Name of the Subject – Integrated Circuits

Weekly Work Load(in Hrs)	Lecture	Tutorial	Practical
	04		02

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
50	50	50		25	100	

1.1Syllabus

Unit I : OP-AMP Basics (6 Hrs)

Block diagram of OP-AMP, Differential Amplifier configurations, Differential amplifier analysis for dual-input balanced-output configurations using ‘r’ parameters, Need and types of level shifter, current mirror circuits. Voltage series and voltage shunt feedback amplifier and its effect on Ri, Ro, bandwidth and voltage gain.

Unit II : Linear Applications of OP-AMP (8 Hrs)

Inverting and Non-inverting amplifier, voltage follower Summing, averaging scaling amplifier, difference amplifier, Ideal integrator, practical integrator with frequency response, Ideal differentiator, practical differentiator with frequency response Instrumentation amplifiers

Unit III : Non-linear Applications of OP-AMP (8 Hrs)

Comparator, characteristics of comparator, applications of comparator, Schmitt trigger (symmetrical/asymmetrical), clippers and clampers, voltage limiters, Square wave generator, triangular wave generator, Need of precision rectifier, Half wave , Full wave precision rectifiers, peak detectors, sample and hold circuits.

Unit IV : Converters using OP-AMP (6 Hrs)

V-F, I-V and V-I converter, DAC: types of DAC, characteristics, specifications, advantages and disadvantages of each type of DAC, ADC: types of ADC, characteristics, specifications, advantages and disadvantages of each type of ADC.

Unit V : Phase Locked Loop &Oscillators (8 Hrs)

Block diagram of PLL and its function, PLL types, characteristics/parameters of PLL, and different applications of PLL. Oscillators principle, types and frequency stability, design of phase shift, wein bridge, Quadrature, voltage controlled oscillators.

Unit VI : Active filters (8 Hrs)

Design and frequency scaling of First order and second order Active LP, HP, BP and wide and narrow band BR Butterworth filters and notch filter. All pass filters.

1.2 Course Objectives

The main objective of this course is to

- Introduce the characteristics of Op-Amp and identify its internal structure.
- Explain various and performance based parameters.
- Understand linear and nonlinear applications of Op-amp, their circuits and working principle.
- Introduce special purpose IC's such as PLL, Oscillators, Converters using Op-amp and their applications.
- Create Design and learn Frequency scaling of active filters using Op-amp.

1.3 Course Outcomes

After successfully completing the course students will be able to:

- **Explain** internal structure and characteristics of Op-Amp.
- **Determine** various performance parameters of op-amp and explain their significance.
- **Analyze and Implement** linear and nonlinear applications of Op-Amp.
- **Design** converters, Oscillators and filters using Op-amp.
- **Explain** and **Apply** functionalities of PLL.
- **To Improve** written, oral, and presentation skills related to Integrated Circuits and engage in life-long learning.

1.4Text Books:

1.Ramakant A. Gaikwad, "Op Amps and Linear Integrated Circuits", Pearson Education 2000.
2.Salivahanan and KanchanaBhaskaran, "Linear Integrated Circuits", Tata McGraw Hill,India 2008

1.5 Reference Books:

1. George Clayton and Steve Winder, "Operational Amplifiers", 5th Edition Newnes.
2. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", Tata McGraw Hill.
3. Bali,"Linear Integrated Circuits", Mc Graw Hill 2008.
4. Gray, Hurst, Lewise, Meyer, "Analysis & Design of Analog Integrated Circuits", Wiley Publications

