GUJARAT TECHNOLOGICAL UNIVERSITY

INSTRUMENTATION & CONTROL ENGINEERING (17)

ANALOG SIGNAL PROCESSING

SUBJECT CODE: 2141706

B.E. 4th Semester

Type of course: Core Engineering

Prerequisite:

1. Fundamental of Basic electronics
2. Electronics devices like transistor, diode etc.

Rationale: This subject deals with how to process sensor's output and make it suitable for next stage of any measurement system.

Teaching and Examination Scheme:

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

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE- End Semester Examination; PA- Progressive Assessment; OEP-Open Ended problem; AL-Active learning;

Sr No.		Content	Total Hr	% weight
1	**Introduction to OP-AMP**		4 Hr	11%
	1.1	**Basic ideas about**:- Dual input-balanced output differential amplifier, inverting and non inverting inputs, Dual input-Unbalanced output differential amplifier, Single input-balanced output, Single input-Unbalanced output differential amplifier.		
	1.2	Basic Introduction to block diagram of a typical op-amp, Basic introduction to equivalent circuit of the 741 op-amp, Schematic symbol and 8 pin functions and power supply of op-amp		
	1.3	Equivalent circuit of op-amp, Open loop op-amp configuration, The differential amplifier, The inverting amplifier, The Non-inverting amplifier, positive saturation output, negative saturation output.		
	1.4	**Definition and explanation to the terms of op-amp as**:- Input offset voltage, input offset current, Differential Input resistor, Input capacitance, Offset Voltage Adjustment Range, Input voltage range, Common mode rejection ratio, supply Voltage rejection ratio, output voltage swing, output resistance, output short circuit current, supply current, Slew Rate, Average temperature Coefficient of input offset voltage(and current), Long-term input offset voltage(and current). :- Basic ideas about compensating network for offset voltages compensation , CMRR compensation, SVRR compensation, temperature compensation		
2	**An Op-amp with Negative feedback (closed loop)**		3 Hr	6%
	2.1	Introduction, Block diagram representation of feedback configuration		
	2.2	2.2.1. Voltage series feedback amplifier (Non-inverting amplifier with feedback), Derivation of closed loop voltage gain, voltage follower. 2.2.2. Voltage shunt feedback amplifier(Inverting amplifier with feedback), Derivation of closed loop voltage gain, current to voltage converter. 2.2.3. Differential amplifier with one op-amp, voltage gain		

3	**General Linear application**		8 Hr	11%
	3.1	**DC amplifier:-**		
		3.1.1:- Inverting amplifier, Non-Inverting amplifier, Differential amplifier 3.1.2:-Inverting amplifier with external offset voltage-compensating network, Non- Inverting amplifier with external offset voltage-compensating network, Differential amplifier with external offset voltage-compensating network		
	3.2	**AC Amplifier:-**		
		3.2.1 :- AC Inverting Amplifier 3.2.2 :- AC Non-inverting Amplifier 3.2.3 :- AC amplifier with single supply voltage (similar to clampers)		
	3.3	The Peaking amplifier		
	3.4	**Summing Scaling and Averaging Amplifier**		
		3.4.1 :- Inverting configuration:-Summing amplifier, Scaling amplifier, Averaging amplifier 3.4.2 :- Non-Inverting configuration:- Summing amplifier, Averaging amplifier 3.4.3 :- Differential configuration:- A Subtractor, Summing amplifier		
	3.5	Voltage to Current converter with floating load, Voltage to current converter with grounding load, Current to voltage converter		
	3.6	**Very High Input Impedance circuit:-**		
		3.6.1. DC-Coupled voltage follower 3.6.2. AC – coupled voltage follower with input resistance bootstrapped		
	3.7	**The Integrator**, with its 0db gain frequency (f_b) and gain limiting frequency derivation(f_a), **The differentiator**, with its 0db gain frequency(f_a) and gain limiting freq derivation(f_b),		
4	**Comparators and Converters**		8 Hr	20%
	4.1	Basic comparator, Zero Crossing Detector, Schmitt Trigger,		
	4.2	Comparator Characteristics, Limitation of OP-AMP as Comparator		
	4.3	OP-AMP as Voltage Limiter:- Positive voltage limiter and Negative voltage limiter		
	4.4	**CLIPPER:-**		
		4.4.1:- Positive clippers, Negative clippers 4.4.2 :- small signal half wave rectifiers		
	4.5	CLAMPERS:- Positive and Negative clampers		
	4.6	Absolute Value output circuit, Peak Detector, Sample and hold circuit		
	4.7	**Digital to Analog Converter(DAC):-**		
		4.7.1 :- D/A converter with binary - weighted resistor 4.7.2 :- D/A converter with R and 2R resistor		
	4.8	**Analog to Digital Converters (ADC):-**		
		4.8.1 :- Successive approximation A/D converter		
	4.9	Voltage to frequency and frequency to voltage converters		
		4.9.1 :- V/F Converter:- 1) 9400 V/F converter equivalent circuit, connection diagram, waveforms and its working. 2) V/F Design procedure, 3) Single supply operation 4.9.2 :- F/V Converter :- 1) 9400 F/V Design procedure 2) Single supply operation		
5	**Active and Passive Filters**		6 Hr	12%
	5.1	Introduction to active and Passive filters, Introduction to low pass and high pass filters		
	5.2	**Low pass Filters:-**		
		5.2.1:- Passive First order low pass filter with its transfer function, 5.2.2 :- Active First order low pass butter worth filter with its transfer function, filter design 5.2.3:- Active Second order low pass butter worth filter with transfer		

