

Concept map


MULTI SENSOR DATA FUSION
requires
demands
includes
demands knowledge of
entails
1 INTRODUCTION
2 ALGORITHMS FOR DATA FUSION
3 ESTIMATION
4 ADVANCED FILTERING
5 HIGH PERFORMANCE DATA STRUCTURES
seeks basics of
needs to know
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comprises of
1.1 Sensors and sensor data
1.2 Use of multiple sensors
1.3 The inference hierarchy: output data.
1.4 Data fusion model, Architectural concepts and issues.
1.5 Benefits of data fusion
1.6 Mathematical tools used: Algorithms
1.7 Co-ordinate transformations, rigid body motion
1.8 Dependability and Markov chains, Meta – heuristics
2.1 Taxonomy of algorithms for multisensor data fusion
2.2 Data association
2.3 Identity declaration
3.1 Kalman filtering
3.2 Practical aspects of Kalman filtering
3.3 Extended Kalman filters
3.4 Decision level identify fusion
3.5 Knowledge based approaches
4.1 Data information filter
4.2 Extended information filter
4.3 Decentralized and scalable decentralized estimation
4.4 Optimal sensor fusion using range trees recursively
4.5 Distributed dynamic sensor fusion
5.1 Tessellated, trees, graphs and function
5.2 Representing ranges and uncertainty in data structures
5.3 Designing optimal sensor systems with in dependability bounds
5.4 Implementing data fusion system

Course Contents and Lecture schedule

No.	Topic	No. of Lectures
1	**INTRODUCTION**	
1.1	Sensors and sensor data	1
1.2	Use of multiple sensors, Fusion applications.	1
1.3	The inference hierarchy: output data.	1
1.4	Data fusion model, Architectural concepts and issues.	1
1.5	Benefits of data fusion	1
1.6	Mathematical tools used: Algorithms	1
1.7	Co-ordinate transformations, rigid body motion	1
1.8	Dependability and Markov chains, Meta – heuristics	1
2	**ALGORITHMS FOR DATA FUSION**	
2.1	Taxonomy of algorithms for multi sensor data fusion	4
2.2	Data association	2
2.3	Identity declaration	2
3	**ESTIMATION**	
3.1	Kalman filtering	2
3.2	Practical aspects of Kalman filtering	1
3.3	Extended Kalman filters	1
3.4	Decision level identify fusion	1
3.5	Knowledge based approaches	3
4	**ADVANCED FILTERING**	
4.1	Data information filter	1
4.2	Extended information filter	1
4.3	Decentralized and scalable decentralized estimation	2
4.4	Optimal sensor fusion using range trees recursively	3
4.5	Distributed dynamic sensor fusion	1
5	**HIGH PERFORMANCE DATA STRUCTURES**	
5.1	Tessellated, trees, graphs and function	2
5.2	Representing ranges and uncertainty in data structures	1
5.3	Designing optimal sensor systems with in dependability bounds	3
5.4	Implementing data fusion system	2
	Total	40

Syllabus

INTRODUCTION

Sensors and sensor data, Use of multiple sensors, Fusion applications. The inference hierarchy: output data. Data fusion model. Architectural concepts and issues. Benefits of data fusion, Mathematical tools used: Algorithms, co-ordinate transformations, rigid body motion. Dependability and Markov chains, Meta – heuristics.

ALGORITHMS FOR DATA FUSION

Taxonomy of algorithms for multisensor data fusion. Data association. Identity declaration.

ESTIMATION

Kalman filtering, practical aspects of Kalman filtering, extended Kalmal filters. Decision level identify fusion. Knowledge based approaches.

ADVANCED FILTERING

Data information filter, extended information filter. Decentralized and scalable decentralized estimation. Sensor fusion and approximate agreement. Optimal sensor fusion using range trees recursively. Distributed dynamic sensor fusion.

HIGH PERFORMANCE DATA STRUCTURES

Tessellated, trees, graphs and function. Representing ranges and uncertainty in data structures. Designing optimal sensor systems with in dependability bounds. Implementing data fusion system.