1.6 Reference Web Links/ Research Paper/ Referred Book other than Mention in Syllabus:

www.nptel.ac.in
www.nptelvideos.in
ocw.mit.edu

1.7 Teaching Plan

Lecture No.	Unit	Book	Details of the Topic covered
1	1	T1	Block diagram of OP-AMP, Explanation of each block
2,3,4		T1	Differential amplifier configurations, Differential amplifier analysis (AC and DC) for DIBO Configurations using 'r' parameters.
		T1	Numerical on DC and AC analysis
5		T1	Need and types of Level shifter.
6		T1	Current mirror circuits.
7,8,9		T1, T2	Ideal parameters and practical parameters of OP-AMP and their comparison
10,11	2	T1	Inverting and Non-inverting amplifier, voltage follower, voltage scaling, difference amplifier
12,13,		T1	Ideal integrator, errors in ideal integrator, practical integrator, frequency response of practical integrator, applications of integrator
14,15		T1	Ideal differentiator, errors in ideal differentiator, practical differentiator, frequency response of practical differentiator, applications of differentiator
16,17		T1	Requirements of Instrumentation amplifier, 3 OP-AMP Instrumentation amplifier, Instrumentation amplifier applications.
18	3	T1	Comparator, characteristics of comparator, applications of comparator
19		T1	Schmitt trigger (symmetrical/asymmetrical) with numerical
20		T1	Square wave generator with numerical
22		T1	Triangular wave generator with numerical
25		T1	Problems in basic rectifier, Need of precision rectifier, Half wave , Full wave precision rectifiers
26		T1	Peak detectors, sample and hold circuits.
27,28	4	T1	V-F converter
29,30		T1	F-V converter
31		T1	I-V and V-I converter with applications , Current amplifier
32,33,		T1	DAC: types of DAC, characteristics, specifications, advantages and disadvantages of each type of DAC
34,35 36		T1	ADC, types of ADC, characteristics, specifications, advantages and disadvantages of each type of ADC
37,38	5	T1	PLL types block diagram of PLL, function and types of each block, characteristics/parameters of PLL, and different applications of PLL.
39,40		T1	Oscillators principle, types and frequency stability, design of phase shift, wein

			bridge, Quadrature, voltage controlled oscillators.
41,42	6	T1	Design and frequency scaling of First order and second order Active LP, HP
43,44 45			Design and frequency scaling of First order and second order Active BP and wide and narrow band BR Butterworth filters and notch filter. All pass filters.

1.8 Unit wise Lecture Plan

1.8 a. Unit No.-I

Pre-requisites:-

Sr.No.	Broad Topic to be covered	Linkage with previous subjects in the curriculum
1	Block diagram of OP-AMP, Explanation of each block	Basic structure of Transistors and its working, r parameters covered in EDC subject
2	Differential amplifier configurations, Differential amplifier analysis (AC and DC) for DIBO Configurations using ‘r’ parameters.	
3	Numerical on DC and AC analysis	
	Need and types of Level shifter.	
	Current mirror circuits.	
	Ideal parameters and practical parameters of OP-AMP and their comparison	

Objectives:-

- Introduce the characteristics of Op-Amp and identify its internal structure.
- Explain various performance based parameters.

Outcomes:-

At the end of the course the Students will be able to:

- Explain internal structure, characteristics of Op-Amp.
- Describe various performance parameters, frequency response and frequency compensation of Op-amp.

Lecture No.	Details of the Topic to be covered	References
1	Block diagram of OP-AMP, Explanation of each block	**T1 & T2**
2,3,4	Differential amplifier configurations, Differential amplifier analysis (AC and DC) for DIBO Configurations using ‘r’ parameters.	
	Numerical on DC and AC analysis	
5	Need and types of Level shifter.	
6	Current mirror circuits.	
7,8,9	Ideal parameters and practical parameters of OP-AMP and their comparison	

1.10.a Question Bank: Theory

Sr.No	Questions	CO Mapped
Q. 1	With neat diagram explain the necessity and working of current mirror circuit.	CO1
Q. 2	Derive the expression for A_d, R_i and R_o for dual input balanced output difference amplifier using r-parameter. Draw the small signal model for the same.	CO1
Q. 3	State the values for all ideal parameter of Op-amp.	CO2
Q. 4	Define and explain the following terms with respect to Op-amp: CMRR, PSRR, Slew rate, Gain bandwidth product.	CO2
Q. 5	State the different Op-amp technologies and compare them.	CO2
Q. 6	The following specification are given for dual input balanced output difference amplifier: Rc=2.2kΩ, R_E= 4.7kΩ, Rin_1=Rin_2=50Ω, +V_{CC}=10V, -V_{EE}= -10V, β_{ac}=β_{dc}=100, V_{BE} = 0.715 V Determine: i) Operating point i.e. I_{CQ} and V_{CEQ} ii)Voltage gain iii)Input resistance iv)Output resistance	CO1
Q. 7	Explain the effect of temperature on :	CO2

