II Year –I semester

Core Courses

PH6101- Switching theory and Logic Design **L: 4 T:0 P:0 C:4**

Number Systems and Codes. Positional Number Systems, Octal and Hexadecimal Numbers, Numbers System Conversions, Subtraction, Representation of Negative Numbers, Binary Arithmetic, Binary codes, Gray code, Character codes.

Switching Algebra. Axioms, Single variable theorems, two-and three-variable theorems, n-variable theorems, Duality, Standard representation of Logic functions, canonical sum, canonical product.
Combinational-Circuit analysis, Combinational-Circuit Synthesis, Circuit descriptions and designs, Circuit manipulations, Circuit minimisation, Karnaugh maps, Minimising Sums of Products, Simplifying Products of Sums.

Digital Circuits. Analog Vs Digital, Logic signals and Gates, Logic families, CMOS: Logic levels, Basic Inverter circuit, NAND, NOR Gates, Fan-In, Non Inverting Gates, AND-OR-INVERT and OR-AND-INVERT Gates, Electrical Behaviour of CMOS circuits, Data Sheets and Specifications, CMOS steady-state Electrical Behaviour, Logic levels and noise margins, circuit behaviour with resistive Loads and non ideal inputs, Fan-out, Effects of
Loading, Current spikes and decoupling Capacitors. CMOS Dynamic Electrical behaviour, transmission time, propagation delay and power consumption, CMOS Transmission Gates, Three state outputs, open drain outputs, wired Logic, Driving LEDs, Schmitt-Trigger inputs. CMOS Logic Families: HC and HCT, VHC and VHCT and their electrical characteristics, FCT and FCT-T electrical characteristics. TTL Families, Schottky TTL Families and their characteristics. CMOS HTL Interfacing, Low-Voltage CMOS Logic and Interfacing.

Combinational Logic Design. Decoders, Designing 2-to-4 and 3-to-4 binary decoders, 74X139 and 74X138 IC Decoders, Cascading Binary Decoders, and Seven Segment Decoders.
Encoders, Designing a 8-input priority encoder, The 74X148 IC Priority encoder, it's function table and Logic diagram, Using 74X148s for higher input priority encoders. Three-state Devices, Multiplexers, Standard MSI multiplexers(74X151, 74X157 and 74X153 Expanding ICs), Exclusive-OR Gate and Parity Circuits, Comparators, Iterative Circuits, Standard MSI Comparator 74X85, 74X682. Half Adder, Full Adder, Ripple Adder, Subtractor, Carry Lookahead Adders, MSI Adder 74X283.

Sequential Logic Design Principles & Practices. Bistable elements, Latches and Flip-Flops, S-R Latch, D-Latch, Edge-triggered D flip-flops, Master/Slave S-R, J-K and T- flip-flops, Clocked Synchronous State-Machine Structure, Output Logic, Analysis of state-machines with D flip-flops, Clocked Synchronous State-Machine Design. Sequential circuit Documentation standards, Multibit Registers and Latches, Ripple Counters, Synchronous Counters, MSI Counters and

Applications, Shift Registers, MSI Shift Registers and Applications, Serial/Parallel conversions, Ring Counters and Johnson Counters.

Reading:

1. John F Wakerly, Digital Design; Principles and Practices, 4th Edition, Pearson, Prentice Hall 2008.
2. Zvi Kohavi and Niraj K. Jha, Switching and Finite automata Theory, 3rd Edition, Cambridge University Press,
2010.

PH6102- Material Science **L: 4 T:0 P:0 C:4**

Imperfections in solids: Points defects: thermodynamics of point defects, experimental evidence of point defects. Dislocations: Geometry of dislocations, evidence of dislocations. Grain boundaries: Terminology and Definitions, Low and High angle grain boundaries. Computation of Resolved Shear Stress and Stress-to-Initiate-Yielding. Tensile strength and Ductility Determinations. Estimation of Grain Size.

Phase Transformations: Kinetics of phase transformations, Nucleation and Growth, homogeneous and heterogeneous nucleation, energies involved in homogeneous nucleation, kinetic consideration of Critical Nucleus Radius and Activation free energy.

Diffusion: Diffusion mechanisms, Steady and non-steady state diffusion, Fick's Law of Diffusion, Factors including diffusion, doping in semiconductors, The atomic model of diffusion, Determination of diffusion flux and diffusion constant, Estimation of activation energy.

Phase Diagrams: Solubility limits, Phase Equilibria, Unary phase diagram, Gibbs phase rule, Binary isomorphous systems, Derivation of lever rule, interpretation of phase diagrams, Determination of phase amounts, Equilibrium and non-equilibrium solidification, Binary eutectoid and peritectic reactions, Congruent phase transformations, Ternary phase diagrams, Applications of phase diagrams, Estimation of temperatures and compositions of all eutectic, eutectoid, peritectic, and congruent phase transformations, Determination of phase transformations. Determination of phases present and computation of phase compositions.

Industrial Applications of Phase Transformations of Iron-Carbon Alloys: Development of microstructural and their property changes, Determination of relative amounts of ferrite, cementite and pearlite microconstituents, Isothermal transformation diagrams, Continuous cooling transformation, Tempered Martensite, Solidification and Crystallization, The glass transition.

Corrosion and Degradation of Materials: Electrochemical corrosion of metals, Galvanic cells, Corrosion rates, Corrosion reactions and polarization, passivation, types of corrosion, Mechanism of oxidation, Oxidation rates, Corrosion control.

Material selection and Design Considerations: Classification of materials (metals, superconductors, semiconductors, magnetic materials, ceramics and polymers), Designing different materials with specific structure and properties.

Readings:

1. William D. Callister, Material Science & Engineering: An Introduction, John Wiley & Sons (2007).
2. William F. Smith, Fundamentals of Material Science & Engineering, McGraw Hill International Edition (1993).
3. V. Raghavan, Material Science and Engineering: A First Course, 5th Edition, Prentice Hall India Pvt Ltd. (2010).
4. Ashby, M. F. and D. R. H. Jones, Engineering Materials: An Introduction to their Properties, Applications, and Design, 4th edition, Butteworth-Heinemann, Oxford, England (2012).
5. Askeland, D.R., P. P. Fulay, and W. J. Wright, The Science and Engineering of Materials, 6th edition, Cengage Learning, Stanford, CT(2011).

PH6103- Opto-Electronics **L: 4 T:0 P:0 C:4**

Light Propagation in Wave Guides: Introduction-Some physical properties of wave guides and optical fibers-Maxwells Equations-Guided modes in planar waveguides-Optical confinement factor-Guided modes in optical fibers-waveguide couplers.

Optical Sources: Introduction-Requirements of optical emitter-Advantages of LEDs-Material systems for LEDs-Direct and indirect Band gap Semiconductors-Doped Semiconductors-PN-Junction and Led operation-Carrier injection and spontaneous emission-LED Structures -Hetro junction LEDs-Surface emitting and Edge Emitting LEDs-Quantum efficiency and LED Power-Led performance considerations and applications- Semiconductor Lasers-Introduction- Lasing in pumped active medium-Threshold condition-Semiconductor Laser Rate equations-Quantum Efficiency-Resonant frequencies and spectrum of Laser Diode-Laser Diode structures and radiation patterns-BurriedHetrostructures-VCSE laser-Distributed feedback Lasers-DBR Lasers-Temperature dependence of Laser output-Direct Analog and Digital Modulation-Laser Noise.

Light Detectors: Introduction-Detector performance parameters-Thermal Detectors-Image Intensifiers-Thermoelectric detectors-Pneumatic detectors-Pyroelectric detectors-Photoemissive

detectors-Vacuum photodiodes-and photomultipliers and their performance-Photoconductive detectors-PN-Photodiode-I-V Characteristic-PIN Photodiode-Operation-Photocurrent and responsivity-Avalanche Photodiode-Responsivity-Noise sources in photodetectors-S/N calculation-Detector response Time and Banndwidth.

Pick-up and Display Devices: Introduction-The Iconoscope-Image Orthicon-Vidicon-Plumbicon Camera tubes-Principles and operation-CCDs-Operation-Display devices-Classification-Electroluminiscence and cathode Luminiscence-Monochrome and colour CRTs-Picture Tubes-LED, LCD, plasma and field emission displays

Light Modulators: Introduction-Electro Optic and Kerr modulators-Magneto Optic and Acousto Optic modulators-Photonic Switches and Applications.

Reading:

1)Optoelectronics-An Introduction-J.Wilson ;J.F.B.Hawkes,(PH) 2001

2)Optical Fiber Communications,G.Keiser,(MGH),2001

3)Fundamentals of Photonics.B.E.A.Salesh;M.C.Teich(Weiley),1991

PH6104- Linear Integrated Circuit Applications **L: 4 T:0 P:0 C:4**

Operational amplifiers: Op-amp- Internal circuit –Block diagram representation of op-amp-Stages of op-amp-Ideal op-amp, Basic differential amplifier- transfer characteristics, low frequency small signal analysis, differential mode gain, common mode gain, circuits for improving CMRR, Practical op-amp - Open loop & closed loop configurations – measurement of Op-amp parameters, DC & AC performance characteristics of op-amp – Frequency compensation, Differential operational amplifiers.

Applications of op-amps: Voltage follower - Summing, scaling & averaging amplifiers - AC amplifier. Linear Applications: Instrumentation Amplifiers- V-to-I & I-to-V converters-Differentiators & Integrators. Non-linear Applications: Precision Rectifiers, peak detectors, Wave Shaping Circuits (Clipper and Clampers) – Log and Antilog Amplifiers – Analog voltage multiplier circuit and its applications, Phase sensitive detector (PSD) – Operational Trans-Conductance Amplifier (OTA) – Power amplifiers-Comparators and its applications – Sample and Hold circuit.