Reference Books

1. David L. Hall, Mathematical techniques in Multisensor data fusion, Artech House, Boston, 1992.
2. R.R. Brooks and S.S. Iyengar, Multisensor Fusion: Fundamentals and Applications with Software, Prentice Hall Inc., New Jersey, 1998.
3. Arthur Gelb, Applied Optimal Estimation, The M.I.T. Press, 1982.
4. James V. Candy, Signal Processing: The Model Based Approach, McGraw –Hill Book Company, 1987.

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Sub code	Lectures	Tutorial	Practical	Credit
CNEP / KES	**3**	**1**	**0**	**4**

CNEP / KES Real Time Operating System **3:1**
(Common to M.E. Power System Engineering)

Preamble

Real-time systems are complex embedded systems that operate with real time constraints. Examples of real-time systems include automotive electronics, air traffic control, nuclear power plants, telecommunications, and robotics. Real time systems use a real time operating system (RTOS) that determines which applications should run in what order and how much time should be allowed for each application before giving processor access to another process. The functions of the RTOS are to manage the sharing of internal memory among multiple tasks, to handle input and output to and from attached hardware devices such as serial ports, buses, and I/O device controllers and to send messages about the status of operation and any errors that may have occurred.

Competencies

At the end of the course the student will be able to:

1. Make use of different program models for embedded system programming
2. Explain interprocess communication and synchronization in embedded system
3. Understand the OS services, file, I/O and memory management, interrupt handling and scheduling mechanism in RTOS
4. Explain the RTOS Programming concepts
5. Design an Embedded System by programming using RTOS µCOS-II

Assessment pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	20	20	20
2	Understand	40	40	40
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. What is the role of RAM in an embedded system?
2. What are the different steps in the design process an embedded system?
3. Define critical section of a task?
4. What is the advantage and disadvantage of disabling interrupts during running of a critical section of a process?
5. Write the operation done when the function OSSemPend ( ) is executed.
6. How is an anonymous object denoted in UML?

Understand

1. Explain the different hardware components in embedded system.

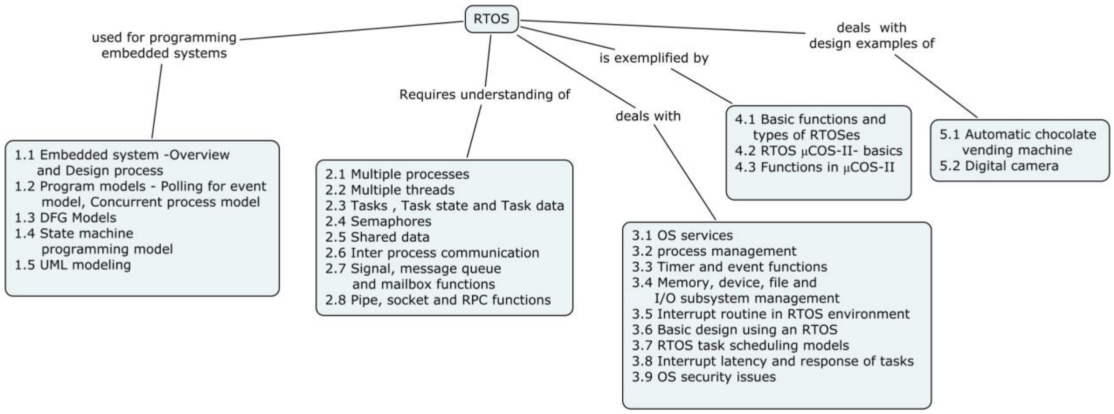
2. Explain the DFG model of programming with an example.

3. Why RTOS is required in an embedded system?
4. Why polled waiting loop method is not preferred in many applications?
5. How semaphore is used to execute critical section of a task in a multitasking system?
6. Describe any three task related functions in μCOS-II.