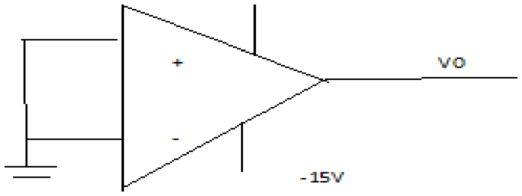
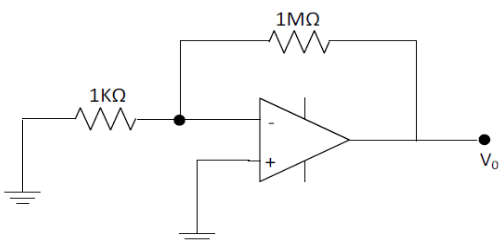
	i) Input bias current ii)Input offset current iii)Input offset voltage iv)Output offset voltage.	
Q. 8	Draw the block diagram of Op-amp and explain the function of each block in detail.	CO1
Q. 9	Explain any two level shifter circuits used in Op-amp used to shift the level.	CO1
Q. 10	Design dual input balanced output differential amplifier with constant current bias using diodes to satisfy the following requirements. [Dual supply is + or - 10V]: i) Differential voltage gain=45 ii) Current supplied by the constant current bias circuit=4.5mA iii) Supply voltage |VCC|=|-VEE|=10V.	CO1
	Find the Q- point VC and IB for dual input balanced output differential amplifier when R_E=R_C=65kΩ. Assume I_E=I_C, β=100 for both transistor Q_1 and Q_2; V_S=+ or- 12V.	CO1

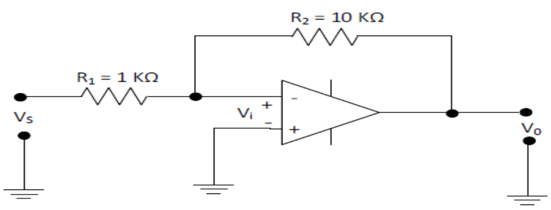
1.10.b Question Bank: Oral

Sr,No	Question	CO mapped
Q1	Draw block diagram of Op-amp	CO1
Q2	Mention the methods to improve CMRR	CO1
Q3	Draw two transistor operational amplifier	CO1
Q4	What is need of Rcomp in the circuit	CO2
Q5	Draw unity gain amplifier	CO2
Q6	What is gain of voltage follower and why	CO2
Q7	Draw pinout of Opamp 741	CO1
Q8	List down the ideal and practical values of parameter of opamp	CO2
Q9	What is meant by frequency compensation and why is it required	CO2
Q10	Why there is need of feedback	CO2
Q11	What is need of Level shifter	CO1

Q12	List down the different level shifter circuits	CO1
Q13	Why a constant current biasing is required	CO1
Q14	741 has in built compensation for Vio	CO2
Q15	Slew rate of one IC is less and the other IC is more. Which IC would you prefer	CO2

1.10.c Question Bank: MCQ

Sr. No	Questions	CO Mapped
Q1	If the Op – Amp in the figure has an input offset voltage of 5 mV and an open-loop voltage gain of 10,000 then V0 will be  Supply voltage is +15v and -15 v a. 0 V b. 5 mV c. + 15 V or -15 V d. +50 V or -50 V	CO2
Q2	An Op – Amp has offset voltage of 1mV and is ideal in all other respects. If this Op – Amp is used in the circuit shown in figure. The output voltage will be (Select the nearest value)  a. 1 mV b. 1 V **c. ± 1V** d. 0 V	CO2
Q3	An op amp has a voltage gain of 200,000. If the output voltage is 1 V, the input voltage is a. 2 µV **b. 5 µV**	CO2

	c. 10 V d. 1 V Q4. The voltage follower has a CO2 a. **Closed-loop voltage gain of unity** b. Small open-loop voltage gain c. Closed-loop bandwidth of zero d. Large closed-loop output impedance	
Q5	If the cutoff frequency is 20 Hz and the mid-band open-loop voltage gain is 1,000,000 the unity-gain frequency is a. 20 Hz b. 1 MHz c. 2 MHz **d. 20 MHz**	CO2
Q6	A 741 C has a. A voltage gain of 100,000 b. An input impedance of 2 MΩ c. An output impedance of 75 Ω **d. All of the above**	CO1
Q7	The inverting op-amp shown in the figure has an open-loop gain of 100. The closed-loop gain V0 / VS is  a. – 8 b. – 9 **c. – 10** d. – 11	CO2