		function, filter design		
	5.3	**High pass Filters:-**		
		5.3.1 :- Passive First order high pass filter with its transfer function 5.3.2 :- Active First order High pass butter worth filter with its transfer function, filter design 5.3.3 :- Active Second order High pass butter worth filter with transfer function, filter design		
	5.4	**Higher order active filters** :- Third order and fourth order low pass butter worth filter		
	5.5	Band Pass Filters :- 1) Wide Band Pass Filter and 2) Narrow band pass filters		
	5.6	Band–Reject Filters :- 1) Wide band-reject filter and 2) Narrow band-reject filter(Notch Filter)		
	5.7	All Pass Filter		
6	**OSCILLATORS**		5 Hr	12%
	6.1	Introduction to oscillator, Oscillator principles, Oscillator Block diagram		
	6.2	Phase Shift oscillator, Wien Bridge Oscillator, Quadrature Oscillator, Square wave Generator, Triangular Wave Generator, Sawtooth Wave Generator		
	6.3	Voltage - Controlled Oscillator NE/SE 566		
7	**Specialized IC Applications**		3 Hr	20%
	7.1	**The 555 Timer:-** 7.1.1 :- Introduction to 555 timer Ic, 555 timer pin connection diagram and block diagram 7.1.2.:- 555 timer as a Monostable Multivibrator :- operation and circuit diagram 7.1.3 :- Monostable Multivibrator applications :- 1) Frequency divider, 2) Pulse stretcher 7.1.2.:- 555 timer as an Astable Multivibrator :- Operation and circuit diagram 7.1.3 :- Astable Multivibrator applications :- 1) Square wave oscillator, 2) Ramp generator		
	7.2	**Instrumentation amplifier**	3Hr	
		7.2.1 :- Instrumentation amplifier using three op-amp for resistive transducer and bridge 7.2.2 :- Instrument amplifier for High gain and High input impedance (Text Book 3- page 161) 7.2.3.:- Instrumentation amplifier using RTD. Circuit design for converting the change in resistance of RTD into 0 to 5 V output with compensation of offset voltages, CMRR, temperature compensation for the range of 30^{o}C to 200^{o}C.		
	7.3	**Special Purpose amplifiers**	4 Hr	
		Logarithmic amplifier, Isolation amplifier, chopped stability amplifier, Programmable Gain amplifier, Matching sensor to circuit (Text Book 3- page 139)		
8	**Compensating networks for op-amp (Practical op-amp)**		4 Hr	8%
		Input offset voltage, offset voltage compensating network design, Input offset current, Input bias current, Total output offset voltage, Thermal drift, Effect of variation in Power supply voltages on offset voltage, Common mode configuration and Common mode rejection ratio.		

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks				
R Level	U Level	A Level	N Level	E Level
21	21	14	7	7

Legends: R: Remembrance ; U = Understanding; A = Application 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. The Art of Electronics (second edition) by Paul Horowitz and Winfield Hill, Cambridge University Press
2. Op-amps and Linear Integrated Circuits by Ramakant A. Gayakward, Prentice Hall India.
3. Design with operational amplifiers and Analog integrated circuits by Sergio Franco, McGraw Hill
4. Introduction to biomedical equipment technology (fourth edition) by Joseph J Carr and John M. Brown

Course Outcome:

- After learning the course the students should be able to design amplifier and filter for signal conditioning.
- Students should be able to design the signal conditioning circuit for RTD using instrumentation amplifier.
- Students should be able to find appropriate op-amp application for the application.

List of Experiments:

1. To study and perform inverting and non-inverting and differential amplifier using op-amp without feedback.
2. To study and perform offset voltages and its compensation network.
3. To study and perform CMRR configuration and its compensation network.
4. To study the effect of temperature co-efficient and its compensation network
5. To study and perform inverting and non-inverting and differential amplifier using op-amp with feedback.
6. To study and perform summing amplifier and subtractor
7. To study and perform voltage to current converter with grounded load and with floating load
8. To study and perform current to voltage converter
9. To study and perform comparator circuit using op-amp and make PWM wave forms.
10. To study and perform Schmitt trigger circuit using op-amp.
11. To study and perform positive and negative clippers
12. To study and perform positive and negative clampers
13. To study and perform the integrator and the differentiator
14. To study and design first order low pass filter and high pass filter using op-amp.
15. To measure Frequency using Wien bridge oscillator.
16. Design and study of monostable, and astable multivibrators using IC555.
17. To study and perform Instrumentation amplifier using RTD. Design a Circuit for converting the change in resistance of RTD into 0 to 5 V output with compensation of offset voltages, CMRR and temperature compensation for the range of 30^{o}C to 200^{o}C.

Note:- All The Student must have to make a working model (circuit board) of 7.2.3 in a lab session with all compensation component in the group of 1/2 students and submit it.

Open Ended Problems:

Major Equipment: specified with list of experiments

741 IC, OP07, Voltage regulator IC, NE555 IC, CRO, Function Generator

List of Open Source Software/learning website:

http://nptel.ac.in/video.php?subjectId=117103063
http://www.learnabout-electronics.org/Amplifiers/amplifiers60.php

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.