Apply

1. Show how the timer functions can be applied
   a) to reduce the light level in a mobile phone with full brightness
   b) to switch off the LCD display in a mobile phone after 15 seconds from the time it was switched on.
2. Draw an FSM model of an automatic chocolate-vending machine program. The machine permits only one type of coin, Rs. 1, one chocolate at a time and one chocolate cost is Rs. 8.
3. Illustrate the class diagram and state diagram for the automatic chocolate vending machine.
4. How will you create and display SMS message in T9 keypad of a mobile phone? Use the states, FSM model and state tables for all keys 0, 1 to 9 with T9 keypad. Use suitable templates.
5. Write exemplary codes for using the μCOS-II functions for time delay and semaphore.
6. How will you create, remove, open, close a device by applying RTOS functions? Take an example of a pipe delivering an I/O stream from a network device.

Concept Map



Course contents and Lecture Schedule

S.No.	Topics	No. of Lectures
1.	**Introduction and Programming of Embedded systems**	
1.1	Embedded system – Overview and Design process	1
1.2	Program modeling concepts- Polling for events model, concurrent process model	1
1.3	DFG models	2
1.4	State machine programming model	2
1.5	UML modeling	2
2.	**Interprocess communication and synchronization**	
2.1	Multiple processes	1
2.2	Multiple threads	1
2.3	Tasks, Task state and Task data	1
2.4	Semaphores	2
2.5	Shared data	2
2.6	Interprocess communication	2
2.7	Signal, message queue and mailbox functions	1
2.8	Pipe, socket and RPC functions	2
3	**Real time operating systems**	
3.1	OS services	1
3.2	Process management	1
3.3	Timer and event functions	2
3.4	Memory, device, file and I/O subsystem management	2
3.5	Interrupt routine in RTOS environment	2
3.6	Basic design using an RTOS	2
3.7	RTOS task scheduling models	2
3.8	Interrupt latency and response of tasks	2
3.9	OS security issues	1
4	**RTOS programming**	
4.1	Basic functions and types of RTOS	1
4.2	RTOS µCOS-II- basics	1

4.3	Functions in µCOS-II	3
5	**Design examples with µCOS-II**	
5.1	Automatic chocolate vending machine	3
5.2	Digital Camera	2
	Total	**45**

Syllabus

Introduction and Programming of embedded systems
Embedded system – Overview and Design process- Program modeling concepts- Polling for events model – Concurrent process model- DFG models – State machine programming model - UML modeling

Interprocess communication and synchronization

Multiple processes - Multiple threads – Tasks, Task state and Task data – Semaphores – Shared data – Interprocess communication – Signal, message queue and mailbox functions – Pipe, socket and RPC functions.

Real time operating systems

OS services- process management – Timer and event functions – Memory, device, file and I/O subsystem management, Interrupt routine in RTOS environment – Basic design using an RTOS – RTOS task scheduling models-Interrupt latency and response of tasks – OS security issues.

RTOS programming

Basic functions and types of RTOSes – RTOS µCOS-II- basics - Functions in µCOS-II

Design examples with µCOS-II

Automatic chocolate vending machine - Digital Camera

Reference Books

1. Raj Kamal, "Embedded Systems- Architecture, Programming and Design" Second edition , Tata McGraw Hill, 2008.
2. David E.Simon, "An Embedded Software Primer", Pearson Education, 2006
3. C.M. Krishna, Kang, G.Shin, "Real Time Systems", McGraw Hill, 1997.
4. Phillip A. Laplante, Real Time Systems Design and Analysis, An Engineer's Handbook, Second Edition, PHI India, 1997.

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CNEQ	**3**	**1**	**-**	**4**

CNEQ Nonlinear Control 3:1

Preamble

Physical systems are inherently non linear. So non-linear control systems have gained importance in many industrial areas and research has undergone significant developments recently. Nonlinear control theory studies how to apply existing linear methods to these more general nonlinear control systems. Additionally, it provides novel control methods that cannot be analyzed using LTI system theory. This course aims at giving an adequate exposure in perturbation theory, singular perturbations, gain scheduling and feedback linearization, sliding mode and backstepping control.

