SREEPATHY INSTITUTE OF MANAGEMENT AND TECHNOLOGY

COURSE HANDBOOK

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

SEMESTER 3

EET 201 CIRCUITS & NETWORKS

COURSE INFORMATION SHEET:

Program: **Electrical & Electronics Engineering**	Degree :**B-Tech**
Course**: Circuits & Networks**	Course code**: EET 201**
L-T-P**:-2-2-0-4**	Credit**:4**

SYLLABUS:

MODULE	CONTENT	HOURS	UNIVERSITY % MARKS
I	Network theorems – Superposition theorem – Thevenin's theorem – Norton's theorem – Reciprocity Theorem – Maximum power transfer theorem – dc and ac steady state analysis – dependent and independent sources	12	20
II	Analysis of first and second order dynamic circuits: Formulation of dynamic equations of RL, RC and RLC series and parallel networks with dc excitation and initial conditions and complete solution using Laplace Transforms - Time constant - Complete solution of RL, RC and RLC circuits with sinusoidal excitation using Laplace Transforms – Damping ratio – Over damped, under damped, critically damped and un damped RLC networks.	9	20
III	Transformed circuits in s-domain: Transform impedance/admittance of R, L and C - Mesh analysis and node analysis of transformed circuits in s-domain. Transfer Function representation – Poles and zeros Analysis of Coupled Circuits: – Dot polarity convention – Sinusoidal steady state analysis of coupled circuits - Linear Transformer as a coupled circuit - Analysis of coupled circuits in s-domain.	9	20
IV	Three phase networks and resonance: Complex Power in sinusoidal steady state. Steady state analysis of three-phase three-wire and four-wire unbalanced Y circuits, Unbalanced Delta circuit, Neutral shift. Resonance in Series and Parallel RLC circuits – Quality factor – Bandwidth – Impedance Vs Frequency, Admittance Vs Frequency, Phase angle Vs frequency for series resonant circuit.	6	20
V	Two port networks: Driving point and transfer functions – Z, Y, h and T parameters - Conditions for symmetry & reciprocity – relationship between parameter sets – interconnections of two port networks (series, parallel and cascade) — T-π transformation	9	20

TEXT BOOKS:

1	Hayt and Kemmerly: Engineering Circuit Analysis, 8e, Mc Graw Hill Education , New Delhi, 2013.

2	Ravish R. Singh, "Network Analysis and Synthesis", McGraw-Hill Education, 2013

REFERENCES:

1	SiskandC.S:ElectricalCircuits,McGrawHill
2	Joseph.A.Edminister:TheoryandproblemsofElectriccircuits,TMH
3	DRoyChaudhuri:NetworksandSystems,NewAgePublishers
4	A.Chakrabarti:CircuitTheory(AnalysisandSynthesis),DhanpatRai&Co
5	Valkenberg:NetworkAnalysis,PrenticeHallofInd
6	B.R.Gupta:NetworkSystemsandAnalysis,S.Chand&Companyltd

PREREQUISITE: Basics of Electrical Engineering / Introduction to Electrical Engineering

COURSE OBJECTIVES:

1	To learn about various techniques available to solve various types of circuits and network
2	To gain the capability to synthesize a circuit for a particular purpose.

COURSE OUTCOMES:

After successful completion of the course, the students should be able to:

CO's	DESCRIPTION
CO 1	Apply circuit theorems to simplify and solve complex DC and AC electric networks.
CO 2	Analyse dynamic DC and AC circuits and develop the complete response to excitations.
CO 3	Solve dynamic circuits by applying transformation to s-domain
CO 4	Analyse three-phase networks in Y and Δ configurations
CO 5	Solve series /parallel resonant circuits
CO 6	Develop the representation of two-port networks using network parameters and analyse

CO-PO-PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		PSO1	PSO2	PSO3
CO1	**3**	**3**										**2**		**2**	**1**	**1**
CO2	**3**	**3**										**2**		**2**		
CO3	**3**	**3**										**2**		**2**		
CO4	**3**	**3**										**2**		**1**		
CO5	**3**	**3**										**2**		**1**		
CO6	**3**	**3**										**2**		**1**		

CO-PO MAPPING JUSTIFICATION:

EET 201	**CO1**	**PO1**	**3**	Student will be able to apply the knowledge of Engineering fundamentals to write equations using Network Theorems
		PO2	**3**	Student will be able to simplify equations of complex DC and AC circuits
		PO12	**3**	Student will be able to solve equations of complex DC and AC circuits
	CO2	**PO1**	**3**	Student will be to able to apply the knowledge of Engineering fundamentals to determine the Laplace transform
		PO2	**3**	Student will be able analyse the transient response of various circuits and predict the performance
		PO12	**3**	Student will be able to solve solutions for problems associated with various circuits based on the transient response
	CO3	**PO1**	**3**	Student will be to able to apply the knowledge of transformation of S domain
		PO2	**3**	Student will be able analyse the coupled circuit in s domain
		PO12	**3**	Student will be able to solve solutions for problems associated with s domain
	CO4	**PO1**	**3**	Student will be able to apply engineering fundamentals and an engineering specialization to the solution of star and delta configuration
		PO2	**3**	Student will be able to simplify equations of star and delta configuration
		PO12	**3**	Student will be able to solve the problems associated with star and delta configuration
	CO5	**PO1**	**3**	Student will be able to apply the knowledge of Engineering fundamentals to write equations using resonance circuits
		PO2	**3**	Student will be able to simplify equations of series and parallel resonance circuits
		PO12	**3**	Student will be able to solve the problems associated with resonance circuits
	CO6	**PO1**	**3**	Student will be able to determine the network parameters using fundamental engineering aspects
		PO2	**3**	Student will be able to analyse the performance of any circuit using two port approach
		PO12	**3**	Student will be able to solve the problems associated with two port networks

CO-PSO MAPPING JUSTIFICATION:

