COURSE INFORMATION SHEET

Course code: EE501
Course title: Advanced Digital Signal Processing
Pre-requisite(s): Basics of signals and systems, transform methods, Filter theory.
Credits: 3 L T P
3 0 0
Class schedule per week: 3 Lectures
Class: M.Tech
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

A.	Enumerate the basic concepts of signals and systems, frequency response of discrete-time systems using various techniques like Z-transform, Hilbert transform, DFT, FFT;
B.	Apply digital IIR and FIR filters applying different techniques and finally construct using different realisation structures.
C.	Illustration of the concept of Decimation and Interpolation, Sampling rate conversion by a rational factor, Multi stage implementation of sampling rate conversion.
D.	Development of adaptive filter and its application. adaptive linear combiner (ALC), Signal processing applications in the area of speech and image, Adaptive signal processing applications to biomedical engineering.
E.	Apply DSP processor in processing of 1D and 2D signals.

Course Outcomes:
At the end of the course, a student should be able to:

1.	State sampling theorem and reproduce a discrete-time signal from an analog signal; frequency response of discrete-time systems by applying Z-transform, understand the basic of Hilbert transform, DFT, FFT algorithms, STFT for spectral analysis.
2.	Apply FIR filters using filter approximation theory, frequency transformation techniques, window techniques and finally construct different realisation structures. Realization of IIR filters.
3.	Illustrate the concept of Decimation and Interpolation, Multi stage implementation of sampling rate conversion.
4.	Development of adaptive filter and its in the area of speech and image, Adaptive signal processing applications to biomedical engineering.
5.	Construct (structure) and recommend environment-friendly filter for real- time applications. Design FIR and IIR filters used as electronic filter, digital filter, mechanical filter, distributed element filter, waveguide filter, crystal filter, optical filter, acoustic filter, etc. Application of DSP processor.

EE501 Advanced Digital Signal Processing

Module 1: Introduction: (8L)

Review of the basic digital and analog signal processing, Overview of discrete time signal and systems, ADC and DAC conversion, Time domain analysis of discrete-time linear time invariant systems, Analysis and characterization of LTI systems using Z-transform, Frequency domain analysis of signals using DFT and FFT algorithm. Hilbert transform, Spectral analysis using DFT, Short term DFT.

Module 2: Filter function approximation, IIR and FIR filter design and implementation:(8L)

Review of approximation of ideal analog filter response. Buttorworth, Chebyshev type I & II, Digital filter structures: Direct form I & II, Cascade, Parallel and ladder realization. IIR filter designs based on impulse invariant and Bilinear transformation.Characteristic of FIR, Symmetric and antisymmetric FIR filters, design of linear phase FIR filters using windows and frequency sampling methods, comparison of FIR and IIR filters.

Module 3: Multirate signal processing: . *(8L)*

Decimation: Time domain characterization, frequency domain characterization, Interpolation, Sampling rate conversion by a rational factor, Multi stage implementation of sampling rate conversion

Module 4: Adaptive Filter: . *(8L)*

Introduction to adaptive filter, adaptive linear combiner (ALC), Signal processing applications in the area of speech and image, Adaptive signal processing applications to biomedical engineering

Module 5: DSP Processor and applications (8L)

Introduction to DSP processor, Types of architectures, DSP support tools, code composer studio, compiler, assembler and linker, Introduction TMS320 C6x architecture, functionalunits, fetch and execute packets, pipe lining, registers, linear and circular addressing modes. Convolution, DFT, FFT implementation using DSP processor

Books Recommended:

Text Book

1. John G. Proakis, Dimitris G. Mamalakis, Digital Signal Processing, Principles, Algorithms and Applications.
2. Alan V. Oppenheim Ronald W. Schafer, Digital Signal Processing, PHI, India.

Reference Book

1. Antonious, Digital Filter Design, Mc-Graw-Hill International Editions.
2. S. Salivahanan C Gnanapriya, Digital Signal Processing, Tata McGraw Hill Education Private Limited.