Competencies

At the end of the course the student will be able to:

1. Explain perturbation theory and its methods to non linear systems.
2. Analyze non linear system using singular perturbation method.
3. Apply gain scheduling approach to control non-linear systems for different operating points.
4. Transform nonlinear system into an equivalent linear system using feedback linearization.
5. Apply sliding mode control for altering dynamics of nonlinear system.
6. Design stabilizing control for a special class of nonlinear systems using back stepping control.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	20	20	20
2	Understand	20	20	20
3	Apply	60	60	60
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. What is meant by perturbation?
2. What is meant by non vanishing perturbations?
3. What are the time scale properties?

4. What is meant input/output linearization?
5. Define sliding mode control.
6. Nme the different methods of gain scheduling.

Understand

1. Explain standard singular perturbation model?
2. Explain the need for gain scheduling
3. Explain the method of achieving full state linearization?
4. What is the role of high gain observer?
5. Explain the basic mechanism of back stepping control?
6. Describe the regulation via integral control.

Apply

1. Consider the second-order system $\overset{\circ}{X}_1 = X_2$, $\overset{\circ}{X}_2 = \Psi(X_1, X_2) + u$ where Ψ is an unknown function that satisfies $|\Psi(X_1, X_2)| < X_1^2 + X_2^2$ for all *X*.

   (a) Design a state feedback, continuous, sliding mode control to globally stabilize the origin.

   (b) Estimate how small ε should be to ensure asymptotic stability of the origin.

2. Consider the second-order system $\overset{\circ}{X}_1 = X_1 + \frac{X_2}{1+X_1^2}$, $\overset{\circ}{X}_2 = -X_2 + u$ Using backstepping, design a globally stabilizing state feedback control law.

3. Consider the second-order system $\overset{\circ}{X}_1 = -X_1 - X_2 + \psi(X_2)$, $\overset{\circ}{X}_2 = X_1 + \psi(X_2) + u$, $y = X_2$ where *Ψ* is a continuously differentiable function such that $\Psi(0)=0$, $\Psi'(0)=1$, and $0 < \Psi'(x_2) < 1$ for all $x_2 \neq 0$.

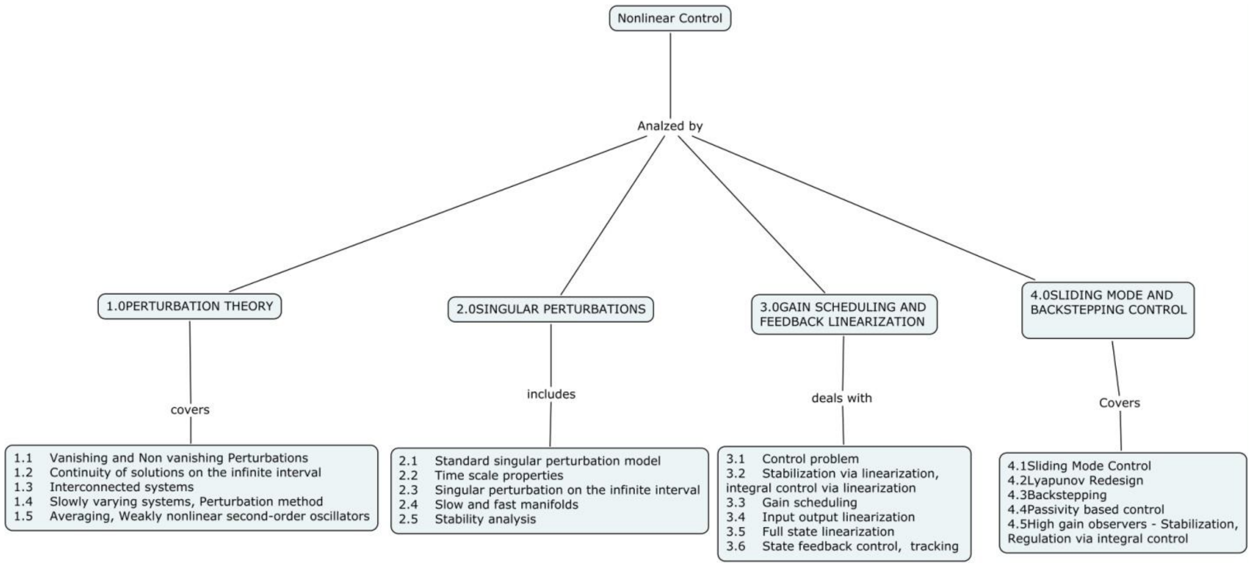
   (a) Is the system input-output linearizable?