	CO1	**PSO1**	**2**	Graduates will able to apply the equations using network theorem
		PSO2	**1**	Graduates will able to apply different methods for solving the networks
		PSO3	**1**	Graduates will able to understand the problems that occur in network
	CO2	**PSO1**	**2**	Graduates will be able apply the Laplace transforms in a network.
	CO3	**PSO1**	**2**	Graduates will be able apply the transformation in s domain
	CO4	**PSO1**	**1**	Graduates will be able identify the three phase network
	CO5	**PSO1**	**1**	Graduates will able to design a resonant network
	CO6	**PSO1**	**1**	Graduates will be able design a two port network

EET 205 ANALOG ELECTRONICS

COURSE INFORMATION SHEET:

Program: **Electrical & Electronics Engineering**	Degree :**B-Tech**
Course**: Analog Electronics**	Course code**: EET 205**
L-T-P**:3-1-0-4**	Credit**:4**

SYLLABUS:

MODULE	CONTENT	HOURS	UNIVERSITY % MARKS
I	Bipolar Junction Transistors: Review of BJT characteristics-Operating point of BJT – Factors affecting stability of Q point. DC Biasing–Biasing circuits: fixed bias, collector to base bias, voltage divider bias, role of emitter resistance in bias stabilization. Stability factor (Derivation of stability factors for Voltage Divider Biasing only).Numerical problems. Bias compensation using diode and thermistor. BJT Model- h-parameter model of BJT in CE configuration. Small signal low frequency ac equivalent circuit of CE amplifier –Role of coupling capacitors and emitter bypass capacitor. Calculation of amplifier gains and impedances using h parameter equivalent circuit.	10	20
II	Field Effect Transistors: Review of JFET and MOSFET(enhancement mode only) construction, working and characteristics- JFET common drain amplifier-Design using voltage divider biasing. Frequency response of Amplifiers: Internal Capacitances at high frequency operations of BJT-Hybrid Pi model of BJT. Low and high frequency response of Common Emitter amplifier. Frequency response of CE amplifier, Gain bandwidth product	8	20
III	Multistage amplifiers: Direct, RC, transformer coupled Amplifiers, Applications. Power amplifiers using BJT: Class A,Class B,Class AB,Class C and Class D. Conversion efficiency – derivation (Class A and Class B). Distortion in power amplifiers. Feedback in Amplifiers-Effect of positive and negative feedbacks. Oscillators: Barkhausen's criterion RC oscillators (RC Phase shift oscillator and Wein Bridge oscillator) –LC oscillators (Hartley and Colpitt's)– Derivation of frequency of oscillation- Crystal oscillator.	9	20
IV	Operational Amplifiers: Fundamental differential amplifier-Modes of operation. Properties of ideal and practical Op-amp -Gain, CMRR and Slew rate. Parameters of a typical Op-amp IC 741. Open loop and Closed loop Configurations-Concept of virtual short. Negative feedback in Op-amps. Inverting and non- inverting amplifier circuits. Summing and difference	10	20

	amplifiers, Instrumentation amplifier.		
V	OP-AMP Circuits: Differentiator and Integrator circuits- practical circuits – Design –Comparators: Zero crossing and voltage level detectors, Schmitt trigger. Comparator IC: LM311. Wave form generation using Op-Amps: Square, triangular and ramp generator circuits using Op-Amp- Effect of slew rate on waveform generation. Timer 555IC: Internal diagram of 555IC–Astable and Mono stable multi-vibrators using 555 IC.	8	20

TEXT BOOKS:

1	Bell D. A., Electronic Devices and Circuits, Prentice Hall of India 2007
2	Malvino A. and D. J. Bates, Electronic Principles7/e, Tata McGraw Hill, 2010.
3	Boylestad R. L. and L. Nashelsky, Electronic Devices and Circuit Theory, 10/e, Pearson Education India, 2009.
4	Choudhury R.,Linear Integrated Circuits, New Age International Publishers. 2008.

REFERENCES:

1	Floyd T.L., Fundamentals of Analog Circuits,, Pearson Education, 2012.
2	Robert T. Paynter and John Clemons, Paynter's Introductory electronic devices & circuits, Prentice Hall Career & Technology, New Jersey
3	Millman J. and C. C. Halkias, Integrated Electronics: Analog and Digital Circuits andSystems, Tata McGraw-Hill, 2010.
4	Streetman B. G. and S. Banerjee,Solid State Electronic Devices, Pearson Education Asia,2006.
5	Gayakward R. A., Op-Amps and Linear Integrated Circuits, PHILearning Pvt.Ltd., 2012.

PREREQUISITE: Fundamentals of Electronics and semiconductor devices.

COURSE OBJECTIVES:

1	To impart an in depth knowledge in electronic semiconductor devices & circuits giving importance to the various aspects of design & analysis
2	To provide knowledge about different types amplifier & oscillator circuits and their design.
3	To provide a thorough understanding of the operational amplifier circuits and their functions

COURSE OUTCOMES:

After successful completion of the course, the students should be able to:

CO's	DESCRIPTION

1	Design biasing scheme for transistor circuits.
2	Model BJT and FET amplifier circuits.
3	Identify a power amplifier with appropriate specifications for electronic circuit applications.
4	Describe the operation of oscillator circuits using BJT
5	Explain the basic concepts of Operational amplifier(OPAMP)
6	Design and develop various OPAMP application circuits.