Specialized IC applications: Waveform Generators: Sine-wave Generators – Square / Triangle / Saw-tooth Wave generators. IC XR-2206 function generator and its applications. IC 555 Timer:

Monostable operation and its applications – Astable operation and its applications. ICS 566 VCO and its applications. PLL: Operation of basic PLL-Closed loop analysis of PLL- IC 565 and its applications,

Active Filters & Voltage Regulators: Active Filters:-Active Network Design – Filter Approximations-Design of LPF, HPF, BPF and Band Reject Filters – All Pass filters and higher order filters and their design, VCVS and IGMF configuration. Voltage Regulators: Basics of Voltage Regulator – IC Regulators (78xx, 79xx, LM 317, LM 337, 723)-Switching Regulators.

Readings:

1. Ramakanth, A. and Gayakwad, *Op–Amps and Linear integrated circuits*, Fourth Edition, Prentice Hall of India, New Delhi, 2000.
2. Roy Choudhury, D. and Shail B. Jain, *Linear Integrated Circuits*, Fourth Edition, New Age International, New Delhi, 2011.
3. George Clayton and Steve Winder, *Operational Amplifiers*, Fifth Edition, Newnes-Elsevier, 2011.
4. Sergio Franco, Design with Operational Amplifiers and Analog Integrated Circuits, Third Ed, Mc Graw Hill, 2014.
5. Bakshi U.A., Godse A.P., Bakshi A.V., *Linear Integrated circuits and Applications*, Technical Publishers, Pune, 2010.

PH6105- Measurement Techniques and Error analysis **L: 4 T:0 P:0 C:4**

Measurements and Measurement Systems :Significance and methods of measurement. Instruments mechanical, electrical and electronic. Classification of Instruments :Analog and Digital modes of operation , functions of instruments and measuring systems

Static Characteristics: Static calibration-static characteristics : True value-static error and correction, scale span and range ,error calibration curve Accuracy, Precision, resolution, repeatability, reproducibility, drift, linearity, hysteresis , threshold, dead time , dead zone, Loading effects due to series and shunt connected instruments-Impedance matching and maximum power transfer theorem

Dynamic response characteristics : Introduction to dynamic response and behaviour- and frequency domain analysis-LTI systems-application to electric and mechanical systems, thermal systems. Transfer function ,order of a system. Time domain response of first and second order systems to step, ramp, impulse forcing functions.Frequency response of first and second order systems

Errors in measurement systems : Limiting errors-types of known errors- gross , systamatic ,instrumental , observational and environmental errors, errors in digital instrument reading - random errors-causes and reduction methods -mean and median . Graphical data analysis techniques- .Variance and standard deviation of combination of components. Digital errors : Bit errors, quantization error, error correlation , error correction coding emulation , error mapping

Mathematical Methods of Error analysis : Probability density function , estimating errors, error estimation, propagation, errors on mean , guassian , correlation , least squares fit , weighted LSF, Aggregation of errors from separate measurement system components -- Uncertainity analysis and its propagation.-Estimation of total error in combination of multiple inputs , decorrelation and degrees of fredom , sinusoidal variabilty, spectral analysis, , fourier and z-transforms, uncertainities and spectra , normalization , orthogonal function s, data characterization

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Measurement of Resistance and Potentiometers: DC bridges- low, high, precise resistance measurement, Megger. Potentiometers- standard type potentiometer- Polar and co-polar type, A.C. potentiometers – their applications.

Impedance and Magnetic Measurements : Q of a coil – Maxwell bridge –Wien bridge – Hay's bridge – Schering bridge – Anderson bridge – Campbell bridge to measure mutual inductance – Errors in A.C. bridge methods and their compensations Measurement of flux, magnetizing force and permeabilityHibbert's magnetic standard – flux meter – Hall Effect gauss meter

Thermocouples and Pyrometers : Gas, bimetal,nuclear .,acoustic . Resistance change based thermal sensors,: Metal, thermistors, thermoem fbased ,thermocouples. Thermal radiation sensors-total radiation, multiwaveband, spectral radiation, ration type.

Pressure Measurement and Flow Measurement :Bourdon Tubes, Diaphgrams,Bellows. Basics of flow dynamics-pressure gradient technique-thermal transport sensors, ultrasonic and electromagnetic sensors

Displacement Measurement : Resistive potentiometers, strain gauges, semiconductor strain gauges,(ac and dc bridges and half bridges). Inductive sensors-sensitivity and linearity, LVDT, (ac bridge and other interfacing methods) RVDT , piezoelectric , magneto strictive transducers, principles of operation, construction, theory, advantages and disadvantages and applications, of capacitive transducers , application and interfacing , hotwire anemometers

Readings:

1. Doebelin, E.O., "Measurement systems Application and Design", International Student Edition, 5th Edition, Mc-Graw Hill Book Company, 2004.

2. Liptak, B. G., "Instrumentation Engineers Handbook (Measurement)", CRC Press, 2005.

3. A. K. Sawhney, 'A course in Electrical & Electronic Measurement and Instrumentation', DhanpatRai and Co (P) Ltd., 2004.

4. R. K. Jain, 'Mechanical and Industrial Measurements', Khanna Publishers, New Delhi, 1999.

II Year –II semester

(Electronics Specialization)

Core Courses

PH6151- Structured Digital System Design **L: 4 T:0 P:0 C:4**

Combinational circuit design: barrel shifter, floating point and dual-priority encoder, VHDL, sequential circuit design features and practices, SSI latches and flip-flops, counters, shift registers in VHDL, introduction to memory. CPLDS and FPGAS: ROM & RAM-structure, decoding, timing and applications, CPLDS and FPGAS and programming.

Reading:

1. John F. Walkerly, Digital Design: Principles and Practices, 3rd Edition, Pearson, 2002.

2. Yalamanchili Sudhakar, Introductory VHDL: from Simulation to Synthesis, Pearson, 2002.

PH6152- Microprocessor and Interfacing **L: 4 T:0 P:0 C:4**

The Microprocessor and its Architecture: Introduction to microprocessor and computer-Internal microprocessor architecture –Real mode memory addressing-Introduction to memory mode addressing –Memory paging.

Addressing modes: Data addressing modes –Programming memory –addressing memory – Stack memory
addressing modes.

Assembly Language Programming: Data movement instructions-Architecture and logical instructions –program control instructions- program examples.

Memory and I/O Interfacing: Memory devices and address decoding – Memory mapping and interfacing-Basics of I/O interface. I/O port address decoding. Programmable Peripheral Interface 82C55 with examples.8279 Programmable Keyboard/Display Interface – 8254 Programmable Interval Timer.

Interrupts and DMA Interrupt Processing -8259A programmable Interrupt Controller –DMA operation –
8237 DMA controller –Shared bus operation.

Pentiums Processors: Introduction to Pentium Microprocessor –Special registers- Memory management –
Memory instructions –Introduction to Pentium II,III ,IV and V microprocessors.

Readings:

1.The Intel Microprocessor: Architecture, Programming of Interfacing by Barry E.Bray ,viii edition, Pearson education, 2009.

2.Mciroprocessors and Interfacing : Programming and Hardware –Douglas V.Hall TMH 2008.

PH6153- Communication Systems **L: 4 T:0 P:0 C:4**

Introduction to Communication Systems: Introduction-Power measurement -EM Spectrum-Bandwidth and information capacity--Electronic Communication Systems-Need for modulation-Overview of signals and Systems-Power and Energy spectra-Effects of bandlimiting on signals-Linear summing-Nonlinear Mixing-Distortionless transmission through systems.

Noise: Introduction-Classsification of Noise-Voltage and current models of a noisy resistor-Addition of noise due to several sources-Addition of noise due to several amplifiers in cascade-Spectral densities-Noise in Reactive Circuits-Calculation of thermal Noise for single and multiple sources-S/N Ratio-Noise Figure-calculation-Noise Figure from Equivalent Noise Resistance-Experimental determination of Noise Figure-Noise Temperature-Noise equivalent Bandwidth.

Amplitude Modulation Systems: Introduction-representation of Single Tone and Multi Tone AM-Salient features of AM wave-Frequency Spectrum-Power relations-Transmission Efficiency-Generation of AM wave-Low and High Level AM Systems-Demodulation of AM wave-Square-Law Detector-Envelop Detector-DSB-SC System-Generation –Balanced Modulator-Ring Modulator-Frequency Spectrum-Demodulation of DSB-SC signal-synchronous detection-Envelop Detection after suitable carrier re-insertion-Effect of frequency and phase errors in synchronous Detection-Carrier acquisition in DSB-Sc System-Coastas receiver-QAM.

SSB-Sc System-Frequency Spectrum-Generation of SSB-SC signal-The Filter Method-The Phase Shift Method-The Weaver Method-Detection of SSB-Sc Signal-Generation and detection of VSB Signals-ISB-System.

Frequency Modulation: Introduction-Mathematical expression for Single Tone FM-Salient Features of FM Wave-Frequency Spectrum of FM wave- Generation of FM-Direct Methods and indirect Methods- Reactance Modulator-Varactor diode Methods-Armstrong Method-Single tone Narrow Band FM-Mathematical Expression and Generation.FM generation with VCO. Detection of FM-Slope Detector-Balanced Slope Detector-Foster Seeley Discriminator-Ratio detector-PLL FM Demodulator-

Radio receivers: Introduction-TRF Receiver-The Mixer-The Superhetrodyne Receiver-Receiver Characteristics-RF,IF amplifier Sections-AGC and Delayed AGC.