3. A. NagoorKani, Digital Signal Processing, McGraw Hill Education Private Limited.

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATIONPROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Quizzes (3)	3x10 = 30
Seminar	10
Teacher's Assessment	10
Semester EndExamination	50

INDIRECT ASSESSMENT –

1. Students' Feedback on Course Outcome

MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	1	1	1
CO2	1	1	3	1	1	1
CO3	1	1	2	3	2	1
CO4	1	1	1	3	3	3
CO5	1	2	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Gaps in the syllabus (to meet Industry/Profession requirements):

1. Visualize different signal processing techniques in real time.
2. Application of real time implementation of digital filter

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced

topics/Design:Course Delivery Methods

CD	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Industrial visits/in-plant training
CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Mapping Between COs and Course Delivery (CD) methods	
Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3,CD5
CO2	CD1, CD2, CD3,CD5
CO3	CD1, CD2, CD3,CD5
CO4	CD1, CD2, CD3, CD5
CO5	CD1, CD2, CD3,CD5

COURSE INFORMATION SHEET

Course title: ADVANCED POWER ELECTRONICS

Course code : EE507

Pre-requisite(s): Operating Principle of Semiconductor Devices

Credits: 03 L:3 T:0 P: 0 C: 03

Class schedule per week:

03Class: M.Tech.

Semester / Level: I/05

Branch: Electrical Engineering

Course Objectives:

This course enables the students to:

A	Remember classifications of power converters based on different criteria such as soft switching/ hard switching and isolated/non-isolated configuration etc.
B	Explain the working principle of different class of power converters and relate them with different area of application
C	Analyse shortcomings of different types of power converters.
D	Evaluate cost of power converter based topology terms of dynamic parameters of system, overall efficiency and cost.
E	Design power converter based topologies for energy management.

Course Outcomes:

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

CO1	List different types of semiconductor devices and remember their operating characteristics. Explain the working principle of different semiconductor devices.
CO2	Classify different types of power converters. Show suitability of a power converter for a particular application. Solve power management related problems with application of power electronics based topologies.
CO3	Outline shortcomings of each class of power converters and solve those using proper modifications. Identify potential areas for power electronics applications.
CO4	Estimate the cost and long term impact of power electronics technology on a large scale project of socio-economic importance.
CO5	Design new power converter topologies and Plan to develop a power processing unit for a particular requirement in industrial plants as well as domestic applications.

Syllabus

Module I :

Power Electronic Devices: Review of switching devices-operating principle, Static & dynamic characteristics, Datasheet ratings; Thermal characteristics of power devices; Sample Gate Driver circuit. [8L]

Module II:

Switched Mode Power Supply:

Forward and flyback converter circuits: operation of flyback converter and waveforms analysis, operation of forward converter and waveforms analysis, Double ended forward converter, Push Pull converter, Half Bridge isolated converter, Full bridge isolated converter, Bidirectional powersupplies , small signal analysis of DC-DC converters and closed loop control.

[8L]

Module III:

PWM inverter modulation strategies & dual bridge: Sine wave with third harmonic, space vector modulation and predictive current control techniques; PWM rectifier; Input side bidirectional power flow requirement for regeneration & Dual Thyristor Bridge. Multi- level inverter : Basic topology and waveform, Diode clamped multilevel inverter, Flying capacitor multilevel inverter, cascaded multilevel inverter improvement in harmonics and high voltage application, comparison of different multilevel inverters, application of multilevel inverters;

[8L]

Module IV:

Resonant Inverters: Operating principle of series resonant inverter, waveforms analysis, switching trajectory, losses and control, Operating principle of series resonant inverter with bidirectional switches, Frequency response of resonant series loaded, parallel loaded, and series parallel- loaded inverter, Parallel resonant inverter, ZCS resonant converter, ZVS resonant converter.

[8L]

Module V:

Introduction to application oriented chips: Industrial PWM driver chips for power supplies suchas UC 3843, 3825 or equivalent; Industrial gate driver chips for PWM voltage source inverters with isolation and protection circuits. Intelligent power modules.

[8L]

Books recommended:

TEXT BOOK

1. M.H. Rashid,"Power Electronics: Circuits, Device and Applications",2nd Ed.n, PHI, NewJersey, 1993
2. Mohan, Underland, Robbins; Power Electronics Converters, Applications and Design, 3rdEdn., 2003, John Wiley & Sons Pte. Ltd.
3. M. D. Singh, K. B. Khanchandani, "Power Electronics", 2nd Edn., Tata McGraw-Hill,2007.

REFERENCE BOOK

1. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control ", 1st Edn., PrenticeHall,2001
2. B. K. Bose, "Modern Power Electronics & AC Drives" , 1st Edn., Prentice Hall, 2001
3. L. Umanand, "Power Electronics: Essentials & Applications", 1st Edn. Wiley India PrivateLimited, 2009
4. Jeremy Rifkin, "Third Industrial Revolution: How Lateral Power is Transforming Energy,the Economy, and the World", 1st Edn., St. Martin‟s, Press, 2011

Course code: EE584

Course title: ENERGY STORAGE SYSTEM AND CONVERSION

Pre-requisite(s): Chemistry & Power Electronics
Credits: 03 L:3 T:0 P: 0 C: 03

Class schedule per week: 03 Class: M.Tech.
Semester / Level: I/05

Branch: Electrical Engineering

Course Objectives:

This course enables the students to:

A	Remember different types energy storage system
B	Explain the working principle of types energy storage system
C	Analyze pros and cons of different types energy storage system.
D	Evaluate cost of power converter based topology terms of dynamic parameters of system, overall efficiency and cost.
E	Design bidirectional energy management system.