CO-PO-PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		PSO1	PSO2	PSO3
CO1	2	2	2											3		
CO2	2	2	2												3	
CO3			1	2												2
CO4	2	2	2											3		
CO5			1	2										3		
CO6	2	2	2													3

CO-PO MAPPING JUSTIFICATION:

CO 1	**PO1**	**2**	Students will be able to apply the basic knowledge of mathematics and engineering science.
	PO2	**2**	Students will be able to discuss and analyze the different types of biasing methods
	PO3	**2**	Students will be able to draw the Small signal equivalent of differential amplifier and derive the equations for Input resistance,
CO 2	**PO1**	**2**	Students will be able to apply basic engineering science to understand the concept of power semiconductor devices
	PO2	**2**	Students will be able to analyze JFET and MOSFET characteristics.
	PO3	**2**	Students will be able to design and model the BJT large signal amplifier as per the requirement
CO 3	**PO2**	**2**	Students will be able to discuss the different feedback topologies and compare different power amplifiers
	PO3	**2**	Students will be able to design different oscillator circuits
CO 4	**PO1**	**2**	Students will be able to analyze the properties of an ideal op-amp

	PO2	**2**	Students will be able to design various basic op-amp circuits.
	PO3	**2**	Students will be able to generate different desired waveforms using op-amp
CO 5	PO3	**1**	Students will be able to realize multi vibrators using 555 IC
	PO4	**2**	Students will be able to draw the internal block diagram of 555 Timer IC and explain
CO 6	**PO1**	**2**	Students will be able to explain the working of a ramp generator circuit using opamp
	PO2	**2**	Students will be able to design and set up an op-amp integrator circuit and plot the input and output waveforms.

CO-PSO MAPPING JUSTIFICATION:

CO1	**PSO1**	**3**	Students will be able to analyze the vehicle dynamics
CO2	**PSO2**	**3**	Graduates will have deep Knowledge on different schemes of electric hybrid vehicle resources and its connections.
CO3	**PSO3**	**2**	Graduates will be able to find suitable control strategies for hybrid electric vehicle motors
CO4	**PSO1**	**3**	Graduate will be able to identify and analyze the energy storage for hybrid electric vehicle
CO5	**PSO1**	**3**	Graduates will be able to identify and analyze the scheme for electric hybrid vehicles
CO6	**PSO3**	**3**	Graduates will be able to form basic communication network for hybrid electric vehicle

EET 203 MEASUREMENTS AND INSTRUMENTATION

COURSE INFORMATION SHEET:

Program: **Electrical & Electronics Engineering**	Degree :**B-Tech**
Course**: Measurements and instrumentation**	Course code**: EET 203**
L-T-P**:3-1-0**	Credit**:4**

SYLLABUS:

MODULE	CONTENT	HOURS	UNIVERSITY % MARKS
I	Measurement standards–Errors-Types of Errors- Statistics of errors, Need for calibration. Classification of instruments, secondary instruments–indicating, integrating and recording operating forces - essentials of indicating instruments - deflecting, damping, controlling torques. Ammeters and voltmeters - moving coil, moving iron, constructional details and operation, principles shunts and multipliers – extension of range.	10	20
II	Measurement of power: Dynamometer type wattmeter – Construction and working - 3- phase power measurement-Low Powerfactor wattmeters. Measurement of energy: Induction type watt-hour meters- Single phase energy meter – construction and working, two element three phase energy meters, Digital Energy meters -Time of Day(TOD) and Smart metering (description only). Current transformers and potential transformers – principle of working -ratio and phase angle errors. Extension of range using instrument transformers, Hall effect multipliers.	9	20
III	Classification, measurement of low, medium and high resistance- Ammeter voltmeter method (for low and medium resistance measurements)-Kelvin's double bridge Wheatstones bridge- loss of charge method, measurement of earth resistance. Measurement of self inductance-Maxwell's Inductance bridge, Measurement of capacitance – Schering's, Measurement of frequency-Wien's bridge. Calibration of Ammeter, Voltmeter and Wattmeter using DC potentiometers. High voltage and high current in DC measurements- voltmeters, Sphere gaps, DC Hall effect sensors.	9	20
IV	Magnetic Measurements: Measurement of flux and permeability - flux meter, BH curve and permeability measurement - hysteresis measurement- ballistic galvanometer – principle- determination of BH curve - hysteresis loop.	8	20

	Lloyd Fisher square — measurement of iron losses. Measurement luminous intensity-Photoconductive Transducers-Photovoltaic cells Temperature sensors-Resistance temperature detectors-negative temperature coefficient Thermistors-thermocouples-silicon temperature sensors		
V	Transducers - Definition and classification. LVDT, Electromagnetic and Ultrasonic flow meters, Piezoelectric transducers-modes of operation-force transducer, Load cell, Strain gauge. Oscilloscopes- Principal of operation of general purpose CRO-basics of vertical and horizontal deflection system, sweep generator etc. DSO-Characteristics-Probes and Probing techniques. Digital voltmeters and frequency meters using electronic counters, DMM, Clamp on meters. Phasor Measurement Unit (PMU) (description only). Introduction to Virtual Instrumentation systems- Simulation software's (description only)	9	20

TEXT BOOKS:

1	Sawhney A.K., A course in Electrical and Electronic Measurements & instrumentation, Dhanpat Rai.
2	J. B. Gupta, A course in Electrical & Electronic Measurement & Instrumentation., S K Kataria & Sons

REFERENCES:

1	Golding E.W., Electrical Measurements & Measuring Instruments, Wheeler Pub.
2	Cooper W.D., Modern Electronics Instrumentation, Prentice Hall of India
3	Stout M.B., Basic Electrical Measurements, Prentice Hall
4	Oliver & Cage, Electronic Measurements & Instrumentation, McGraw Hill
5	E.O Doebelin and D.N Manik, Doebelin's Measurements Systems, sixth edition, McGraw Hill Education (India) Pvt. Ltd

PREREQUISITE:NIL

COURSE OBJECTIVES:

1	To gain knowledge on principle of operation and construction of basic instruments for measurement of electrical quantities.
2	To gain knowledge in measurement of basic circuit parameters, magnetic quantities, and passive parameters by using bridge circuits, sensors and transducers.
3	Familiarization of modern digital measurement systems are also included

COURSE OUTCOMES:

After successful completion of the course, the students should be able to:

CO's	DESCRIPTION

1	Identify and analyse the factors affecting performance of measuring system
2	Choose appropriate instruments for the measurement of voltage, current in ac and dc measurements
3	Explain the operating principle of power and energy measurement
4	Outline the principles of operation of Magnetic measurement systems
5	Describe the operating principle of DC and AC bridges, transducers based systems.
6	Understand the operating principles of basic building blocks of digital systems, recording and display units