Analog Pulse Modulation Schemes: Introduction-overview of sampling theorem-Pulse Amplitude Modulation-Mathematical expression for PAM with Natural and Flat top Sampling-Frequency Spectrum-Transmission Bandwidth-Demodulation of PAM- Pulse Width Modulation-Frequency Spectrum-PWM Generation with Multivibrator and 555 Timer-Demodulation of PWM- Generation and Demodulation of PPM. Digital Modulation Formats-ASK,FSK,PSK,BPSKBFSK and QPSK.

Readings:

1) Electronic Communication Systems 4Th Edn,George Kennedy,Bernard Davis,TMH

2) Electronic Communication Systems-Fundamentals through Advanced,5Th Edn, Wyne Tomasi,Pearson

3) Modern Digital and Analog Communication Systems, B.P.Lathi ,Oxford Univ Press

4) Communication Systems, A. Bruce Carlson,Paul.B.Crilly;TMH-2011

5) Communication Systems,5Th Edn,Symon Haykin,Michael Mohar;Wiley-2009

Elective Courses

PH6171- Data Acquisition Systems **L: 3 T:0 P:0 C:3**

INTRODUCTION: Data Acquisition Systems- Objective of a DAS, Components used in DAS–DAS Hardware, Performance metrics**:** Resolution and sampling rate, Signal-to-noise-and-distortion ratio (SNDR or SINAD), Spurious-free dynamic range (SFDR) , HD2 and HD3, Differential operation, Inter-modulation distortion (IMD), Relationship between HD and IMD, Differential and integral non-linearity (DNL and INL) Relationship between SFDR and INL, HD2 and HD3 INL patterns, Saw-tooth INL pattern, Offset and gain error, Accuracy and Precision, Noise, Settling Time, Acquisition Time.

DIGITAL TO ANALOG CONVERTERS (DACs): Principles and design of – weighted resistor, R– 2R ladder, inverted R-2R ladder, monolithic DAC – Parameter specifications.

ANALOG TO DIGITAL CONVERTERS (ADCS): Flash ADC, Flash ADC with interpolation, Multi-step ADC, Sub-ranging ADC, Folding ADC, Pipelined ADC, Successive approximation (SAR) ADC, Pipelined and SAR ADC, Time-interleaved ADC, Sigma-delta ADC, Oversampling and noise shaping, Single-bit modulator, Overloading, First-order modulator, Second-order modulator, Higher order and cascaded sigma-delta modulators, Discrete-time and continuous-time sigma-delta Modulators, Counter ADC, Servo tracking ADC, Integrating type ADCs– Charge balancing, dual slope integration- Parameter specifications.

ERROR BUDGET OF DACs and ADCs: Error sources, error reduction and noise reduction techniques in DACs. Error budget analysis of DAS, case study of a DAC and an ADC.

DESIGN OF DATA ACQUISITION SYSTEMS: Introduction to the Design, Functional Design of High Speed Computer-Based DAS, Requirements, Analysis of Accuracy (Static), Analysis of Accuracy (Dynamic), Portable DAS, Design Guidelines for High-Performance, Multichannel DAS.

Readings:

1. Data Acquisition Systems- From Fundamentals to Applied Design by **Paolo Emilio**, Maurizio,@2013, Springer.
2. Data Acquisition Techniques Using PCs Second Ed Howard Austerlitz@2003, Academic press.
3. Data Converters by GB Clayton.
4. Acquisition & conversion handbook, Datel-Intersil.
5. Practical Data Acquisition for Instrumentation and Control Systems by John Park and Steve Mackay, 2003, Elsevier Publisher.

PH6172- Data Converters and Data Loggers **L: 3 T:0 P:0 C:3**

Introduction to Data Converters: The ideal data converter- sampling- amplitude quantization-Discrete and Fast Fourier transforms-Coding schemes- Data converters specifications-Static and Dynamic Specifications-

A/D &D/A converters: Nyquist -Rate A/D & D/A converters-Circuits for Data converters-Sample and Hold-Diode bridge S &H-Digital Enhancement techniques-Error measurement-Dynamic matching-Testing of D/A & A/D converters:

Introduction to Log Data Basic Log Data-Log data transmission and collection-logs are underrated-security information and event management-log formats and types-log syntax-criteria of good logging.

Log Data sources Syslog-SNMP- Log source classification –Security related host logs-Security related host logs-Log Storage techniques-Log retention policy-log storage formats-Data base storage of log data-Defining data base storage goals-Hadoop log storage- advantages and disadvantages.

Logging Laws and Logging mistakes: Logging laws-laws of collection, retention, monitoring, availability, security, constant changes-Logging mistakes-Not logging at all-not looking at log data-prioritizing before collection-Tools for log analysis and collection.

Readings:

1. Data Converters by Francom Maloberti:Springer publications,2008

2. Logging and Log Management by Anton A. Chuvakin Kevin J. Schmid Christopher Phillips Elsevier publications 2013.

PH6173- High Speed Data Converters **L: 3 T:0 P:0 C:3**

INTRODUCTION: Ideal data conversion, The sampling operation, Sampling theorem, Sampling of bandpass signals, The reconstruction operation, The quantization operation, Coding, Under sampling and oversampling, Decimation and interpolation.

Performance metrics: Resolution and sampling rate, Signal-to-noise-and-distortion ratio (SNDR or SINAD), Spurious-free dynamic range (SFDR) , HD2 and HD3, Differential operation, Inter-modulation distortion (IMD), Relationship between HD and IMD, Differential and integral non-linearity (DNL and INL) Relationship between SFDR and INL, HD2 and HD3 INL patterns, Saw-tooth INL pattern, Offset and gain error, Jitter, Analysis, Intuitive

perspective, Jitter measurement, Types of random jitter, Jitter and phase noise, Bit error rate (BER), Power consumption and figure of merit.

DIGITAL TO ANALOG CONVERTERS (DACS): Principles and design of – weighted resistor, R– 2R ladder, inverted R-2R ladder, monolithic DAC – Parameter specifications.

ANALOG TO DIGITAL CONVERTERS (ADCS): Classification of A/D converters, Principles and design of- Flash, Counter, Servo tracking, Successive approximation, Integrating type– Charge balancing, dual slope integration ADCs- MAX5893 High Speed A/D, Parameter specifications.

NON-LINEAR DATA CONVERTERS (NDC): Basic NDC configurations – Some common NDACS and NADCS – Programmable non-linear ADCS – NADC using optimal sized ROM – High speed hybrid NADC – PLS based NADC – Switched capacitor NDCS.

Readings:

1. High Speed Data Converters by Ahmed M.A. Ali, 2016, IET Publishers.
2. Electronic analog/digital converters, H. Schmid.
3. Data Converters by GB Clayton.
4. Users Handbook of D/A and A/D coverters- E.R. Hnatek.

PH6174- Pulsed Circuits **L: 3 T:0 P:0 C:3**

Linear Wave Shaping : High pass and low pass RC circuits and their response for Sinusoidal, Step, Pulse, Square, & Ramp inputs, High pass RC network as Differentiator, Low pass RC circuit as an Integrator,, RL and RLC Circuits and their response for Step Input, Ringing Circuit.:

Clipping and Clamping circuits Clipping-Diode clippers-The transient clipper-Comparators-Breakaway diode and amplifier-Diode-Differentiator Comparator-Application of Voltage comparators. The clamping operation, Clamping circuits –Clamping circuit theorem-Synchronized clamping-Transistor switch with inductive load.

Multivibrators: The monostable mutivibrator-The emitter-coupled monostable multivibrator-Triggering of monostable multivibrator-The astable collector coupled multivibrator-The stable states of a bistable multivibrator-A fixed biased transistor bistable multivibrator-methods of improving resolution-symmetrical triggering-Schmitt Trigger circuits.

Time base Generators: General features of time base signal-Methods of generating time based waveform-unijunction transistor-Miller and Bootstrap time base generators-Current time based generators-A simple current sweep

Synchronization and Frequency Division: Pulse Synchronization of Relaxation Devices, Frequency division in Sweep Circuit, Astable Relaxation Circuits, Monostable Relaxation Circuits as Dividers, stability of Relaxation dividers Synchronization of a Sweep Circuit with Symmetrical Signals, Sine wave frequency division with a Sweep Circuit.