   (b) Is it minimum phase?

   (c) Is it feedback linearizable?

4. Consider the first-order system $\acute{y} = u - k_1 - k_2 y - k_3 y^2$ where k_1, k_2, and k_3 are positive constants. Using linearization, design a feedback control law to (locally) stabilize the system at $y = y_{ss} > 0$.

Concept Map



Course contents and Lecture schedule

Sl.No.	Topic	No. of Lectures
1.0	**PERTURBATION THEORY**	**10**
1.1	Vanishing and Non vanishing Perturbations	2
1.2	Continuity of solutions on the infinite interval	1
1.3	Interconnected systems	2
1.4	Slowly varying systems, Perturbation method	2
1.5	Averaging, Weakly nonlinear second-order oscillators,	2
1.6	Exercises	1
2.0	**SINGULAR PERTURBATIONS**	**10**
2.1	Standard singular perturbation model	2
2.2	Time scale properties	2
2.3	Singular perturbation on the infinite interval	1
2.4	Slow and fast manifolds	1
2.5	Stability analysis	2
2.6	Exercises	2
3.0	**GAIN SCHEDULING AND FEEDBACK LINEARIZATION**	**10**
3.1	Control problem	1
3.2	Stabilization via linearization, integral control via linearization	2
3.3	Gain scheduling	2
3.4	Input output linearization	2
3.5	Full state linearization	1
3.6	State feedback control, tracking	1
3.7	Exercises	1

4.0	**SLIDING MODE AND BACKSTEPPING CONTROL**	**10**
4.1	Sliding Mode Control	2
4.2	Lyapunov Redesign	1
4.3	Backstepping	2
4.4	Passivity based control	1
4.5	High gain observers - Stabilization, Regulation via integral control	2
4.6	Exercises	2
	Total	40

Syllabus

PERTURBATION THEORY

Vanishing and Non vanishing Perturbations – Continuity of solutions on the infinite interval – Interconnected systems – Slowly varying systems – Perturbation method – Averaging - Weakly nonlinear second-order oscillators – Exercises

SINGULAR PERTURBATIONS

Standard singular perturbation model – Time scale properties – Singular perturbation on the infinite interval – Slow and fast manifolds – stability analysis – exercises

GAIN SCHEDULING AND FEEDBACK LINEARIZATION

Control problem – stabilization via linearization – integral control via linearization – gain scheduling – Input output linearization – Full state linearization – state feedback control – tracking- exercises

SLIDING MODE AND BACKSTEPPING CONTROL

Sliding Mode Control - Lyapunov Redesign - Backstepping - Passivity based control – High gain observers – stabilization – Regulation via integral control - exercises

Reference Books

1. Hasan Khalil," Nonlinear systems and control", 3rd edition, Prentice Hall of India Publisher, 2002.
2. Slotine, J A E Slotine and W Li, "Applied Nonlinear control", 1st edition Prentice Hall of India Publisher, 1991.
3. S.H. Zak," Systems and control", 1st edition, Oxford University Press 2003

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
CNER	**3**	**1**	**0**	**4**

CNER Image Processing and Computer Vision 3:1

Preamble

During the last four decades image processing has grown from a dedicated scientific research field limited to a small set of researchers to technical area that has found use in many scientific and commercial applications. Image processing and computer vision focuses on improvement of pictorial information for human interpretation and Processing of image data for storage, transmission and representation for autonomous machine perception. This course helps the students for a comprehensive understanding of algorithms to perform specific image processing tasks.