Course Outcomes:

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

CO1	List power density and energy density of different storage system
CO2	Solve power management related problems with application energy storage systems.
CO3	Analyze dynamic and steady state requirement of power requirement in order to select a cost effective energy storage system.
CO4	Estimate the cost and long term impact of energy storage technology on socio-economic aspect.
CO5	Design new power converter topologies and Plan to develop a power processing unit for a particular requirement in industrial plants as well as domestic applications.

SYLLABUS

MODULE-I

Introduction to Energy Storage and Conversion: Selected energy storage devices and connect with their electric power applications in electric vehicles, energy requirement of vehicles, power requirement of vehicles, and sizing of energy storage ratings; Overview of energy storage types, Batteries, fuel cells, super capacitors, Hydrogen Energy Storage; Battery Module & Pack Design, BMS Hardware and Software, Thermal Management. Review of the non-isolated DC-DC converter.

[9L]

MODULE-II

Battery Storage System Battery definitions, types and their properties, lithium-ion battery, Battery Requirements- Electrical Requirements, Thermal Requirements, Mechanical Requirements, Components, functions, advantages, and disadvantages of lithium-ion batteries, Growth & development of Li-Ion batteries, charging procedures, Safety of lithium-ion batteries, Lifetime. Types of lithium-ion batteries: Lithium Cobalt Oxide (LCO), Lithium Iron Phosphate Battery (LFP), Lithium Manganese Oxide (LMO), Lithium Nickel Cobalt Aluminum Oxide (LNCA), Lithium Nickel Manganese Cobalt Oxide (LNMC), Lithium Polymer Battery, Comparative Analysis of Energy Density, LifeCycle, Battery parameters, SOC, SOH, DOD, Economic Aspect. Applications of Li-ion battery: Automotive Applications- Drive Cycles, SLI (starting, lighting and ignition) batteries, Start-Stop (Micro) Hybrids, Power Assist Hybrids, Plug-In Hybrids, BEVs.

[9L]

MODULE-III

Fuel Cells: Introduction to fuel cells, components of fuel cells, Types of fuel cells: Alkaline fuel cells, proton exchange membrane fuel cell, phosphoric acid fuel cell, moltencarbonate fuel cell, Working Principle and Application of fuel cells: working principle of the fuel cell, performance characteristics of fuel cells, the efficiency of the fuel cell, fuel cell stack, description of some commercially available fuel cell stacks, fuel cell cars and buses.

[9L]

MODULE-IV

Supercapacitors: Introduction to supercapacitors, equivalent circuit, components in supercapacitor energy storage system, energy efficiency and losses, operating characteristics-Energy density versus power density, storage and regulation ability, mathematical modeling of supercapacitors, few market standards, advantages, and disadvantages, Fly-wheel-based energy storage system. [9L]

MODULE-V

Power electronics for electric vehicle charging; Hybridization of different energy sources; Different topologies of hybrid energy sources; Energy management systems (EMS); Charging infrastructure, types of chargers, standards used for chargers, grid interaction of chargers; Difference between charging station and charging point; Inductivecharging, Flash Charging; Charger protocols, OCPP, V2G, CHADEMO, Bharat Charger; Impact of charging on grid; Renewable energy integration to chargers; Application of IoTto charging infrastructure. [9L]

Text books:

- Lithium-Ion Batteries Basics and Applications by Reiner Korthauer, Springer.
- Lithium-Ion Batteries Science and Technologies by Ralph J. Brodd (auth.), Masaki Yoshio, Ralph J. Brodd, Akiya Kozawa (eds.), Springer.
- Lithium-ion Batteries Fundamentals and Applications. by Wu, Yuping, CRC Press, Taylor, and Francis.
- O'hayre, S.W. Cha, W.G. Colella, F.B. Prinz, Fuel Cell Fundamentals, 3rd edition, Wiley publisher.
- Fuel cells from fundamentals to applications by Subramaniam Srinivasan, Springer.
- Electrochemical Supercapacitors for Energy Storage and Delivery: Fundamentals and Applications by Aiping Yu, Jiujun Zhang, and Victor Chabot.