Readings:

1. Pulses, Digital and Switching waveforms by Jacob Millimna, Herbert Taub &M.S.PrakashRao Mc-Graw hill,2008.

2. Pulses and Digital Circuits A. Anand Kumar PHI Learning,2012

PH6181- Signal Conditioning Circuits **L: 3 T:0 P:0 C:3**

Measurements and Signals : Physical measurements, signals and characteristics : Signal Classification :Single-Ended and Differential Signals - Narrowband and Broad band Signals . Low- and High-Output-Impedance Signals - Definition of signal conditioning -basic sensor signal chain -

Signal conditioning operations- Elements of signal conditioning operations (amplification, filtering ,interfacing , protection and isolation, linearization etc)

Overview of sensors -Typical industrial process control loop-basic elements of a smart sensor Input Characteristics of Interface circuits -Effects of electrical noises and board leakage currents.DC signal conditioning circuits and ac signal conditioning circuits

Amplifier Design: Concepts of Buffering, Chopped dc amplifiers, effects of earthing schemes and EMI instrumentation amplifiers and introduction to error sources, charge amplifiers

Bridge circuits for signal conditioning : The Wheatstone's bridge-disbalanced bridge -balanced bridge with feedback control-null balanced bridge-temperature compensation options in bridge circuits-compensation for leads -opamps circuits with disbalanced resistive bridge . Voltage and current sensitive bridges-AC bridges with push pull inductive and capacitive transducer circuits

Noise in sensors and circuits and minimization methods :-Inherent, transmitted noise and its sources-electric ,magnetic shielding and bypass capacitors -ground loops and ground isolation – optoisolation

Isolation and lineraization and other effects: Importance of isolation ,Two wire, three wire , four wire transmitters, isolation amplifiers ,digital isolation methods, inherently isolated amplifiers ,need for linearization, software and hardware linearization, cold junction compensation, treating high impedance outputs

Specific cases of signal conditioning- Design methodology for specific sensors -specifying a signal conditioner

Reading :

1)Handbook of Modern Sensors: Physics, Designs, and Applications, Jacob Fraden , 3rd ED, AIP Press, Springer

2)Sensors and Signal Conditioning ,Ramon Pallas- G Webster , John Wiley and Sons, 2nd Edition

3) A course in Electrical and Electronic measurements and Instrumentation by A.K.Sawhney, DhanpatRai and Sons—recent edition

(Photonics Specialization)

Core Courses

PH6157- Optical System Design **L: 4 T:0 P:0 C:4**

Gaussian Optics – The cardinal points; Paraxial optics and calculations – Ray tracing – paraxial, finite and oblique rays; Stops- apertures- pupils and diffraction; Optical system considerations – Matrix optics; The primary aberrations- Aberration correction and residuals

Third-order aberration theory and calculation; Radiance and Lambert's law – radiometry of images – spectral radiometr;

Optical system layout – Telescope – microscope- range finders- zoom systems

Image evaluation – Aberration tolerances - Geometric OTF - Strehl ratio - spot diagram – MTF

Optimization techniques in lens design, damped least square method, orthonormalisation – tolerance analysis; Achromatic doublets, apochromats and aplanats, Cooke triplet and its derivatives; Mirrors and Catadioptric systems.

Readings:

1. " Modern optical engineering", W.J.Smith, 4th Ed., Tata McGraw Hill, 2008
2. "Optical system design", R.Kingslake, Academic Press, 1983
3. "Lens design fundaments", R.Kingslake, Academic Press, 1978
4. "Optimization techniques in Lens Design" T.H.Jamieson, Adam Hilger.

PH6158- Optical Instruments **L: 4 T:0 P:0 C:4**

Radiometry in optical systems, Radiometry of extended sources, Search lights, Illuminators, Telecentricity, Optical filters; Magnifiers and Eyepieces, Afocal systems, Autocollimators, Schlieren systems, Refractometers, Ellipsometers

Spectroscopic instrumentation; Fabry-Perot interferometer, diffraction gratings, Fourier transform spectroscopy;

Interferometric instrumentation for testing; shearing, polarization interferometers; Scanning microscopy, Imaging modes, depth discrimination, super resolution, practical aspects, measurements on semiconducting devices, near-field techniques; Displays, liquid crystal displays, video projectors;

Opto-medical Instruments, Keratometers, opthalmoscopes, optometers, optical coherence tomography;

Infrared instrumentation, I.R. telescopes, focal plane arrays, cryo-cooling systems, scanning and stabilization mechanisms, smart weapon seekers, space-based sensors;

Space optics, Satellite cameras, high-resolution radiometers, space telescopes;

Optical metrology, Surface inspection, optical gauging and profiling, techniques for nondestructive testing, Moire self imaging and speckle metrology.

Readings:

1. Geometrical and Instrumental Optics – D. Malcara (Academic).

2. Applied Optics & Optical Engineering – Vol. 4 & 5 – R. Kingslake (Academic).

3. Elements of Modern Optical Design – D.C.O'Shea (John Wiley)

4. Optical Techniques for industrial inspection – P.Cielo (Academic)

Elective Courses

PH6175- Nonlinear Optics **L: 3 T:0 P:0 C:3**

Introduction: Origin of Nonlinear Optics; Description of nonlinear optical processes; Linear and nonlinear susceptibility; Second order and third order nonlinear susceptibility; Nonlinear susceptibility in centrosymmetric and non-centrosymmetric crystals; Miller's rule; Properties of nonlinear susceptibility; Introduction about nonlinear optical materials

Electromagnetic theory of Nonlinear Optics: EM wave propagation in nonlinear optical medium; Coupled wave equation and phase matching conditions; quasi phase matching; The Manley-Rowe relation

Nonlinear optical phenomena due to second order nonlinearity: Sum frequency generation; Second harmonic generation; Difference parametric application; Optical parametric application; Optical parametric oscillator ; Applications

Nonlinear optical phenomena due to third order nonlinearity: Intensity dependent refractive index; Tensor nature of third order nonlinearity; Processes resulting intensity dependent refractive index; Self process; Supercontinuum generation; Fourwave mixing, Optical phase conjugation; Optical bistability and optical switches; Two beam coupling; spatial and temporal Solitons

Readings:

1. R Boyd, *Nonlinear Optics*, Academic Press, 3rd Edition, 2008.

2. Govind P. Agrawal, *Nonlinear Fiber Optics*,3rd Edition, AP, 2001.

PH6176- Lasers and Applications **L: 3 T:0 P:0 C:3**

Quantum Theory of Laser – Radiative and Nonradiative decay of excited state atoms – Emission Broadening and linewidth – Radiation and Thermal equilibrium – Conditions for laser action – Laser Oscillation above threshold - Laser Amplifiers – Requirements for obtaining population inversion – Rate Equations for three and four level systems – Laser pumping requirements – Laser Cavity modes – Stable resonators – Gaussian beams- Special Laser Cavities – Q-switching and Mode locking – Generation of ultra fast Optical pulses- Pulse compression

Laser for detection and ranging- LIDAR applications-Doppler wind LIDAR, Differential Absorption LIDAR for water vapor monitoring.

Laser application in material processing – esp. CO2, YAG , Excimer,Ruby lasers-[material processing, Cutting, Welding, drilling, micro machining] – Interation of laser radiation with matter, Heat Flow Theory, Process characteristics etc.

Laser anemometry, Schlieren Techniques for wind tunnels, Holography etc Lasers for metrology Interferometery for surface characterization, precision length measurement, time standards etc, Medical applications of lasers

Lasers for space applications – free space communication, laser propulsion, laser ignition,Optical Rotation sensors and their applications for space navigation: Sagnac Interferometers and their applications for space, Ring Laser gyros- Laser Resonator Design,

Laser Frequency stabilization techniques, Ring resonator – stable and unstable and their application in Ring Laser Gyros.

Fabrication and metrology of precision laser optics. Ultra High vacuum [production, measurement] techniques relevant to Gas laser processing. Optical gyros error modeling, error compensation, test methodologies and applications for inertial navigation.

Reading:

1. Quantum Elecrtronics, Amnon Yariv, John Wiley [1989]

2. Lasers, Siegman, Anthony E California/University of Science Books/1986

3. Physics of gas lasers, Bennett, W R/Montroll, Elliot W, New York/Gordon and Breach/1977

4. Introduction to gas lasers : Population inversion mechanisms, Willett, Colin S/Haar, D Ter, Oxford/Pergamon press/1974

5. Laser resonators and beam propagation, Hodgson, Norman/Weber, Horst New York/Springer Science/2005, Springer series in optical sciences

PH6177- Adaptive Optics **L: 3 T:0 P:0 C:3**

Introductions and overview of Adaptive Optics; atmospheric effects on light; overview of an AO system. Building blocks of an AO system; examples; applications of AO; background optical concepts.

Wave-front sensors : Shack-Hartmann, shearing interferometer. Kelvin-Helmholtz instabilities; development of turbulence; inertial subrange; outer and inner scales, Phase structure function; characteristic scales: Fried coherence length, Greenwood frequency, isoplanatic angle.

Review of Fourier optics; the Parabolic Wave Equation. Imaging through a phase screen; scintillation; effects on the PSF, Statistical imaging metrics: Strehl ratio, mean MTF, encircled energy, contrast.

Deriving basic requirements of an AO system; sources of residual wave-front error, Deformable mirrors: rigidly actuated face sheets, MEMS devices, LC arrays, Controlling non-common-path aberrations; PSF calibration; speckle statistics, Optimizing an AO system design; minimizing total MS wave-front error.

Tomographic WFS approaches and issues, Multi-conjugate AO, multi-object AO, ground-layer AO, AO for ophthalmology and Astronomy.

Readings:

1. Principles of Adaptive Optics (4th Edition), R. K. Tyson, CRC Press
2. Adaptive Optics for Biological Imaging , Joel A Kubby, 2013 CRC Press

PH6178- Polarization Optics **L: 3 T:0 P:0 C:3**

Polarization overview. Polarization states. Polarization ellipse. Polarization elements. Diattenuation. Retardance. Depolarization. Partially polarized light.

Polarized light in nature. Stokes polarimeters. Polarized, partially polarized, and unpolarized light. Black body polarization. Polarization of the sky. Polarization sensitivity in the human eye and animal eyes. Natural and manmade polarization signatures. Polarization of astronomical objects, Electromagnetic description of polarized light. Jones vectors. Stokes vectors. Poincare sphere. Coherence. Interference of polarized light. Fresnel equations.

Anisotropic materials and polarization elements. Uniaxial and biaxial materials. Birefringence. Dichroism. Optical activity. Polarizers. Retarders. Polarization dependent loss. Polarization mode dispersion. Achromatic elements. Field of view effects.

Polarization calculus. Jones calculus. Mueller calculus. Depolarization. Pauli matrix decompositions and the structure of the polarization calculi. Matrix roots and order independent decompositions.

Polarimetry. Light measuring. Sample measuring. Spectropolarimetry. Imaging polarimetry. Ellipsometry. Mueller matrix polarimetry. Discrete Fourier transform. Singular value decomposition. Polarization devices.