CO-PO-PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		PSO1	PSO2	PSO3
CO1	**2**	**1**												**3**		
CO2	**3**	**1**												**3**		
CO3	**3**	**1**													**3**	
CO4	**3**													**3**		
CO5	**3**				**1**							**2**		**3**		
CO6	**3**				**2**							**2**		**2**		**3**

CO-PO MAPPING JUSTIFICATION:

CO's	PO's	JUSTIFICATION
CO1	**PO1**	Students will be able to apply the knowledge of engineering fundamentals to identify the factors affecting measurement system.
	PO2	Students will be able to identify the equations related to measurement system.
CO2	**PO1**	Students will be able to apply the knowledge of engineering fundamentals to identify appropriate instruments for measuring parameters.
	PO2	Students will be able to formulate different equations for the measurement of different parameters in AC and DC using appropriate instruments.
CO3	**PO1**	Students will be able to apply the knowledge of engineering fundamentals for power and energy measurement.
	PO2	Students will be able to analyze and formulate equations for power and energy measurement.
CO4	**PO1**	Students will be able to apply the knowledge of engineering fundamentals for magnetic measurement systems.
CO5	**PO1**	Students will be able to apply the knowledge of engineering fundamentals

		for writing the equations for capacitance frequency and inductance measurements.
	PO5	Students will be able to apply appropriate techniques for the measurement of displacement and force and strain and model different transducer systems.
	PO12	Students will be able to recognize the need for different bridges for the measurement of resistance and have ability to engage in independent and lifelong learning in the broadest context of technological change
CO6	**PO1**	Apply the knowledge of engineering fundamentals for understanding of characteristics of oscilloscopes and digital voltmeters.
	PO5	Students will be able to select, and apply appropriate techniques for the analysis of different waveforms and measurements.
	PO12	Students will be able to recognize the need for different digital, display and recording systems and ability to engage in independent and lifelong learning in the broadest context of technological change

CO-PSO MAPPING JUSTIFICATION:

CO's	PSO's	JUSTIFICATION
CO1	**PSO1**	Graduates will be able to identify the errors occurring in measurement systems.
CO2	**PSO1**	Graduates will be able to identify appropriate Instruments for the voltage and current measurement in AC and DC measurements.
CO3	**PSO2**	Graduates will be able to apply different methods for power and energy measurement.
CO4	**PSO1**	Graduates will be able to apply identify the methods for the measurement of flux or magnetic measurements.
CO5	**PSO1**	Graduates will be able to identify different methods for the measurement of unknown resistances and unknown measurement parameters.
CO6	**PSO1**	Graduates will be able to analyse problems associated in the field of Electrical and Electronics Engineering.
	PSO3	Graduates will be able to understand the techniques used with digital and recording systems for the analysis of different systems.

HUT 200 Professional Ethics

COURSE INFORMATION SHEET:

Program: **Electrical & Electronics Engineering**	Degree :**B-Tech**
Course**: Professional Ethics**	Course code**:HUT 200**
L-T-P**:2-0-0**	Credit**:2**

SYLLABUS:

MODULE	CONTENT	HOURS	UNIVERSITY % MARKS
I	Morals, values and Ethics – Integrity- Academic integrity-Work Ethics- Service Learning- Civic Virtue Respect for others- Living peacefully- Caring and Sharing- Honestly-courage-Cooperation commitment Empathy-Self Confidence -Social Expectations	5	20
II	Senses of Engineering Ethics - Variety of moral issues- Types of inquiry- Moral dilemmas –Moral Autonomy – Kohlberg's theory- Gilligan's theory- Consensus and Controversy-Profession and Professionalism- Models of professional roles-Theories about right action –Self interest-Customs and Religion- Uses of Ethical Theories.	5	20
III	Engineering as Experimentation – Engineers as responsible Experimenters- Codes of Ethics- Plagiarism A balanced outlook on law - Challenges case study- Bhopal gas tragedy	5	20
IV	Collegiality and loyalty – Managing conflict- Respect for authority- Collective bargaining- Confidentiality Role of confidentiality in moral integrity-Conflicts of interest-Occupational crime- Professional rights Employee right- IPR Discrimination.	5	20
V	Multinational Corporations- Environmental Ethics- Business Ethics- Computer Ethics -Role in Technological Development-Engineers as Managers- Consulting Engineers-Engineers as Expert witnesses and advisors-Moral leadership.	5	20

TEXT BOOKS:

1	M Govindarajan, S Natarajan and V S Senthil Kumar, Engineering Ethics, PHI Learning Private Ltd, New Delhi,2012
2	R S Naagarazan, A text book on professional ethics and human values, New age international (P) limited ,New Delhi,2006

REFERENCES:

1	Mike W Martin and Roland Schinzinger, Ethics in Engineering,4th edition, Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi,2014.
2	Charles D Fleddermann, Engineering Ethics, Pearson Education/ Prentice Hall of India, New Jersey,2004
3	Charles E Harris, Michael S Protchard and Michael J Rabins, Engineering Ethics- Concepts and cases, Wadsworth Thompson Learning, United states,2005.

PREREQUISITE:Nil

COURSE OBJECTIVES:

1	To enable students to create awareness on ethics and human values

COURSE OUTCOMES:

After successful completion of the course, the students should be able to:

CO's	DESCRIPTION
1	Understand the core values that shape the ethical behaviour of a professional.
2	Adopt a good character and follow an ethical life.
3	Explain the role and responsibility in technological development by keeping personal ethics and legal ethics.
4	Solve moral and ethical problems through exploration and assessment by established experiments
5	Apply the knowledge of human values and social values to contemporary ethical values and global issues.