Competencies

At the end of the course, the student will be able to:

1. Understand the Image enhancement and restoration process.
2. Apply the Image enhancement and restoration techniques.
3. Understand the Image compression and morphological process.
4. Apply the Image compression and morphological techniques.
5. Describe the various segmentation methods.
6. Explains the object recognition methods
7. Understand the basics concept of Texture analysis

Assessment pattern

	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	20	20	20
2	Understand	40	40	40
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning Objectives

Remember

1. Define the property of energy compaction of a unitary transform
2. Define data redundancy.
3. Differentiate Image Enhancement and image Restoration.

4. Define Gaussian noise.
5. Define image Segmentation and need of segmentation.
6. Give the Conditions for perfect transform?

Understand

1. Discuss about different types basic gray level transformation employed in image enhancement.
2. Explain about 2 D DFT and discuss about its properties.
3. With an example explain Huffman Coding technique in image compression
4. Explain the role of various histogram processing methods in image enhancement.
5. Discuss basic steps for filtering in the frequency domain.
6. Explain and compare Weiner filter and inverse filter.

Apply

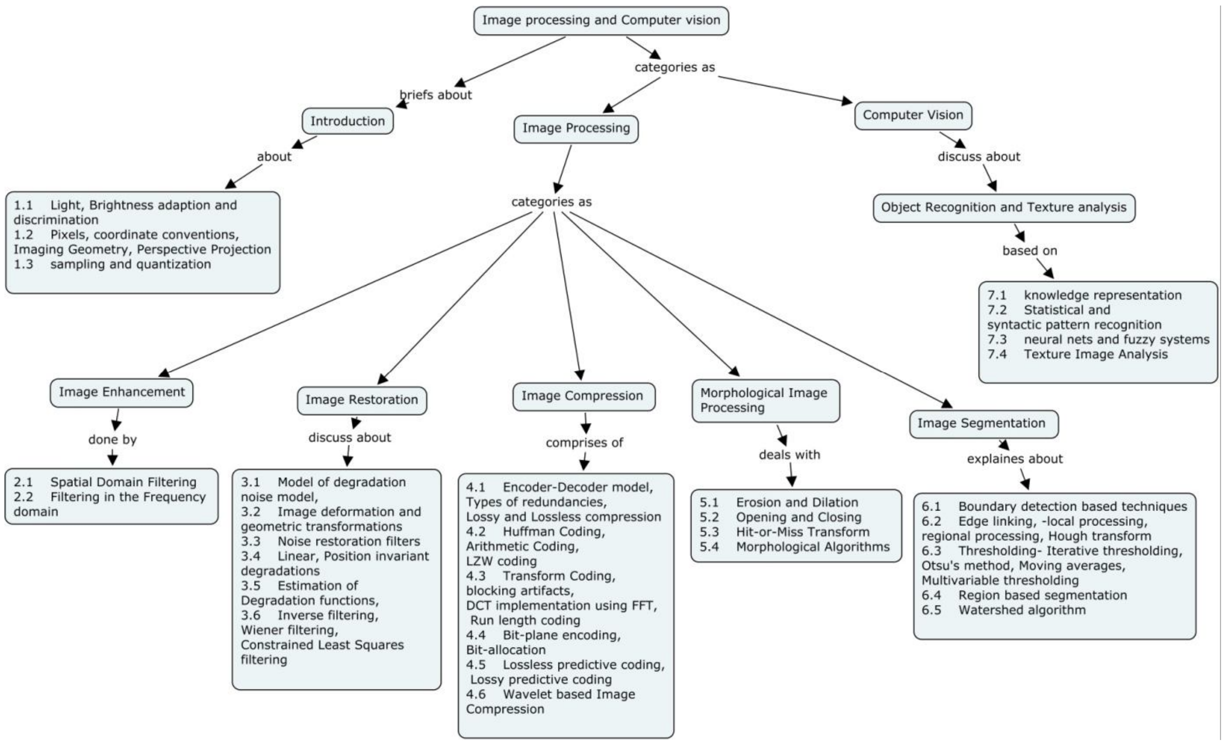
1. Compute Discrete Cosine Transform for given 3x3 image.