Q8	The 741 C has a unity-gain frequency of a. 10 Hz b. 20 Hz **c. 1 MHz** d. 15 MHz	CO1
Q9	For an op-amp having a slew rate SR = 5 V/ms, what is the maximum closed-loop voltage gain that can be used when the input signal varies by 0.2 V in 10 ms? a. 150 b. 200 **c. 250** d. 300	CO2
Q10	Op-amp used in unity gain circuit has input sine wave of amplitude 5V having frequency of 63.662khz. The minimum slew rate required for the op-amp is a. 0.8 **b. 1.2566** c. 2 *d. 0.5*	CO2
Q11	For a differential amplifier using ± 10 v supply with Rc =4.7kΩ and Re = 10kΩ the value of ICQ is approximately -------------- a. 0.66mA b. 0.855mA c. 0.465mA d. 1.055mA	CO1
Q12	The operational amplifier can be nulled by __________. a. **using an offset voltage compensating net**work b. using an error minimizing resistance c. cutting off the power supplies d. None of the above.	CO2
Q13	Slew rate is defined by **a. dv/dt(max)** **b.** di/dt(max) **c.** dv/dt d. none of the above	CO2
Q14	The amplifier gain varies with frequency. This happens mainly due a. Miller effect b. **Presence of external and internal capacitance** c. Logarithmic increase in its output d. Inter stage transformer	CO2
Q15	What is the level of the roll-off in most op-amps? a. –6 dB / decade b. –20 dB / octave c. –6 dB / decade or –20 dB / octave d. –**20 dB / decade or –6 dB / octave**	CO2

Q16	The input offset voltage drift is a parameter directly related to VOS and ____. a. ID b. power dissipation c. **Temperature** d. Phase shift	CO2
Q17	The ideal Op – Amp has the following characteristics. a. **Ri = ∞, A = ∞, R0 = 0** b. Ri = 0, A = ∞, R0 = 0 c. Ri = ∞, A = ∞, R0 = ∞ d. Ri = 0, A = ∞, R0 = ∞	CO1
Q18	If the differential voltage gain and the common mode voltage gain of a differential amplifier are 48 dB and 2 dB respectively, then its common mode rejection ratio is a. 23 dB b. 25 dB c. **46 dB** d. 50 dB	CO2
Q19	The input offset current equals the a. **Difference between the two base currents** b. Average of the two base currents c. Collector current divided by current gain d. Difference between the two base-emitter voltage.	CO1
Q20	The op amp can amplify a. AC signals only b. DC signals only c. **Both ac and dc signals** d. Neither ac not dc signals	CO1
Q21	When the two input terminals of a diff amp are grounded a. The base currents are equal b. The collector currents are equal c. **An output error voltage usually exists** d. The ac output voltage is zero.	CO1

Q21	The common-mode rejection ratio is a. Very low b. **As high as possible** c. Equal to the voltage gain d. Equal to the common-mode voltage gain	CO2
Q22	The typical input stage of an op amp has a a. Single-ended input and single-ended output b. Single-ended input and differential output c. Differential input and single-ended output d. **Differential input and differential output**	CO1
Q23	The input offset current is usually a. **Less than the input bias current** b. Equal to zero c. Less than the input offset voltage d. Unimportant when a base resistor is used	CO1
Q24	An ideal op-amp is an ideal a. voltage controlled current source b. **voltage controlled voltage source** c. current controlled current source d. current controlled voltage source	CO1
Q25	An ideal op-amp can drive infinite number of circuit without difficulty because---------- a. Zero common mode gain **b. Zero Output resistance** c. Zero input bias current d. Infinite CMRR	CO2

