GUJARAT TECHNOLOGICAL UNIVERSITY

POWER ELECTRONICS (24)

ANALOG ELECTRONICS AND ITS APPLICATIONS

SUBJECT CODE: 2142405

B.E. 4th SEMESTER

Type of course: Engineering Science (Electronics)

Prerequisite: 1) 2130901 -Circuits and Networks, **2)** 2132404 -Principles of Power Electronics

Rationale: This subject focuses on the study of linear applications of the Diode, BJT and Op-Amp in the field of Power Electronics. It details the students about use of analog electronics in power electronics control.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	**Diodes & Bipolar Junctions Transistors:** • Diode as a rectifier: HW, FW and Bridge Rectifier with and without Capacitor Filter – Review of CE, CB, CC Configurations of BJT – Review of Low Frequency Response of BJT – The Basics of High Frequency Response and h-Parameters • Different Areas of Application of BJT	4	10
2	**Linear Applications of BJT:** • Single stage transistor amplifiers – Classification – Principle – Practical circuit – DC and AC equivalent circuits – Load line analysis – Gain and Input impedance – Equivalent Circuit – Classification – Different amplifiers like Cascaded Amplifier, Coupled Amplifier, Feedback Amplifier, Cascode Amplifier, Class A, B, AB & C amplifiers – Frequency response of amplifier – bootstrapping circuit • Block diagram and working of Linear regulated power supplies – Zener Shunt – Series Pass – Shunt Regulated – Feedback – Series Voltage Regulator – IC based regulated linear power supplies like 78xx, 79xx & TL431 • Design of simple series/shunt regulated power supplies using BJT, Design of simple regulated power supplies based on 78xx, 79xx and TL431 ICs.	8	**15**
3	**Operational Amplifier Basics:** • The Op-Amp – Block Diagram – Characteristics – Equivalent Circuit – Types – Important parameters from datasheet	8	15

	• The Ideal Op-Amp – Open Loop – Close Loop Configurations along with the different types of feedback • The Practical Op-Amp – Characteristics – Input Offset Voltage – Input Bias & Offset Current – Total Output Offset Voltage – CMRR – Thermal & Time Drift – PSRR – Effect of Power Supply Variation on Offset Voltage – Frequency Response and Slew Rate – Input Protection Circuit for Op-Amp – Noise in Op-Amp		
4	**Linear Applications of Op-Amp:** • AC-DC Amplifier – Peaking Amplifier – Summing, Scaling and Averaging Amplifier – Instrumentation Amplifier – Differential Input-Output Amplifier – V to I converter (Grounded & Floating Load) – Very High Input Impedance Circuit – Integrator & Differentiator – A/D & D/A Converters • Comparators – Zero Crossing Detector – Schmitt Trigger – Voltage Limiter – Voltage Level Detectors –Clipper (Limiting Circuits) & Clampers – Peak Sample & Hold Circuit – Precision Rectifier Detector	8	20
5	**Op-Amp Based Filters & Oscillators:** • Introduction to Filters – Passive Filters & Active Filters – Basic Filter Responses and their Transfer Function (Low Pass, High Pass, Band Pass, Band Reject, Notch, All Pass) – First & Second Order Butterworth Filter • Gyrator – Negative Impedance Converter (NIC) – Frequency Dependent Negative Resistance (FDNR) • Oscillators – Principles & Types – Frequency Stability – Phase Shift Oscillator – Wien Bridge Oscillator – Quadrature Oscillator • Square Wave Generator – Triangular Wave Generator – Saw Tooth Wave Generator	8	15
6	**Special Circuits and Applications:** • Switched Capacitor Circuits – Principle – Advantages like Input Impedance Improvement, CMRR Improvement – Applications of Switched Capacitor Circuits like amplifier, filter, etc. – MF5 Switched Capacitor Filter • 555 Timer – different modes and their configuration • Block Diagram and Working V/F, F/V Converters, VCO PLL, PWM circuits and Voltage Regulators	8	15
7	**Logic Families:** • Review of Logic Gates – Construction of Logic Gates using Discrete Components like Diode, Resistor, Transistor, etc. – Diode Transistor Logic (DTL) – Transistor Transistor Logic (TTL) – Resistor Transistor Logic (RTL) and other logic families – Comparison of Logic Families	4	10

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks				
R Level	U Level	A Level	N Level	E Level
20%	25%	25%	20%	10%