$$A = \begin{bmatrix} 1 & 1 & -2 \\ 1 & 0 & 2 \\ 1 & -1 & 3 \end{bmatrix}$$

2. Find the number of bits to store a 128X128 image with 64 gray levels.
3. For the symbols a, b, c, d, e, f the respective probabilities are p(a)=0.1, p(b)=0.4, p(c)=0.06, p(d)=0.1, p(e)=0.04, p(f)=0.3. Find the average length of the code and the Huffman code efficiency.
4. An image described by the function $f(x, y) = 2\cos 2\pi(3x+4y)$ is sampled such that $\Delta x = \Delta y = 0.2$. Find the reconstructed image if the sampled image is low pass filtered with a filter having rectangular region of support with cutoff frequencies at half the sampling frequencies.
5. For the 2×2 transform A and the image U calculate the transformed image V and the basis images.

$$A = \frac{1}{\sqrt{3}}\begin{vmatrix} \sqrt{2} & 1 \\ -1 & \sqrt{2} \end{vmatrix} \quad U = \begin{bmatrix} 2 & 3 \\ 1 & 3 \end{bmatrix}$$

Concept Map



Course content and Lecture Schedule

S.No.	Topics	No of lectures
1	**Introduction**	
1.1	Light, Brightness adaption and discrimination	1
1.2	Pixels, coordinate conventions, Imaging Geometry, Perspective Projection	1
1.3	sampling and quantization	1
2	**Image Enhancement**	
2.1	Spatial Domain Filtering	
2.1.1	Intensity transformations, contrast stretching, Arithmetic/Logic Operations	1
2.1.2	Histogram processing	1
2.1.3	Smoothing filters, sharpening filters	1
2.1.4	gradient and Laplacian	1
2.2	Filtering in the Frequency domain	
2.2.1	Discrete Fourier Transforms and properties	1
2.2.2	FFT (Decimation in Frequency and Decimation in Time Techniques), Convolution, Correlation	1
2.2.3	Discrete Cosine Transform, KL Transform	1
2.2.4	Smoothing Frequency Domain Filters	1
2.2.5	Sharpening Frequency Domain Filters	1

2.2.5	Homomorphic Filtering.	1
3	**Image Restoration**	
3.1	Model of degradation/restoration process, noise model,	1
3.2	Image deformation and geometric transformations	1
3.3	Noise restoration filters- mean filters, Adaptive filters	1
3.4	Linear, Position invariant degradations	1
3.5	Estimation of Degradation functions,	1
3.6	Inverse filtering, Wiener filtering, Constrained Least Squares filtering	1
3.7	Case study- Night Vision image Enhancement and filtering	1
4	**Image Compression**	
4.1	Encoder-Decoder model, Types of redundancies, Lossy and Lossless compression	1
4.2	Huffman Coding, Arithmetic Coding, LZW coding	1
4.3	Transform Coding, blocking artifacts, DCT implementation using FFT, Run length coding	1
4.4	Bit-plane encoding, Bit-allocation	1
4.5	Lossless predictive coding, Lossy predictive coding	1
4.6	Wavelet based Image Compression	
4.6.1	Expansion of functions, Multi-resolution analysis	1
4.6.2	Scaling functions, Wavelet series expansion	1
4.6.3	Discrete Wavelet Transform (DWT), Fast Wavelet Transform, 2-D wavelet Transform	1
4.6.4	Digital Image Watermarking.	1
4.7	Case study – Photograph image compression	1
5	**Morphological Image Processing**	
5.1	Erosion and Dilation	1
5.2	Opening and Closing	1
5.3	Hit-or-Miss Transform	1
5.4	**Morphological Algorithms –** Boundary Detection, Hole filling, Connected components, convex hull, thinning, thickening, skeletons, pruning	1
6	**Image Segmentation**	
6.1	Boundary detection based techniques- Point, line detection, Edge detection	1
6.2	Edge linking, -local processing, regional processing, Hough transform	1
6.3	Thresholding- Iterative thresholding, Otsu's method, Moving averages, Multivariable thresholding	1
6.4	Region based segmentation	1
6.5	Watershed algorithm	1
7	**Object Recognition and Texture analysis**	
7.1	knowledge representation	1
7.2	Statistical and syntactic pattern recognition	1
7.3	neural nets and fuzzy systems	1
7.4	Texture Image Analysis	
7.4.1	Co-occurrence matrices	1
7.4.2	Fractal texture description.	1
7.5	Case study- Medical image segmentation and classification	1
	Total	45