CO-PO-PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		PSO1	PSO2	PSO3
CO1								**2**			**2**					
CO2								**2**			**2**					
CO3								**3**			**2**					
CO4								**3**			**2**					
CO5								**3**			**2**					

CO-PO MAPPING JUSTIFICATION:

	CO1	**PO8**	**2**	Student learns, uses, applies various ethical values, responsibility and norms of the engineering practice to meet social expectations.
		PO11	**2**	Student develop the ability to use various values in daily life, work place and there by develop their personality, professionalism, spirituality and learns to apply the same in multi - disciplinary

				environments.
	CO2	**PO8**	**2**	Student learns, applies, ethical theories, moral dilemmas, moral autonomy understands theories of right action and uses ethical theories.
		PO11	**2**	Student develop ability to use ethical theories, principals of moral theories, uses different roles of professional action techniques, skills and management principles to do work as a member and leader in a team, to manage projects in multi-disciplinary environments
	CO3	**PO8**	**3**	Student develops ethics of engineering experimentation practices uses codes of ethics develops balanced outlook on law, u responsibility and norms of the engineering practice.
		PO11	**2**	Student develops ability to use ability to use engineering as a tool of experimentation understand the need of codes of ethics and various case study techniques.
	CO4	**PO8**	**3**	Student understand and apply collegiality and loyalty, learns to manage conflict, learns the roles of confidentiality, discriminate various IPRs, find out solution to reduce occupational crimes, understands professional rights, responsibility and norms of the engineering practice.
		PO11	**2**	Students develop an ability to use the values of collegiality and loyalty, confidentiality, understand the need to protect professional rights, employee rights, develop ability to IPR discrimination.
	CO5	**PO8**	**3**	Students apply environmental ethics, computer ethics, develops roles in technical development, understand the role of engineer as managers, consultants, expert witness, advisors and work as a moral leader.
		PO11	**2**	Students develop an ability to use environmental ethics principles, computer ethics and develop engineering skills to understand their roles as managers, consultants, expert witness, advisors and moral leaders.

MA201 LINEAR ALGEBRA AND COMPLEX ANALYSIS

COURSE INFORMATION SHEET:

Program: **Electrical & Electronics Engineering**	Degree :**B-Tech**
Course**: Linear Algebra and Complex Analysis**	Course code**: MA 201**
L-T-P**:3-0-1**	Credit**:4**

SYLLABUS:

MODULE	CONTENT	HOURS	UNIVERSITY % MARKS
I	Complex differentiation Text 1[13.3,13.4] Limit, continuity and derivative of complex functions Analytic Functions Cauchy–Riemann Equation(Proof of sufficient condition of analyticity & C R Equations in polar form not required)-Laplace's Equation Harmonic functions, Harmonic Conjugate	9	15
II	Conformal mapping: Text 1[17.1-17.4] Geometry of Analytic functions Conformal Mapping, Mapping $w = z^2$ conformality of $w = e^z$. The mapping z w z 1 Properties of z w 1 Circles and straight lines, extended complex plane, fixed points Special linear fractional Transformations, Cross Ratio, Cross Ratio property-Mapping of disks and half planes Conformal mapping by w sinz & w cos z (Assignment: Application of analytic functions in Engineering	9	15
III	Complex Integration. Text 1[14.1-14.4] [15.4&16.1] Definition Complex Line Integrals, First Evaluation Method, Second Evaluation Method Cauchy's Integral Theorem(without proof), Independence of path(without proof), Cauchy's Integral Theorem for Multiply Connected Domains (without proof) Cauchy's Integral Formula- Derivatives of Analytic Functions(without proof)Application of derivative of Analytical Functions Taylor and Maclaurin series(without proof), Power series as Taylor series, Practical methods(without proof) Laurent's series (without proof)	10	15
IV	Residue Integration Text 1 [16.2-16.4] Singularities, Zeros, Poles, Essential singularity, Zeros of analytic functions Residue Integration Method, Formulas for Residues, Several singularities inside the contour Residue Theorem. Evaluation of Real Integrals (i)	10	15

	Integrals of rational functions of sinT and cosT (ii)Integrals of the type ^{3} f ff (x)dx (Type I, Integrals from 0 to f) (Assignment : Application of Complex integration in Engineering)		
V	Linear system of Equations Text 1(7.3-7.5) Linear systems of Equations, Coefficient Matrix, Augmented Matrix Gauss Elimination and back substitution, Elementary row operations, Row equivalent systems, Gauss elimination-Three possible cases, Row Echelon form and Information from it. Linear independence-rank of a matrix Vector Space-Dimension-basis-vector spaceR3 Solution of linear systems, Fundamental theorem of non homogeneous linear systems(Without proof)-Homogeneous linear systems (Theory only	9	20
VI	Matrix Eigen value Problem Text 1.(8.1,8.3 &8.4) Determination of Eigen values and Eigen vectors-Eigen space Symmetric, Skew Symmetric and Orthogonal matrices –simple properties (without proof) Basis of Eigen vectors- Similar matrices Diagonalization of a matrix Quadratic forms- Principal axis theorem(without proof) (Assignment-Some applications of Eigen values(8.2))	9	20

TEXT BOOKS:

1	Erwin Kreyszig: Advanced Engineering Mathematics, 10th ed. Wiley

REFERENCES:

1	Dennis g Zill&Patric D Shanahan-A first Course in Complex Analysis with Applications-Jones&Bartlet Publishers
2	B. S. Grewal. Higher Engineering Mathematics, Khanna Publishers, New Delhi
3	Lipschutz, Linear Algebra,3e (Schaums Series)McGraw Hill Education India 2005
4	Complex variables introduction and applications-second edition-Mark.J.Owitz-Cambridge Publication

PREREQUISITE:NIL

COURSE OBJECTIVES:

1	To equip the students with methods of solving a general system of linear equations
2	To familiarize them with the concept of Eigen values and diagonalization of a matrix which

	have many applications in Engineering
3	To understand the basic theory of functions of a complex variable and conformal Transformations

COURSE OUTCOMES:

After successful completion of the course, the students should be able to:

CO's	DESCRIPTION
1	**Solve** any given system of linear equations
2	**Find** the Eigen values of a matrix and how to diagonalise a matrix
3	**Identify** analytic functions and harmonic functions
4	**Evaluate** real definite Integrals as application of Cauchy integral theorem
5	**Evaluate** real definite Integrals as application of Residue Theorem
6	**Identify** conformal mappings(vi) find regions that are mapped under certain Transformations