Readings:

1. Dennis Goldstein, Polarized Light, 3d Edition, (CRC Press, 2010)
2. Jay Damask, Polarization Optics in Telecommunications, (Springer, 2005)
3. C. Brosseau, Fundamentals of Polarized Light, (Wiley, 1998)
4. D. Kliger, J. Lewis, C. Randall, Polarized Light in Optics and Spectroscopy (1990).
5. R.M.A. Azzam, and N. M. Bashara, Ellipsometry and Polarized Light, 2d ed. (North-Holland, Amsterdam, 1987).

III Year –I semester

(Electronics Specialization)

Core Courses

PH7101- Digital Signal Processing **L: 4 T:0 P:0 C:4**

Fundamentals of Signals and Systems: Signals, Systems ,Properties, Convolution, Time domain and Frequency domain analysis Signals, Continuous time Fourier Transform and Discrete Time Fourier Transform-Examples.

The Z Transform : Introduction-Definition of Z Transform,Z- Transform and ROC of Finite and Infinite duration sequences, ROC and properties, properties of Z-Transform, Inverse Z-Transform-Partial Fraction Expansion,Long Division and Residue methods-Examples.

Discrete Fourier Transform: Introduction, Properties of Discrete Time Fourier Series,Definition of DFT and its Inverse,Direct evaluation of DFT and IDFT, Matrix Relation for computing DFT and IDFT(DFT as a Linear Transformation),Properties of DFT,Useful DFT Pairs,Circular Convolution,Filtering Long Duration Sequences-Overlap and ADD ,Overlap and Save Methods-Examples.

Fast Fourier Transform: Introduction-The Fast Fourier Transform, Decimation in Time Algorithm,Butterfly Diagrams,Summery Steps of Radix-2 DIT-FFT Algorithm,Decimation in Frequency Algorithm,Summery Steps of Radix-2 DIF-FFT Algorithm and Butterfly Diagrams,Differences between DIT and DIF Algorithms,IDFT using FFT algorithms,Frequency analysis of signals using DFT.

Design of IIR Filters: Introduction, Analog Filter Specifications,Classification of Analog Filters, Classification of Analog Filters,Butterworth Filters,Frequency Transformations and Special Transformations,Design of Low Pass Butterworth Filters, Chebyshev Filters,Digital Filters-Backward Difference Method,Bilinear Transformation,Impulse Invarient Transformation and matches Z-Transform Design-Analog Design using Digital Filters,Advantages and Disadvantages of IIR Filters,Examples.

Design of FIR Filters: Introduction-Linear Phase FIR Filters,Frequency Response of Linear Phase FIR Filters, Location of Zeros of a Linear Phase FIR Filters,The Fourier Series Method of Designing FIR Filters, Desidn of FIR Filters using Windows,Frequency sampling Method of Designing FIR Filters,Equiripple Filters, Examples.

Realisation of Digital Filters: Introduction, Direct Form Realisation of IIR Filters,Signal flow Graphs and Transposed Structures,Cascade Realisation of IIR Filters,Parallel Realisation of IIR

Filters,Realisation of Linear –Phase FIR Filters, FIR Lattice Structure and IIR Lattice Structure, Examples.

Finite Word Length Effects in Digital Filters: Introduction, Fixed and Floating Point Numbers, Quantisation Noise,Input Quantisation Error,Product Quantisation Error, Signal Scaling,Quantisation in Floating Point Realisation of IIR Filters,Finite Word Length Effects in FIR Digital Filters,Quantisation Effects in the Computation of the DFT,Quantisation Errors in FFT Algorithms, Examples.

Special Topics: Fixed Point and Floating Point Digital Signal Processors-Architecture, Implementation of FIR And IIR Filters Using MATLAB, Spectral Estimation and Applications of DSP.

Readings:

1) Digital Signal Processing-Principles,Algorithms and Applications – John G. Proakis, Dimitris G.Manolakis,PHI 2000.
2) Digital Signal Processing – A Computer Based Approach, Sanjit K. Mitra, Tata Mc Graw Hill, 2007. 3.
3) Digital Signal Processing-Theory,Analysis and Digital-Filter Design-B.Somanathan Nair-PHI-2004.
4) Digital Signal Processors-Architectures,Implementations and Applications-Sen M.Kuo,Woon-Seng Gan-Pearson-2005
5) Discrete-Time Signal Processing", A.V.Oppenheim, R.W. Schafer and J.R. Buck, 8th Indian Reprint, Pearson, 2004.

PH7102- Microcontrollers and Embedded Ststems **L: 4 T:0 P:0 C:4**

The Intel mcs-51 Microcontroller Family Architecture:
8051 Internal architecture – I/O pins- Memory organization – I/O ports –Serial I/O, Timers and Counters –Interrupts –The enhanced members of 8051 family :8052,80515 –A/D and D/A equipped family members

Assembly Language programming of 8051
Data transfer instructions- Data processing instructions – programming flow control instructions – example programs.

PIC Microcontrollers
Introduction to PIC microcontrollers' family.PIC 18F452 Device overview – Special features of CPU-Capture/Compare/PWM module-USART-A/D module – Master synchronous serial port module.

Programming PIC Microcontrollers:
Instruction set of PIC 18f452 microcontroller and assembly language programming – Development Tools- MPLAB IDE, MPLABICD2, PIC START PLUS.

Hardware and Software Aspects of Interfacing
Interfacing of LCD, Key Board- Sensors and Stepper motors – Overview of Device Drivers.

Communication Interface Protocols:
Serial protocols: RS232, I^2C, CAN USB
Wireless protocols: IrDA, Bluetooth, IEEE 802.11

Readings:
1.THE 8051 MICROCONTROLLER ARCHITECTURE, PROGRAMMING AND APPLICATIONS By Kenneth J.Ayala v edition 2008.
2.Programming and interfacing the 8051 microcontroller by Sencer Yerralan, Asutosh Ahluwalia. Addison-Wesley, 2009.
3.www.microchip.com

Elective Courses

PH7116- Digital Communication **L: 3 T:0 P:0 C:3**

SAMPLING & QUANTIZATION: Low pass sampling – Aliasing- Signal Reconstruction- Quantization - Uniform & non-uniform quantization - quantization noise - Logarithmic Companding of speech signal- PCM – TDM

WAVEFORM CODING: Prediction filtering and DPCM - Delta Modulation - ADPCM & ADM principles-Linear Predictive Coding

BASEBAND TRANSMISSION: Properties of Line codes- Power Spectral Density of Unipolar / Polar RZ & NRZ – Bipolar NRZ - Manchester- ISI – Nyquist criterion for distortionless transmission – Pulse shaping – Correlative coding - Mary schemes – Eye pattern – Equalization

DIGITAL MODULATION SCHEME: Geometric Representation of signals - Generation, detection, PSD & BER of Coherent BPSK, BFSK & QPSK - QAM - Carrier Synchronization - structure of Non-coherent Receivers - Principle of DPSK.

ERROR CONTROL CODING: Channel coding theorem - Linear Block codes - Hamming codes - Cyclic codes - Convolutional codes - Vitterbi Decoder

Readings:

1. S. Haykin, "Digital Communications", John Wiley, 2005
2. B. Sklar, "Digital Communication Fundamentals and Applications", 2nd Edition, Pearson Education, 2009
3. B.P.Lathi, "Modern Digital and Analog Communication Systems" 3rd Edition, Oxford University Press 2007.
4. J.G Proakis, "Digital Communication", 4th Edition, Tata Mc Graw Hill Company, 2001.

PH7117- Electronic Instrumentation **L: 3 T:0 P:0 C:3**

Oscilloscopes and logic analyzers: Basic operation and advanced techniques, digital storage oscilloscope- sampling methods; controls- display, vertical, horizontal, trigger and acquisition controls; Measurements- voltage, time, frequency, pulse, rise time and fully automated measurements. Logic analyzer- types, logic timing analyzer (LTA), logic state analyzer (LSA), block diagram, interfacing.

Signal sources, arbitrary waveform generators and pattern generators: Introduction, fixed and variable AF oscillator, standard signal generator, laboratory type signal generator, AF sine and square wave generator, function generator, square and pulse generator, sweep generator, arbitrary waveform generators.

Spectrum and network analyzers: Wave analyzers- resonant, frequency selective, heterodyne-applications; Harmonic distortion analyzer, Spectrum analyzers, applications of spectrum analyzers, fundamental principles of network analyzer.

Virtual instrumentation: Personal computer for data acquisition and instrument control, instrument drivers and driver software, GPIB – VXI, PCI and PXI bus standards, application software lab view.

Calibration of instruments: Calibration of practical instruments, types of DMM, general DMM calibration requirements, calibration of oscilloscopes, calibration of high speed DSO's automated calibration and calibration software.

Readings:

1. Kularatna, A.D.V.N., *Digital and analogue instrumentation: testing and measurement*, Prentice Hall of India, Private Ltd., New Delhi, 2001.

2. M.M.S. Anand., *Electronic Instruments and Instrumentation Technology*, PHI India, 2005.

3. H.S. Kalsi., Electronic Instrumentation, Mc Graw Hill Education, 3rd ed. 2015.

4. David A. Bell., Electronic Instruments and Measurements, Oxford Higher Education, 3rd Ed., 2015.

PH7118- Fiber Optic Communication **L: 3 T:0 P:0 C:3**

Introduction to optical fiber communications: Introduction-Elements of an optical fiber transmission link- Advantages of optical fibers – Evolution of optical fiber systems and applications.