Syllabus

Introduction

Light, Brightness adaption and discrimination, Pixels, coordinate conventions, Imaging Geometry, Perspective Projection, sampling and quantization.

Image Enhancement

Spatial Domain Filtering- Intensity transformations, contrast stretching, histogram processing, Arithmetic/Logic Operations, Smoothing filters, sharpening filters, gradient and Laplacian. Filtering in the Frequency domain - Discrete Fourier Transforms and properties, FFT (Decimation in Frequency and Decimation in Time Techniques), Convolution, Correlation, Discrete Cosine Transform, KL Transform, Smoothing Frequency Domain Filters, Sharpening Frequency Domain Filters, Homomorphic Filtering.

Image Restoration

Model of degradation/restoration process, noise model, Image deformation and geometric transformations, Noise restoration filters-mean filters, Adaptive filters, Linear, Position invariant degradations, Estimation of Degradation functions, Inverse filtering, Wiener filtering, Constrained Least Squares filtering, Case study- Night Vision image Enhancement and filtering.

Image Compression

Encoder-Decoder model, Types of redundancies, Lossy and Lossless compression, Huffman Coding, Arithmetic Coding, LZW coding, Transform Coding, blocking artifacts, DCT implementation using FFT, Run length coding, Bit-plane encoding, Bit-allocation, Lossless predictive coding, Lossy predictive coding. Wavelet based Image Compression- Expansion of functions, Multi-resolution analysis, Scaling functions, Wavelet series expansion, Discrete Wavelet Transform (DWT), Fast Wavelet Transform, 2-D wavelet Transform, Digital Image Watermarking, Case study – Photograph image compression.

Morphological Image Processing

Erosion and Dilation, Opening and Closing, Hit-or-Miss Transform, Morphological Algorithms - Boundary Detection, Hole filling, Connected components, convex hull, thinning, thickening, skeletons, pruning.

Image Segmentation

Boundary detection based techniques- Point, line detection, Edge detection, Edge linking, -local processing, regional processing, Hough transform, Thresholding, Iterative thresholding, Otsu's method, Moving averages, Multivariable thresholding, Region based segmentation, Watershed algorithm, Case study- Medical image segmentation and classification.

Object Recognition and Texture analysis

Knowledge representation, Statistical and syntactic pattern recognition, neural nets and fuzzy systems, Texture Image Analysis-Co-occurrence matrices, Fractal texture description.

Reference Books

1. Rafael C Gonzalez and Richard E Woods, "Digital Image Processing", Pearson Education, 3rd Edition,2009
2. Milan Sonka, Vaclav Hlavac and Roger Boyle, "Image Processing, Analysis and Machine Vision", Vikas Publishing House, 2nd edition, 2010
3. Anil K Jain, "Fundamentals of Digital Image Processing" PHI Learning Private Limited, 2010.

Course designers

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