Reference Books:

- Handbook of lithium-ion battery pack design chemistry, components, types, and terminology by Warner, John T, Elsevier.

- Fundamentals and Application of Lithium-ion Battery Management in Electric Drive Vehicles by San Ping Jiang, Wiley.
- Lithium-ion rechargeable batteries by edited by Kazunori Ozawa, Wiley.
- E. Lipman, A. Z. Weber, Fuel Cells and Hydrogen Production, A Volume in the Encyclopedia of Sustainability Science and Technology, Second Edition, Springer reference.
- Modern electric, hybrid electric, and fuel cell vehicles fundamentals, theory, and designby Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, CRC press.

COURSE INFORMATION SHEET

Course code: EE503

Course title: Modern Control Theory
Pre-requisite(s): B.E./B.Tech. in ECE/EEE with basic courses on Control Theory
Co- requisite(s): Linear Algebra
Credits: 3L T P
3 0 0
Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	state basic concepts of state variables, state diagrams, controllability, observability;
2.	extend comprehensive knowledge of mathematical modelling of physical system;
3.	illustrate basics of transformations and decompositions for controllability and observability tests;
4.	enhance skills with application of different control strategy for designing a control problem;
5.	design controller for any type of linear plants.

Course Outcomes:
At the end of the course, a student should be able to:

CO1	demonstrate an understanding of the building blocks of basic and modern control systems by creating mathematical models of physical systems in input-output ortransfer function form;
CO2	organize state representations to satisfy design requirements using transformations and decompositions;
CO3	examine state space equations for time domain analysis;
CO4	assess a system for its stability, controllability, and observability properties leading to design of controller and observer in a feedback control system;
CO5	aspire for pursuing a carrier in control, recognize the need to learn, to engage and to adapt in a world of constantly changing technology and play role of team leader or supporter of team.

SYLLABUS

EE503 Modern Control Theory

Module I

Background and Preview, Modelling, Highlights of Classical Control Theory; Block diagram, Transfer functions, State Variables and State Space description of dynamic systems, State diagrams, Differential equations to state diagrams, State diagrams to Transfer function, State diagrams to state and output equations, State equations from system's linear graph.

(8L)

Module II

Fundamentals of Matrix Algebra, Vectors and Linear Spaces, Simultaneous Linear Equations, Eigenvalues and Eigenvectors, Functions of Square Matrices, Similarity Transformations, CCF, OCF, DCF and JCF forms, Decomposition of Transfer Functions, The Caley-Hamilton Theorem and it's applications.

(8L)

Module III

Analysis of Continuous and Discrete-Time Linear State Equations, Local linearization of non-linear models, State Transition Matrix, Significance, Properties and Evaluation of STM, Stability analysis using direct method of Lyapunov.

(8L)

Module IV

Controllability and Observability concept for linear Systems, Relationship among Controllability, Observability and Transfer Functions, Invariant theorems on Controllability and Observability.

(8L)

Module V

Design of Linear Feedback Control Systems, pole placement design through state feedback,Design of servo systems, State observers, Design of Regulator Systems with observers, Design of control systems with Observers, Quadratic Optimal Regulator Systems.

(8L)

Books Recommended:

Text Book

1. Modern Control Theory by Brogan, Pearson, 3rd edition. (**T1**)
2. Systems and Control by Zak, 1st edition, Oxford University Press. **(T2)**
3. Modern Control System Theory by M. Gopal, New Age International(P) Ltd., 2nd edition. (**T3**)

4. Automatic Control Systems by F. Golnaraghi and B.C.Kuo, Wiley Student Edition, 9th edition. (**T4**)
5. Modern Control Engineering by K. Ogata, Pearson, 5th edition (**T5)**

Reference Book

1. Digital Control & State Variable Methods – M. Gopal, Tata McGraw Hill Education. (**R1**)
2. Linear Systems by Thomas Kailath, Prentice-Hall Inc.,1980. (**R2**)

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATIONPROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Quizzes (3)	3x10 = 30
Seminar	10
Teacher's Assessment	10
Semester EndExamination	50

INDIRECT ASSESSMENT –

1. Students' Feedback on Course Outcome

MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	1	3	-	-
CO2	3	-	1	3	-	1
CO3	3	1	2	3	-	1
CO4	3	2	2	3	2	2
CO5	3	3	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus: PO5& PO6

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects, Fractional order controller.