Power Launching and Coupling: Source to fiber power launching –Lensing schemes for coupling-Fiber end preparation-Fiber to Fiber Joints- Splicing – Connectors.

Optical Receivers and Transmission Systems: Fundamental Receiver operation – Digital Receiver performance – Analog Receivers – Digital Transmission systems – Point-to-Point links

–Power and rise time budget- Analog Systems – Carrier-to-noise ratio – Coherent optical fiber communication techniques.

WDM Concepts and Components: Principle of WDM – Passive components – Couplers – Multiplexers –Fiber grating filters –Phase array based WDM devices –Tunable sources and filters.

Optical Amplifiers: Basic applications and types of optical amplifiers –Semiconductor optical amplifiers- Erbium Doped fiber amplifiers – Noise – Wavelength converters.

Optical Networks: Basic networks – SONET/SDH – Broadcast-and-select WDM networks – Wavelength Routed Networks – Nonlinear effects on network performance – Performance of WDM + EDFA system-Solitons – Ultrahigh Capacity Networks.

Measurements: Measurement Standards and Test Procedures – Test Equipment – Attenuation and Dispersion measurements – OTDR applications – Eye Patterns – OSA applications.

Readings:

1. Optical fiber Communications, Gerd Keiser, Tata McGraw-Hill Education, 2008
2. Fiber Optic Communications, V edition, Joseph C.Palais-Pearson Education – 2011.
3. Optical Fiber Communications, John M. Senior- Third Edition– Pearson Education-2009.
4. Optical Fiber Communications Principles and Systems – A. Selvarajan, Subrat Kar, T.Srinivas Tata McGraw-Hill Education, 2003
5. Fiber Optic Communications Systems, Third Edition- Govind P.Agarwal, Wiley; 4 edition -2010

PH7119- Medical Instrumentation **L: 3 T:0 P:0 C:3**

Overview of Human body - Origin of biopotentials -ENG, EMG,ECG and EEG- Heart and ECG Waveform - standard lead system and functional blocks - Biofluid mechanics - Blood pressure measurement – Different blood flow meters - Electric impedance plethysmography - photo plethysmography - pulse oximetry.

Reading:

1. Brown, B.H., Medical Physics and Biomedical Engineering, Institute of Physics Publishing, 1999.
2. John. G. Webster, Medical Instrumentation : Application and Design, 2nd Edition, John Wiley and Sons, 1995

PH7120- Solar Energy Systems **L: 3 T:0 P:0 C:3**

Introduction to solar energy systems: Why solar energy-Types of solar energy harvesting technologies-Different applications of solar energy-Photo voltaic solar energy-Crystalline silicon solar cell and module technology-CdTe solar cells.

Control Issues in Solar System: Sun tracking-tracking systems-Solara irradiance over PTC-Solar irradiance estimation and forecast-Control of the energy conservation units.

Photo Voltaic: Power point tracking- solar tracking- automatic tracking strategy-Basic control of parabolic troughs-modeling and simulation approaches- basic control algorithms-new trends-Direct steam generation.

Central Receiver systems: Control of central receiver systems-Technologies and subsystems-advances in modeling and control of solar CRS-The heliostat field control system- Aiming strategies-Power stage control

Methods of Energy Storage Electrical generation capacity-The energy density problem-Thermal Energy systems-Electrical and Electro mechanical storage systems- Battery and Battery technology.

Readings:

1. Building Integrated Solar Energy Systems by Robert E.Parking, CRC Press,2012.

2.Control of Solar Energy Systems by E.F.Camacho,M.Berenguel,F.R.Rubio,D.Martinez by Springer publishes 2014.

PH7121- Display Technologies **L: 3 T:0 P:0 C:3**

Introduction to display optics Ray tracing; polarization; birefringence

Liquid crystal displays Physical properties of nematic, chiral nematics and blue phase; TFT basics; Liquid crystal display modes: Twisted nematic (TN), Super twisted nematic mode (STN), Double super twisted nematic (DSTN), Inplane switching mode (IPS), Liquid Crystal on silicon (LCoS), Patterned vertical alignment mode (PVA); Chiral systems and scattering displays.

Emissive display technology Brief discussion about semiconductors; Cathode Ray Tube (CRT); Field emission display (FED); Surface-conduction Electron-emitter Display (SED); Vacuum Fluorescent Display (VFD); Electroluminescent Displays (ELD); Light-Emitting Diode Displays

(LED); Plasma Display Panel (PDP); Electrochemical Display (ECD); Organic Light Emitting Diode (OLED); Polymer Light Emitting Diode (PLED).

Emerging display technologies, Quantum Dot Display (QDLED); Laser Phosphor Display (LPD); Organic Light Emitting Transistor (OLET); Nanocrystal Display; Thick-film dielectric electroluminescent (TDEL); Inferometric Modulator Display (IMOD)

Readings

1. Peter J. Collings and Michael Hird, Introduction to Liquid Crystals, Taylor and Francis, 1997.
2. Articles provided in class plus faculty notes provided in the powerpoint presentations
3. S.T.Lagerwall, P.G.Rudquist, D.S.Hermann: "Liquid crystals", in Encyclopedia of optical Engineering, Marcel Dekker Inc. 2003)
4. D.Demus et al. (editors) Handbook of Liquid Crystals, Volume 1-3, Wiley VCH, 1998
5. Electronic image display (by Jon C. Leachtenauer)
6. Display systems: design and applications (Edited by Lindasay W. MacDonald and Anthony C. Lowe)
7. Introduction to Flat Panel Displays by Jiun-Haw Lee, David N. Liu, Shin-Tson Wu
8. Electronic Information Display Technologies By T J Nelson and J R WullertII
9. Display Technologies by R. Sharan, K.R. Sarma, B. Mazari and S.K. Iyer. ‘
10. Advanced Display Technologies by Paul Anderson

PH7122- Telemetry and Telecommand **L: 3 T:0 P:0 C:3**

Telemetry System Definition Learning Objectives- Telemetry System Overview -Data Collection System -Multiplex System- FDM System- Pulse Code Modulation TDM -Combination of FDM and TDM -Modulator, Transmitter, and Antenna-Transmission or Waveform Channel Antennas, Receivers with RF and IF-Amplifiers, and Carrier Demodulators -Demultiplex System Frequency Division Demultiplexing- Time Division Demultiplexing-Hybrid Systems -Data Processing, Handling, and Display -Supporting Equipment and Operations

Design of FM/FM Systems -System Parameters -Design Procedure -Design Examples-Threshold- Changing the Preemphasis Schedule to Utilize Specified IF or Transmission Bandwidth -Designing to a Specified Transmission Bandwidth-Designing the Preemphasis Schedule for Different Values for the *Dsi* ’s - Designing the Preemphasis Schedule for the Minimum Transmission Bandwidth with Equal *Dsi* ’s (Concurrent All-Channel Dropout) -- Designing the Preemphasis Schedule for All-Channel Dropout and Unequal *Dsi* ’s - Designing

the Preemphasis Schedule for Different Specified Signal-to-Noise Ratios in the Channels - Hardware Implementation of the PreemphasisSchedule Summary of Design Procedures

Reliability and availability-Introduction-Reliability -Availability -SCADA system reliability (or failure) rates -Complete system testing -Improving reliability -Reliability calculation Qualification of the processes.

Integrating telemetry systems into existing radio systems – General-Appropriate radio systems -Traffic loading -Implementing a system -Trunking radio -Ocean data telemetry application - Electromechanical cable -Acoustic modem -Inductive modem -Physiological telemetry application.

Readings

1. Telemetry Systems Engineering by Frank Carden, Russell Jedlicka, Robert Henry published by Artech House Boston · London-2002

2. Practical Radio Engineering and Telemetry for Industry by David Bailey-Newness publications 2003

PH7125- Data Communication **L: 3 T:0 P:0 C:3**

Basic Concepts of Data Communication Introduction – Data communication networks – Standards – ISO reference model –Functions of Layers –Basics of Data Transmission – Asynchronous and Synchronous Data Transmission-Error Detection methods –Data compression –Communication Control Devices –Data modems- Asynchronous and Synchronous, low speed, medium speed and High speed modems.

Protocol Basics and Data link Protocols Introduction –Error Control – Idle RQ –Continuous RQ protocols – Link Management –Data link Protocols – Character and Bit Oriented Protocols.

Introduction to local area networks Medium Access Control -LAN performance - **LAN standards** IEEE 802.2 -IEEE 802.3 CSMA/CD -IEEE 802.4 token bus -IEEE 802.5 token ring - Wireless LANs.

Packet-switched and frame relay networks Evolution of switched communications -X.25 packet-switched networks - Frame relay networks Frame relay traffic management

Internetworking Internetworking requirements -Internetworking techniques-The Internet - Security **Internet protocols** The TCP/IP suite - Internet Protocol - Routing protocols -Transport layer protocols -Virtual private networks -Real-Time Transport Protocol and Voice over IP- Multi Protocol Label Switching (MPLS) 3-Packet over SDH/SONET -IP security -

Introduction to Satellite Communication Systems Satellite Orbits-Geostationary Satellites - Antenna look angles – Satellite classifications – Spacing and frequency allocation –Satellite Antenna radiation pattern –Satellite system link models- Satellite system parameters –Link equations- channel capacity and Radio navigation.

Readings:

1. Data communications, Computer networks and Open Systems –Fred Halsall VI edition Pearson Education, 2013. (Unit 1 & 2)

2. Data Communications for Computer Networks -Second Edition -Michael Duck & Richard Read Pearsonedn 2003. (unit 3,4 & 5)

3. Advanced Electronic Communication Systems –Wayne Tomasi, VIII edition, PHI 2009 (unit 6).

PH7126- Satellite Communication **L: 3 T:0 P:0 C:3**

Introduction: Introduction to Satellite Communications-Early History of satellite communications-Basic satellite system definitions-Satellite Orbits- Kepler's laws-Orbital parameters-Geometry of Geo synchronous links-Satellite sub systems-satellite bus-satellite payload.