CO-PO-PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		PSO1	PSO2	PSO3
CO1	3	3														
CO2	3	3														
CO3	3	3														
CO4	3	3														
CO5	3	3														
CO6	3	3														

CO-PO MAPPING JUSTIFICATION:

CO's	PO's	JUSTIFICATION
CO1	PO1	Apply the knowledge of ,mathematics, science and engineering fundamentals and engineering specialization to the complex engineering problems
	PO2	Identify, formulate and analyze engineering problems using first principle of mathematics and engineering sciences
	PO1	Apply the knowledge of ,mathematics, science and engineering fundamentals and engineering specialization to the complex engineering

CO2		problems
	PO2	Identify, formulate and analyze engineering problems using first principle of mathematics and engineering sciences
CO3	**PO1**	Apply the knowledge of ,mathematics, science and engineering fundamentals and engineering specialization to the complex engineering problems
	PO2	Identify, formulate and analyze engineering problems using first principle of mathematics and engineering sciences
CO4	**PO1**	Apply the knowledge of ,mathematics, science and engineering fundamentals and engineering specialization to the complex engineering problems
	PO2	Identify, formulate and analyze engineering problems using first principle of mathematics and engineering sciences
CO5	**PO1**	Apply the knowledge of ,mathematics, science and engineering fundamentals and engineering specialization to the complex engineering problems
	PO2	Identify, formulate and analyze engineering problems using first principle of mathematics and engineering sciences
CO6	**PO1**	Apply the knowledge of ,mathematics, science and engineering fundamentals and engineering specialization to the complex engineering problems
	PO2	Identify, formulate and analyze engineering problems using first principle of mathematics and engineering sciences

MCN 201 SUSTAINABLE ENGINEERING

COURSE INFORMATION SHEET:

Program:**ELECTRICAL & ELECTRONICS ENGINEERING**	Degree :**B-Tech**
Course**:**SUSTAINABLE ENGINEERING	Course code**: MCN201**
L-T-P**:2-0-0**	Credit**:**

SYLLABUS:

MODULE	CONTENT	HOURS	UNIVERSITY % MARKS
I	Sustainability: Introduction, concept, evolution of the concept; Social, environmental and economic sustainability concepts; Sustainable development, Nexus between Technology and Sustainable development; Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs), Clean Development Mechanism (CDM)	5	20
II	Environmental Pollution: Air Pollution and its effects, Water pollution and its sources, Zero waste concept and 3 R concepts in solid waste management; Greenhouse effect, Global warming, Climate change, Ozone layer depletion, Carbon credits, carbon trading and carbon foot print, legal provisions for environmental protection.	6	20
III	Environmental management standards: ISO 14001:2015 frame work and benefits, Scope and goal of Life Cycle Analysis (LCA), Circular economy, Bio-mimicking, Environment Impact Assessment (EIA), Industrial ecology and industrial symbiosis	6	20
IV	Resources and its utilisation: Basic concepts of Conventional and non-conventional energy, General idea about solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels, Energy derived from oceans and Geothermal energy.	4	20
V	Sustainability practices: Basic concept of sustainable habitat, Methods for increasing energy efficiency in buildings, Green Engineering, Sustainable Urbanisation, Sustainable cities, Sustainable transport	4	20

TEXT BOOKS:

1	

REFERENCES:

1	Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hal
2	Bradley. A.S; Adebayo,A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning
3	Environment Impact Assessment Guidelines, Notification of Government of India, 2006
4	Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998
5	ECBC Code 2007, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications - GRIHA Rating System

PREREQUISITE:NIL

1	To inculcate in students an awareness of environmental issues and the global initiatives towards attaining sustainability
2	The student should realize the potential of technology in bringing in sustainable practices.

COURSE OUTCOMES:

After successful completion of the course, the students should be able to:

CO's	DESCRIPTION
1	Understand the relevance and the concept of sustainability and the global initiatives in this direction
2	Explain the different types of environmental pollution problems and their sustainable solutions
3	Discuss the environmental regulations and standards
4	Outline the concepts related to conventional and non-conventional energy
5	Demonstrate the broad perspective of sustainable practices by utilizing engineering knowledge and principles

CO-PO-PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		PSO1	PSO2	PSO3
CO1						2	3					2				
CO2						2	3					2				
CO3						2	3					2				
CO4						2	3					2				
CO5						2	3					2				

CO-PO MAPPING JUSTIFICATION:

CO1	PO6	2	Fundamental awareness about the concept and importance of sustainability is essential for the existence in future world
	PO7	3	The basic knowledge in sustainability helps to identify and analyze the impact caused to the environment by human activities
	PO12	2	Awareness about concept and importance of sustainability and the impact caused to the environment by human activities develops a strong desire in students for lifelong learning in the broadest context of technological change.
CO2	PO6	2	The study of zero waste and 3R waste concepts helps to assess societal, health, safety, legal and cultural issues
	PO7	3	Learning the basic concepts about types, causes and effects of pollution in sustainability helps to identify and analyze the environmental issues and derive solutions for the same
	PO12	2	Study of environmental pollution problems and its effect on environment develops keenness in students for lifelong learning in the broadest context of technological change.
CO3	PO6	2	Fundamental knowledge about Environmental Impact Assessment creates an awareness about various engineering applications in environmental management
	PO7	3	LCA and EIA study helps the students to understand impact of the engineering solutions in minimizing the environmental pollution to a greater extent
	PO12	2	Study of importance of ISO standards in environment management develops a thirst in students for lifelong learning in the broadest context of technological change.
CO4	PO6	2	Idea about conventional and nonconventional energy sources helps to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
	PO7	3	Basic knowledge of various types of conventional and nonconventional energy sources helps to understand the impact of the professional engineering solutions in societal and environmental contexts.
	PO12	2	Understanding importance of nonconventional energy sources develops a desire in students for lifelong learning in the broadest context of technological change.
CO5	PO6	2	Basic sustainability principles help in understanding the importance of role that sustainability plays in the future existence of society
	PO7	3	Study of sustainable buildings, cities and transportion helps to Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

	PO12	2	Study of importance of sustainable habitat develops a desire in students for lifelong learning in the broadest context of technological change.