POs met through Topics beyond syllabus/Advanced topics/Design: PO5 & PO6

Course Delivery Methods

CD	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors

CD2	Tutorials/Assignments
CD3	Seminars
CD4	Industrial visits/in-plant training
CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Mapping Between COs and Course Delivery (CD) methods	
Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3,CD5
CO2	CD1, CD2, CD3,CD5
CO3	CD1, CD2, CD3,CD5
CO4	CD1, CD2, CD3, CD5
CO5	CD1, CD2, CD3,CD5

COURSE INFORMATION SHEET

Course code: EE582
Course title: Vehicle Dynamics

Pre-requisite(s): Control System, Modern Control Theory
Co- requisite(s):
Credits: L: 3 T: P:
Class schedule per week: 03
Class: M.E.
Semester / Level:03
Branch:EEE
Name of Teacher:

Course Objectives

This course enables the students:

A.	To understand significant dynamic motion and force generation aspects.
B.	To apply mathematical tools to establish relation between motion and steering.
C.	To analyse longitudinal and lateral dynamics in order to achieve a desired trajectory.
D.	To validate suitability of a control architecture for a electric vehicle in given scenario on the road.
E.	To create novel controllers for intelligent transportation system.

Course Outcomes

After the completion of this course, students will:

1.	Remember various forces contributing to lateral and longitudinal motion.
2.	Apply state space based modelling to study vehicle dynamics.
3.	Analyse and improve steady state error, stability and safety.
4.	Predict the potential area of application for intelligent controller for societal benefit
5.	Design intelligent controller based vehicular control system and lead a team of technically skilled people for installation of such controllers.

Syllabus

Module 1: **Introduction:**

Electric Vehicle construction; Two Wheel Model; Four Wheel Model; Driver Assistance System; Active Stability Control; Longitudinal Dynamics; Vehicle Load Distribution – Acceleration and Braking; Brake Force Distribution, Braking Efficiency and Braking Distance; Technologies for addressing traffic congestion; Emissions and Fuel Economy for HEV and EV.

[8L]

Module 2: Lateral Vehicle Dynamics:

Kinematic model of lateral vehicle motion, Tire-Mechanics – Generation of lateral force; Lateral Dynamics

– Bicycle Model; Motion of a car relative to a rotating frame, yaw stability control system; Dynamic model in terms of yaw rate and slip angle from body fixed reference frame; Dynamic model in inertial frame; Lane keeping system.

[8L]

Module 3: Longitudinal Vehicle Dynamics:

Longitudinal vehicle dynamics considering aerodynamic drag force, longitudinal tire force, rolling resistance; Calculation of normal tire force and effective tire radius; Combined lateral-longitudinal force generation on tyre; Drive line dynamics – torque converter, transmission dynamics, motor dynamics, wheel dynamics; longitudinal dynamic control; controller design for cruise control.

[8L]

Module 4: Steering Conditions:

Cornering- Understeer, Neutral Steer, Over Steer; Stability and Steering conditions; Analysis of state space model and steady state error; Analysis of steady state cornering; design of state feedback controller, study of cornering stiffness; Anti-lock braking system; Roll dynamics and rollover prevention; Tire-road friction measurement on highway vehicles

[8L]

Module 5: Suspension Dynamics:

Introduction to Automotive Suspensions, Modal Decoupling and Performance variables for a Quarter Car Suspension, Natural Frequencies and Mode Shapes for the Quarter Car, Approximate Transfer functions using Decoupling, Analysis of Vibrations in the Sprung Mass Mode, Analysis of Vibrations in the Unsprang Mass Mode, Verification using the complete Quarter Car Model, Half Car and Full Car Suspension Models.

[8L]

Text books:

1. “Vehicle Dynamics Control” by Rajesh Rajamani, Springer, ISSN 0941-5122 e-ISSN 2192-063X
2. “Modern Power Electronics & Drives” by B K Bose
3. “Modeling and Dynamics Control for Distributed Drive Electric Vehicles”, Xudong Zhang, Springer; Softcover ISBN 978-3-658-32212-0, eBook ISBN 978-3-658-32213-7; DOI: 10.1007/978-3-658-32213-7
4. “Model Predictive Control System Design and Implementation Using MATLAB” by Liuping Wang, Springer.

Reference Books:

1. “Modeling, Dynamics and Control of Electrified Vehicles”, Hui Zhang, Dongpu Cao and Haiping Du; Elsevier Inc., ISBN 978-0-12-812786-5; DOI: 10.1016/C2016-0-03862-7
2. “Kalman Filtering and Neural Network” by Simon Haykin, Wiley Series