The Space Segment: Introduction-The Power Supply-Attitude Control-Station Keeping-Thermal Control-TT&C Subsystem-Transponders-The Antenna Sub system.

The Earth Segment: Introduction-Receive only home TV systems-Outdoor unit-Indoor unit for analog TV-Master antenna TV System-Communication antenna TV system-Trans receive Earth Stations.

The Space Link: Introduction- Equivalent Isotropic Radiated Power- Transmission Losses- The Link-Power Budget Equation-System Noise- Carrier to Noise Ratio-The Uplink-Downlink - Combined Uplink and Downlink *C/N* Ratio.

Satellite Access: Introduction-Single Access-Preassigned FDMA-Demand-Assigned FDMA-FDMA downlink analysis-TDMA-On-Board Signal Processing for FDMA/TDM Operation-Satellite-Switched TDMA -Code-Division Multiple Access.

Satellite Applications: INTELSAT series-Mobile satellite services-VSAT-GSM-GPS-INMARSAT-LEO-MEO-Satellite Navigational System-DBS-DTH-DAB-TV (BTV)-GRMSAT-Specialized Services.

Text Books:
1. Satellite Communication's & System Engineering: Louis.J.Ippolito.Jr Wiley 2008. (Unit-1)

2. Satellite communications by Dennis Roddy-Mc Grew Hill –IV edition-2006.(Unit2-6)

PH7126- Silicon Photonics **L: 3 T:0 P:0 C:3**

Introduction to Optical properties of Silicon, Limitations of Electronics, Need of Silicon Photonics, Challenges and future astects.

Silicon Optical waveguide; Waveguide materials; Planar , Rib, Ridge, Strip Waveguides; waveguide losses and polarization issues, Effect of stress and birefringence; Resonant Waveguide Structures.

Waveguiding devices; Directional, Star, Multimode, Y-Junction couplers; Coupling schemes of waveguides; Horizontal and Vertical coupling; Prism and grating coupling; coupling ports.

Source and Detectors; Silicon Integrated Light Sources, Properties of Silicon Nanocrystals, Light emitting germanium, Silicon Lasers, Hybrid III-V/silicon light sources; Silicon Germanium Photodetectors

Fabrication Techniques: Spattering, Epitaxial growth, Molecular Bean Epitaxy, Lithography; Integration and packaging methods

Reading :

1. G. P Reed and A. P. Knights, *Silicon Photonics: An Inroduction* ,Willey, 2005.
2. L. Pavesi and D. J. Lookwood, *Silicon Photonics*, Springer, 2008.

(Photonics Specialization)

Core Courses

PH7105- Opto Electronic Sensing and MOEMs **L: 4 T:0 P:0 C:4**

Basics of sensors, sensing parameters, Modulators; Introduction to Optoelectronic Sensors

Fiber Optic Sensors; Fundamentals of fiber technologies, basic classifications, Intensity and phase modulated sensors, Interferometry and polarization based sensors, Fiber optic gyro, various types of sensors and their design characteristics, Introduction to special types of fiber for sensor application

FBG and LPGs and their sensor applications, Introduction to the analyzing equipment like Optical spectrum analyzer, OTDR and Interrogator. Practical implementation of photonic sensor in health monitoring and stress analysis.

Optical switching and multiplexing architectures, distributed sensors, Optical actuation and control, Intelligent Surveillance with opto electronic sensor

Image sensors; Imaging and display technologies, CCD Technology, Optical scanning and printing, Introduction to some display tools.

Introduction to MOEMs, Micro Optics, design, fabrication and implementations of MOEMs systems. Challenges and example studies and applications.

Readings:

1. "Optical Fiber Sensors" Vol I & II, Edited by Brian Culshaw and Jhon Dakin, 1989.

2. "Fiber optic Sensors" Second Edition , Edited by Shizhuo Yin, Paul B. Ruffin, Francis T.S. Yu, T&C publisher, 2008.

3. "MOEMS: Micro-Opto-Electro-Mechanical System" edited by M. E. Motamedi, Springer, 2005.

PH7106- Fourier Optics and Holography **L: 4 T:0 P:0 C:4**

Scalar Diffraction Theory: Introduction -The Intrgrul Theorem of Helmholtz and Kirchhof-Kirchhoff Formulation of Diffraction - The Fresnel-Kirchhoff Diffraction Formula - Rayleigh-Somrnerfeld Formulation of Diffraction - Comparison of the Kirchhoff and Rayleigh-Sommerfeld Theories - Generalization to Nonmonochromatic Waves - The Angular Spectrum of Plane Waves.

Fresnel and Fraunhofer Diffraction: The Huygens-FresnelPrinciple in Rectangular Coordinates-The Fresnel Approximation - Angular Spectrum-The Fraunhofer Approximation - Rectangular Aperture - Circular Aperture - Thin Sinusoidal Amplitude and phase Grating - Examples of Fresnel Diffraction Calculations.

Wave-Optics Analysis of Coherent Optical Systems: Thin Lens as a Phase Transformation - Fourier Transforming Properties of Lenses - Image Formation: Monochromatic Illumination - Analysis of Complex Coherent Optical Systems.

Frequency Analysis of Optical Imaging Systems: Frequency Response for Diffraction-Limited Coherent Imaging - Frequency Response for Diffraction-Limited Incoherent Imaging – OTF - OTF of an Aberration-Free System - Aberrations and Their Effects on Frequency Response - Comparison of Coherent and Incoherent Imaging - Frequency Spectrum of the Image Intensity.

Spatial filtering and optical information processing: Photographic film – Incoherent processing – Systems based on geometrical optics – Frequency domain synthesis – Vander Lugt filter – Character recognition.

Holography: Basic concepts – Gabor zone plate – Inline, off axis holograms – Characteristics of reconstructed images – Types of holograms – Holographic system requirements and practical considerations – Experimental techniques to record hologram – Pulsed laser Holography – Acoustical holography.

Hologram recording materials: Silver Halide – Photoresists– Photo Polymer– DCG– Photo thermoplastic – Photo refractive etc.

Special purpose holography: Fourier transform holograms – Composite holograms – Information storage and reduction – Optical disc-digital computation – Multiplexing and coding – Computer generated holograms – HOE's – Applications of HOE's.

Readings

1. Introduction to Fourier Optics – J.W.Goodman (McGraw Hill)

2. Optical Holography – R.J.Collier et al (Academic)

3. Applied Optics – A guide to optical system deisgn -Vol.2 – Leo Levi, (John Wiley)

4. Laser Speckle and Related Phenomena – J.C.Dainty (Springer)

5. Principle of Optics - Born & Wolf (Pergamon)

6. Holographic Non Destructive Testing – Erf (Academic)

Elective Courses

PH7128- Optical Element Production and Testing **L: 3 T:0 P:0 C:3**

Course content:

Optical glass: types, composition, chemical behavior, mechanical and thermal properties, low expansion materials, fused quartz, crystal quartz, mirror materials.

IR materials: Ge-Si – gallium arsenide, zinc selenide, zinc sulphide, optical crystals, alkaline earth fluorides, Alkali Halides, KDP and homologs, optical plastics, metal optics, ceramic materials.

Material production:

(a) glass making, dry and continuous tank methods, limitations, inspection for flaws

(b) IR materials manufacturing, chemical vapor deposition, CZ method, float zone refining, casting of silicon, horizontal Bridgeman, liquid encapsulated Czochralski.

(c) Growth methods for optical crystals, hydrothermal process, heat exchanger method, solution grown crystals.

Optical shop supplies: abrasives, polishing compounds, pitch, cements, coolants and solvents**.**

Tools and fixtures: spherical and plano tools, spot blocks, diamond tools

Optical fabrication: shaping-milling-grinding-polishing, centering, cementing, thin film coating

Optical shop testing: interferometric testing, spherometry, autocollimator, surface analysis, testing after assembly.

Suggested texts and reference materials:

Reading

Hank H. Karow, *Fabrication Methods for Precision Optics*, John Wiley and Sons, New York, 1993.

David Malacara, *Optical shop testing*, John Wiley and Sons, New York, 1992.