EEL201 CIRCUITS AND MEASUREMENTS LAB

COURSE INFORMATION SHEET:

Program: **Electrical & Electronics Engineering**	Degree : **B-Tech**
Course **:CIRCUITS AND MEASUREMENTS LAB**	Course code**: EEL201**
L-T-P**:0-0-3**	Credit**:2**

Experiments:

1. Verification of Superposition theorem and Thevenin's theorem

2. Determination of impedance, admittance and power factor in RLC series/ parallel circuits.

3. 3-phase power measurement using one wattmeter and two-wattmeter methods, and determination of reactive/apparent power drawn

4. Extension of instrument range by using Instrument transformers (CT and PT)

5. Calibration of 3-phase Energy meter using standard wattmeter

6. Measurement of Capacitance using AC Bridge

7. Determination of B-H curve, μ-H curve and μ-B curve of a magnetic specimen

8. Measurement of Self inductance, Mutual inductance and Coupling coefficient of a 1- phase transformer

9. Determination of characteristics of LVDT, Strain gauge and Load-cell.

10. Determination of characteristics of Thermistor, Thermocouple and RTD

11. Verification of loading effect in ammeters and voltmeters with current measurement using Clamp on meter

12. Calibration of 1-phase Energy meter at various power factors

PREREQUISITE: Basic Electrical Engineering

COURSE OBJECTIVES:

1	To train the students to familiarize and practice various measuring instruments and different transducers for measurement of physical parameters
2	Students will also be introduced to a team working environment where they develop the necessary skills for planning, preparing and implementing basic instrumentation systems.

COURSE OUTCOMES:

After successful completion of the course, the students should be able to:

CO's	DESCRIPTION
1	Analyse voltage current relations of RLC circuits
2	Verify DC network theorems by setting up various electric circuit
3	Measure power in a single and three phase circuits by various methods
4	Calibrate various meters used in electrical systems
5	Determine magnetic characteristics of different electrical devices
6	Analyse the characteristics of various types of transducer systems
7	Determine electrical parameters using various bridges
8	Analyse the performance of various electronic devices for an instrumentation systems and, to develop the team management and documentation capabilities.

CO-PO-PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		PSO1	PSO2	PSO3
CO1	3	3	2						2			3		3		
CO2	3	3							2			3		3		
CO3	3	3							2			3				
CO4	3	3	2						2			3		3		
CO5	3	3							2			3				
CO6	3	3	2						2			3		3		
CO7	3	3							2			3			3	
CO8	3	3	3	3	2				3	3	3	3				

CO-PO MAPPING JUSTIFICATION:

CO's	PO's	JUSTIFICATION
CO1	PO1	Students will be able to apply the knowledge of mathematics, science, engineering fundamentals to design RLC circuits.
	PO2	Students will be able to analyze RLC circuits for impedence admittance and power factor measurements.
	PO3	Students will be able to develop RLC series and parallel circuits and draw the phasor diagram for impedence admittance and power factor measurements.
	PO9	The knowledge on RLC series and parallel circuits will help students for the team work
	PO12	Students can build on their basics to go to the depths of knowledge.
CO2	PO1	Students will be able to apply the knowledge of mathematics, engineering fundamentals for solving network theorems.
	PO2	Identify network theorems for solving engineering problems reaching substantiated conclusions using first principles of mathematics Engineering sciences.
	PO9	Will be able to contribute for the team work in reaching solutions for the problems
	PO12	Students will be able to build up their knowledge in solving advanced network systems using network theorems.
CO3	PO1	Students will be able to apply the knowledge engineering fundamentals to the solution of power measurement.
	PO2	Students will be able to identify, formulate equations for solving power measurement by one wattmeter and two wattmeter method using first principles of mathematics
	PO9	Students will be able to function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings
	PO12	Students will gain an intuitive understanding about power measurement motivates them to explore new technologies in their pursuit of engineering
CO4	PO1	Students will be able to apply the knowledge of engineering fundamentals and an engineering specialization to the solution of complex measurement problems

	PO2	Students will be able to Identify and analyze the errors associated with the measurement problems the need of calibrations.
	PO3	Students will be able to develop solutions for the various problems associated with instruments.
	PO9	The knowledge on caliberation of instruments will help students for the team work
	PO12	Students can build up from the basic knowledge to higher levels of errors and caliberation of instruments.
CO5	**PO1**	Students will be able to apply the knowledge of mathematics engineering fundamentals solution of complex engineering problems
	PO2	Students will be able to analyze the magnetic characteristics of the circuit's complex engineering problems reaching substantiated conclusions using first principles of mathematics and Engineering sciences.
	PO9	The knowledge on magnetic characteristics of different devices will help students for the team work
	PO12	Students can build up from the basic knowledge to higher levels on the study of magnetic characteristics.
CO6	**PO1**	Students will be able to apply the knowledge of mathematics, engineering fundamentals for various transducer based systems.
	PO2	Students will be able to analyze the characteristics of resistance temperature detector thermistor and thermocouple.
	PO3	Students will be able to develop solutions for the various problems associated with transducer based systems.
	PO9	Students will be able to contribute for the team work in reaching solutions for the problems
	PO12	Students can build on their basics to go to the depths of knowledge in transducer based systems and the measurement parameters.
CO7	**PO1**	Apply the knowledge of mathematics engineering fundamentals and an engineering specialization to the solution of capacitance measurement.
	PO2	Students will be able to identify and analyze different bridges for different ac parameter measurements.
	PO9	Students will be able to contribute for the team work in reaching solutions for the measurement of inductance capacitance frequency different ac parameters by solving as different bridge equations.
	PO12	Students will be able to build up their knowledge in advanced systems
CO8	**PO1**	Students will be able to apply the knowledge of mathematics engineering fundamentals and complex engineering problems
	PO2	Students will be able to analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics.
	PO3	Students will be able to develop solutions for the various problems associated with electronic devices for an instrumentation systems.
	PO4	Students will be able to investigate various problems associated with electronic devices for an instrumentation system.
	PO5	Students will be able to apply appropriate techniques for analysing performance of various electronic devices for an instrumentation system.