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Operational Amplifiers and Linear ICs, Third Edition by David Bell, Oxford
2. Electronics Devices and Circuits, Fifth Edition, David Bell, Oxford
3. Op-Amps and Linear Integrated Circuits, 4th Edition by Ramakant Gayakwad, PHI
4. Integrated Electronics by Millman, Halkias and Parikh, McGraw Hill India
5. A monograph on Electronics Design Principles by Goyal and Khetan, Khanna Publishers
6. Digital Electronics: Principles and Applications by Soumitra Kumar Mandal
7. Electronics Devices and Circuits by Boyelsted and Nashelsky, Pearson
8. Fundamentals of Digital Electronics by A. Anand Kumar

Course Outcome:

After learning this course, the students should be able to:

1. Understand the importance of linear applications of semiconductor components like diodes and transistors.
2. Design and fabricate simple series/shunt regulated power supplies using BJT and simple regulated power supplies based on 78xx, 79xx and TL431 ICs.
3. Understand OpAmp characteristics and its applications in building blocks for signal processing in power electronics applications.
4. Analyse and fabricate simple circuits on bread board/GP board based on different applications of OpAmp and special purpose ICs.
5. Understand the fundamentals of different logic families like RTL, DTL, TTL, etc.

List of Experiments (Laboratory Work):

Objectives: The laboratory work is aimed at putting the theory learnt in class in practice and to show the results are nearly matched with theory. In this context, following are the core objectives for laboratory work of this subject.

- Develop understanding of basic applications of diode and BJT.
- Understand the basics of Op-Amp and identify its different parameters from datasheet.
- Develop the understanding of Op-Amp for different linear applications and power supplies.
- Develop understanding of use of Op-Amp for making filters and oscillators.
- Understand the use of Op-Amp in signal processing circuits.

Directions for Laboratory work:

- ✓ The list of experiments is given as a sample.
- ✓ Minimum 10 experiments should be carried out.
- ✓ At least one experiment should be selected from each group.

- ✓ Similar laboratory work fulfilling the objectives can also be considered.
- ✓ As far as possible printed manual should be preferred so that students can concentrate in laboratory experiments and related study.
- ✓ Simulation of various experiments should also be given.

The sample list of experiments is given below.

List of Experiments and Design Based (DP)/Open Ended Problems:

Group A (Diode and BJT):

1. Study & Use of CRO: Measurement of voltage, frequency and phase shift.
2. To study and design Diode half wave, full wave and bridge rectifiers with and without capacitor filters.
3. To study diode clipping and clamping circuits.

Group B (Voltage Regulators):

4. To study and design a simple Zener voltage regulator and Zener voltage regulator with emitter follower output.
5. To study and design 78xx and 79xx based voltage regulators.
6. To study and design TL431 based variable voltage regulators.

Group C (Op-Amp Applications):

7. To study and design Op-Amp based linear circuits like comparator, inverting & non-inverting amplifier, adder, subtractor, integrator, differentiator, etc.
8. Measurement of Op-Amp parameters like CMRR, Input offset Voltage, etc.
9. Phase shift and Wien Bridge oscillator using OPAMPs.
10. Study of frequency response of different filter circuits
11. Waveform generator using Op-Amp.

Group D (Special Applications of Op-Amp):

12. Study of Switched Capacitor Circuits
13. IC 555 based Astable, Mono stable and Bi-stable multi vibrator
14. Study of PLL using Op-Amp

Major Equipments:

- Bread Board, Oscilloscope, LCR/LCRQ meter, OpAmp Trainer Kits, Multimeter, Variable Power Supply, etc.

List of Open Source Software/learning website:

Open Source Software:

- TINA-TI for circuit simulation (http://www.ti.com/tool/tina-ti)
- OSCAD for CAD application (http://www.oscad.in/downloads)
- Fritzing for bread board/GP board wiring planning (http://fritzing.org/download)

Web-base tools for design:

- http://www.fairchildsemi.com/support/design-tools/power-supply-webdesigner/
- http://www.ti.com/lsds/ti/analog/webench/overview.page
- https://www.circuitlab.com/editor/

Open source for Math Tools:

- http://maxima.sourceforge.net/
- http://www.sagemath.org/
- http://www.scilab.org/

- http://www.gnu.org/software/octave/

Learning website:

- http://www.datasheetcatalog.com/
- http://nptel.iitm.ac.in/courses.php
- http://ocw.mit.edu/
- http://www.electrical-engineering-portal.com

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.