PH7129- Biophotonics **L: 3 T:0 P:0 C:3**

Fundamentals of Biology: Basics of Cells and Cell structure, Cellular processes in living body, Protein classification, Types of tissues – Functions

Basics of light-matter interactions in molecules, cells and tissues: Nature of light **,**Refraction, reflection, interference, diffraction **,**Intensity, phase, polarization, scattering, Raman, fluorescence,Optical properties of bio-materials

DNA: How to use light to find out information of our genomes: DNA sequencing, DNA replication/repair, Illumina and PacBio sequencing, Virus detection and identification using PCR

RNA: Why is each tissue different from others? DNA to RNA transcription Count RNA numbers in cells/tissues: qPCR and RNA-FISH

Proteins: Enzyme, antibody, Every cell has different gene expression level: Flow cytometry, Dissect folding dynamics of proteins: Single molecule FRET, Drug screening: SPR sensor

Bioimaging: *Non-fluorescence-based microscopy*, Bright-field/Phase contrast/Dark-field/DIC microscop, Raman imaging (SRS microscopy), *Fluorescence-based microscopy* Fluorophores (Green fluorescent protein), Epi/Confocal/TIRF microscopy

Diagnosing diseases with light: Endoscopy, Optical coherence tomography (OCT): Application to ophthalmology, Photoacoustic tomography: Application to early cancer detection

Treatment of diseases with light: Killing cancer cells with light: Photodynamic therapy, Tissue engineering with light

Optical Imaging: Basic imaging theory, concept of diffraction limit. Optical microscope - Methods for contrast-generation (Dark-field, Phase contrast, DIC, Polarization) - Fluorescence microscopy. Fluorescence techniques (FRET)

Readings:

1. Paras N. Prasad, *Introduction to Biophotonics*, Wiley Interscience (2003)
2. Born, M., and Wolf, E., *Principles of Optics*, Pergamon Press (1965)
3. Atkins, P., and dePaula, J., *Physical Chemistry*, W.H. Freeman, (2002)
4. Graybeal, J. D., *Molecular Spectroscopy*, McGraw-Hill (1988)
5. Lakowitcz, J. R., *Principles of Fluorescence Spectroscopy*, Plenum (1999)
6. Stuart, B., *Biological Applications of Infrared Spectroscopy*, John Wiley & Sons, (1997)
7. Boyd, R.W., *Nonlinear Optics*, Academic Press, (1992)
8. Svelto, O., *Principles of Lasers*, Plenum Press (1998)

9. Diaspro, A., ed., *Confocal and Two-Photon Microscopy: Foundations Applications, and Advances*, John Wiley & Sons, (2002)
10. Ligler, F. S. and Rawe-Taitt, C. A., eds, *Optical Biosensors: Present and Future*, Elsevier (2002)
11. Greulich, K. O., *Micromanipulation by Light in Biology and Medicine*, Birkhäuser Verlag (1999)
12. http://www.microscopyu.com
13. Gould,T. J., Hess, S.T., Bewersdorf, J., Ed.: Yarmush, ML, *Optical Nanoscopy: From Acquisition to Analysis* , Annual Review Of Biomedical Engineering, 14, 231-254 (2012)
14. Gauglitz, G., *Direct optical detection in bioanalysis: an update* , Analytical And Bioanalytical Chemistry, 398, 2363-2372 (2010)
15. Katzir. A, Lasers and Optical Fibers in Medicine, AP, 1993.

PH7130- IR Optics and Thin Films **L: 3 T:0 P:0 C:3**

Introduction to IR Optics: Propagation of electro-magnetic in stratified dielectric medium, Fresnel equations Optical properties of materials, metals, semiconductors and dielectrics, optical glass materials in the visible and near infrared region, IR optical materials, Multilayer thin film optics, Antireflection coatings, Band pass optical filters, edge filters, dichroics, Design – Optimization techniques for thin film multilayer, Merit function as applied to thin film coatings.

Optimization techniques as applied to optical coating: Case studies for design approaches for different categories of optical coatings. Exposure to thin film software packages. Concept of linearly variably and circularly variable filters, Tunable optical filters. Reflective coatings, enhanced reflectors

Thin film technology: Vacuum Science: Viscous, Lamellar and molecular fluid region, Medium, High and Ultra-high vacuum techniques. Mechanical and High vacuum pumps, ultra-high vacuum pumps. High vacuum measurement techniques, principle, calibration and electronics read out Deposition and production of optical thin films: Thin film deposition techniques thermal/electron beam evaporation, RF/DC sputtering, Ion beam sputtering, pulsed laser beam deposition. In-situ thickness monitoring: Optical and quartz micro-balance techniques monitoring techniques. Architecture of modern day coating plants

Characterization of optical thin films: Principles of characterization of optical reflectance, transmittance, absorbance and angle resolved scattering. Principles of spectrophotometers and ellipsometers. FTIR spectrometers Characterization of non-optical properties of thin films: Mechanical adhesion, abrasion and hardness. Surface characterization techniques for thin films: Surface morphology, X-ray structure, Chemical composition. SEM, TEM and AFM instruments for thin film characterization

Space qualification: Different environments encountered by Optical components in ground during storage, instrument assembly and testing, launching and in deep space. Adverse environmental conditions in deep space. Radiation environment in space. Space Qualification of Optical coatings and materials. Effect of space environment on optical materials and thin films.

Readings:

1. Thin film optical filters, Angus Macleod

2. Principles of optics, Born and Wolf,

3. SPIE milestone series on -Design of optical coatings

4. Optical Thin films – User hand book – James D Rancourt SPIE Press – 1996 – ISBN 0819422851

5. Practical Design and Production of Optical Thin Films – Second Edition – Ronald Ron Wiley –CRC Press – 2002 ISBN 0824708490

6. Handbook of Thin Film Technology- Leon –Imaissel & Reihard Glang –Mc Graw –Hill Book Company -1970 –ISBN 0070397422

7. Essential Macloed Software, By Angus Macleod

PH7131- Nano Photonics **L: 3 T:0 P:0 C:3**

Nanotechnology and Nanomaterials: Introduction to Nanotechnology, Physics of Nanotechnology, Physical properties of Nanomaterials, Optical behaviors of Nanamaterials, Introduction to synthesis methods of Nanomaterials, Application

Near field optics: Behaviors of light field at lower dimension, Physical aspects of near field, Near field microscopy, Advantages and limitations.

Photonics at lower dimensions: Metal-dielectric interaction, Origin of plasmonics, Surface plasmon resonance, Plasmonic devices, Quantum well, wire and dots and their fabrication technique and applications.

Photonic crystal: Natural and artificial photonic crystal, Origin of photonic bandgap, 1D, 2D, 3D photonic crystals and their fabrication and applications, Nanophotonic devices.

Reading :

1. S. V Gaponenko, *Introduction to Nanophotonics*, Cambridge University Press, 1st Edition, 2010.
2. P. N. Prasad , *Nanophotonics*, John Wiley & Sons, 3rd Edition, 2008.

PH7132- Integrated Optics **L: 3 T:0 P:0 C:3**

Electromagnetic wave propagation in optical waveguides: Helmholtz's equation; Mode theory, classification of modes; Leaky modes; Modal behavior in symmetric and asymmetric planer optical waveguide. Modal analysis in various types of optical fibers; propagation characteristics in optical fibers; Scalar and vector modes.

Optical waveguide devices: Various types of optical waveguide for optical chip design; Physical characteristics due to guided wave propagation; on chip photon network circuit, Applications**.**

Acoustooptic and Electrooptic effect: Analysis of train optic tensor; Raman-Nath diffraction; Bragg diffraction; Electrooptic effects on KDP and Lithium niobate crystal; Device applications

Fabrication and realization of optical waveguides: various fabrication techniques: Spattering, Epitaxial growth, Molecular Bean Epitaxy, Lithography, Light coupling methods in optical waveguides.

Readings :

1. Robert G. Hunsperger, *Integrated Optics: Theory and Technology*,Springer, 2009.
2. Ajoy Kumar Ghatak, K. Thyagarajan, *Optical Electronics*, Cambridge University Press, 1989.

PH7134- New Lasing Materials **L: 3 T:0 P:0 C:3**

Introduction : Historical Background , Early developments , Technological developments , Laser Materials , Elements of a typical laser oscillator, Gain medium , The laser pumping unit and pumping methods, Optics

Solid State Laser Materials: Properties, Optics, Material design, Mechanical design, Doping Ions, Laser host materials, General Properties of Hosts, Optical properties, Chemical properties, Mechanical properties, Thermal properties

Garnet Crystals as Laser Hosts: Physical Characteristics of Garnets and Mixed Garnets, Chromium- and Neodymium-Doped Garnets, Disordered (Mixed) Garnets , Glass and Crystalline Ceramics

Fluoride Laser Crystals: YLiF4 (YLF), Thermal and Mechanical Properties of YLF, Estimate of thermal load at fracture, Nonradiative Losses in YLF, Neodymium-Doped YLF , Holmium-Doped YLF, Thulium-Doped YLF, Other Fluorides Crystals, Cascade Emission, Upconversion, Applications to upconversion

Photophysics of Solid State Laser Materials: Properties of the Lasing Ion, Absorption, Homogenous and nonhomogenous broadening, Spontaneous emission, Stimulated emission, Oscillator strength, Nonradiative Transition , Energy gap and temperature dependence of multiphonon relaxation, Temperature dependence of nonradiative relaxation

Energy Transfer: Introduction, Radiative Energy Transfer, Nonradiative Energy Transfer , Basic mechanisms of energy transfer, Resonant energy transfer, Exchange interaction, Phonon-assisted energy transfer, Pathways of excited state relaxation, Statistical model (Inokuti-Hirayama model)

Two-Micron Lasers: Holmium- and Thulium-DopedCrystals: Introduction, Advantages of the Holmium Laser, Utilizing energy transfer, Conventional Pumping CW laser operation , Pulsed operation of holmium lasers, Diode Pumping , End-pumped 2 um lasers, Side-pumped 2 um lasers

Reading:

The Physics and Engineering of Solid State Lasers, Yehoshua Y. Kalisky

PH7135- Image Processing **L: 3 T:0 P:0 C:3**

Introduction, Elements of digital image processing, Image model, Sampling and quantization, Relationships between pixels

Image Transforms, Discrete Fourier Transform, Discrete Cosine Transform, Haar Transform, Hadamard Transform

Image Enhancement, Enhancement by point processing, Spatial filtering, Enhancement in the frequency domain, Color Image Processing

Image Segmentation, Discontinuity detection, Edge linking and boundary detection, Thresholding, Region oriented segmentation, Use of motion for segmentation

Representation and Description, Boundary description, Regional description

Morphological Image Processing, Dilation and Erosion, Opening and Closing, Some basic morphological algorithms, Extensions to gray level images.

Readings

Digital Image Processing, Rafael Gonzalez, 2nd edition Addison-Wesley