	PO9	Students will be able to Function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings
	PO10	Students will be able to Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation.
	PO11	Students will be able to demonstrate knowledge and understanding of the instrumentation systems and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
	PO12	Students will gain an intuitive understanding about behaviour of various electronic devices for an instrumentation system which motivates them to explore new technologies in their pursuit of engineering

CO- PSO MAPPING

CO's	PSO's	
CO1	**PSO1**	Apply the engineering knowledge to analyse, design RLC circuits.
CO2	**PSO1**	Apply the engineering knowledge to analyse design and simulate the problems associated in the field of solving network theorems.
CO4	**PSO1**	Apply the engineering knowledge to analyse and calibrate various meters.
CO6	**PSO1**	Apply the engineering knowledge to analyse the characteristics of transducer based systems.
CO7	**PSO2**	Explore the technical knowledge and development of professional methodologies in measurement of various ac parameters using bridges

EEL203 ANALOG ELECTRONICSLAB

COURSE INFORMATION SHEET:

Program: **Electrical & Electronics Engineering**	Degree :**B-Tech**
Course**: Analog Electronics Lab**	Course code**: EEL203**
L-T-P**:0-0-3**	Credit**:2**

Experiments:

1. Measurement of current, voltage, frequency and phase shift of signal in a RC network using oscilloscope.
2. Clipping circuits using diodes.
3. Clamping circuits using diodes.
4. RC coupled amplifier using BJT in CE configuration-Measurement of gain, BW and plotting of frequency response.
5. JFET amplifier-Measurement of gain, BW and plotting of frequency response.
6. Op-amp circuits – Design and set up of inverting and non-inverting amplifier, scale changer, adder, integrator, and differentiator
7. RC phase shift oscillator using Op-amp.
8. Wein’s Bridge oscillator using Op-amps.
9. Waveform generation– Square, triangular and saw tooth wave form generation using OPAMPs
10. Astable and Monostable circuit using555I.
11. Introduction to circuit simulation using any circuit simulation software.
12. Introduction to PCB layout software

PREREQUISITE:

NIL

COURSE OBJECTIVES:

1	To train students to familiarize and practice various kinds of electronic circuits and its applications

COURSE OUTCOMES:

After successful completion of the course, the students should be able to:

CO's	DESCRIPTION
1	Use the various electronic instruments and for conducting experiments.
2	Design and develop various electronic circuits using diodes and Zener diodes
3	Design and implement amplifier and oscillator circuits using BJT and JFET.
4	Design and implement basic circuits using IC (OPAMP and 555 timers)
5	Simulate electronic circuits using any circuit simulation software.
6	Use PCB layout software for circuit design

CO-PO-PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2								2				2		
CO2	2	2	2						2				2		
CO3	2	2	2						2				2		
CO4	2	2	2						2				2		
CO5	1	1			3				3				2		
CO6	1				3				3				2		

CO-PO MAPPING JUSTIFICATION:

CO1	**PO1**	**2**	Students will be able to apply the knowledge of mathematics and engineering fundamentals in all electronic circuit experiments.
	PO9	**2**	Students will be able to function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings.
CO2	**PO1**	**2**	Students will be able to apply the knowledge of mathematics and engineering fundamentals in all electronic circuit experiments
	PO2	**2**	Students will be able to identify ,formulate and analyze different diode circuits
	PO3	**2**	Students will be able to design various diode circuits.
	PO9	**2**	Students will be able to function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings
CO3	**PO1**	**2**	Students will be able to apply the knowledge of mathematics and engineering fundamentals in all electronic circuit experiments
	PO2	**2**	Students will be able to identify, formulate and analyse various oscillator and amplifier circuits using BJT and FET

	PO3	**2**	Students will be able to design and form various kinds of amplifier and oscillatory circuits
	PO9	**2**	Students will be able to function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings
CO4	**PO1**	**2**	Students will be able to apply the knowledge of mathematics and engineering fundamentals in all electronic circuit experiments
	PO2	**2**	Students will be able to identify ,formulate and analyze different ICs (op-amps)
	PO3	**2**	Students will be able to design and form various kinds of circuits using 555 ICs.
	PO9	**2**	Students will be able to function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings
CO5	PO1	**1**	Students will be able to apply the knowledge of mathematics and engineering fundamentals in all electronic circuit experiments
	PO2	**1**	Students will be able to identify different simulation softwares and form simulation for different electronic circuits
	PO5	**3**	Students will be able to create, select and apply appropriate techniques and resources and modern engineering and IT tools including prediction and modeling to complex electronic circuits
	PO9	**3**	Students will be able to function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings
CO6	**PO1**	**1**	Students will be able to apply the knowledge of mathematics and engineering fundamentals in all electronic circuit experiments
	PO5	**3**	Students will be able to create, select and apply appropriate techniques and resources and modern engineering and IT tools including prediction and modeling to complex electronic circuits
	PO9	**3**	Students will be able to function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings

CO- PSO MAPPING JUSTIFICATION

CO1	**PSO1**	**2**	Graduates will be able to apply the engineering knowledge to identify, analyze, design and simulate the circuits in the field of analog electronics
CO2	**PSO1**	**2**	Graduates will be able to apply the engineering knowledge to identify, analyze, design and simulate the circuits in the field of analog electronics
CO3	**PSO1**	**2**	Graduates will be able to apply the engineering knowledge to identify, analyze, design and simulate the circuits in the field of analog electronics

CO4	**PSO1**	**2**	Graduates will be able to apply the engineering knowledge to identify, analyze, design and simulate the circuits in the field of analog electronics
CO5	**PSO1**	**2**	Graduates will be able to apply the engineering knowledge to identify, analyze, design and simulate the circuits in the field of analog electronics
CO6	**PSO1**	**2**	Graduates will be able to apply the engineering knowledge to identify, analyze, design and simulate the circuits in the field of analog electronics