Q26	Opamp block schematic is referred as a. Two stage architecture **b. Three stage architecture** c. Four stage architecture d. Five stage architecture	CO1
Q27	The second stage in Op-Amp block Schematic is a. DuaI input Balanced Output **b. Dual Input Unbalanced Output** c. Single Input Unbalanced Output d. Single Input Balanced Output	CO1
Q28	In Opamp the last stage is emitter follower which provides a.**Low O/P resistance and high voltage gain** b. Low O/P resistance and low voltage gain c.Low O/P resistance and high current gain d. D. Low O/P resistance and low current gain	CO1
Q29	With suitable feedback opamp can be used as a. Ac and Dc signal amplification b. Active filter c. Oscillator d. **All above**	CO1
Q30	For Dual input balanced output differential amplifier Ad a. RC/RE b. Rc/re'+RE c. Rc/2re' d. **Rc/re'**	CO1

Q31	CMRR of the opamp is increases by a. Increase in RE b. Constant current circuit c. Constant mirror circuit d. **All above**	CO2
Q32	The Slew Rate of opamp is decided by a. Level shifter stage b. Differential amplifier stage **c. Output stage** d. All above	CO2
Q33	The compensating network is connected external to Opamp to a. Increase Gain b. Increase Gain c. Maintain gain constant d. **Roll off the gain by -20db**	CO2
Q34	Parameter drift with temperature in case of opamp a. Bias current b. Offset current c. Offset voltage d. **All above**	CO2
Q35	The thermal compensation in current source is provided by **a. diodes** b. FET c. MOSFET d. D. capacitors	CO2

Q36	The circuit in which output current is forced to be equal to input current is called a. differential amplifier b. constant current source **c. Current mirror** d. voltage regulator	CO1
Q37	The circuit commonly used in the output stage of opamp IC is a) multistage amplifier b) differential amplifier **c) push pull amplifier** d) Vbe multiplier	CO1
Q38	Op-amp used in circuit with gain 10 has slew rate of 1.2566 V/usec and it used input sine wave of 2 V p-p, then maximum frequency of operation without distortion is a) 63.66 KHz b) 53.05 KHz **c) 20 KHz** d) d. 7 KHz	
	Calculate the time taken by the output to swing from +14v to -14v for a 741C op-amp having a slew rate of 0.5V/µs? a. 22µs b. 42µs **c. 56µs** d.70µs	

1.8 a. Unit No.-II

Objectives:-

- Understand linear and nonlinear applications of Op-amp, their circuits and working principle.

Outcomes:-

At the end of the course the Students will be able to:

- Identify and Analyze linear applications of Op-Amp.

Lecture No.	Details of the Topic to be covered	References
10,11	Inverting and Non-inverting amplifier, voltage follower, voltage scaling, difference amplifier	T1
12,13,	Ideal integrator, errors in ideal integrator, practical integrator, frequency response of practical integrator, applications of integrator	
14,15	Ideal differentiator, errors in ideal differentiator, practical differentiator, frequency response of practical differentiator, applications of differentiator	
16,17	Requirements of Instrumentation amplifier, 3 OP-AMP Instrumentation amplifier, Instrumentation amplifier applications.	

1.10.a Question Bank: Theory

CO3: Identify and Analyze linear applications of Op-Amp.
CO3 mapped to all questions

Q. 1	Explain practical differentiator circuit with neat circuit diagram. What are the limitations of ideal differentiator?
Q. 2	Draw a neat diagram of inverting summing amplifier with three inputs and obtain the expression for output voltage.
Q. 3	What are the problems associated with the ideal integrator? Draw a neat circuit diagram of practical integrator and explain its operation with its frequency response.
Q. 4	What is the need of frequency compensation? State and explain any one method of external frequency compensation.
Q. 5	Draw and explain three Op-amp instrumentation amplifier. Derive the expression for output voltage.
Q. 6	Compare the salient feature of an integrator and differentiator using Op-amp.
Q. 7	Draw and explain integrator working with run, set and hold modes.

Q. 8	Design practical integrator using Op-amp IC741C to satisfy the following specification: Assume V_{CC}= + or – 15V. i) 3-dB cut-off frequency =1.5kHz ii) D.C. gain=10 Sketch the frequency response of the circuit.
Q. 9	Design a practical differentiator having unity gain at 150Hz.
Q. 10	Design a practical differentiator to differentiate an input signal that varies in frequency from 10Hz to 500Hz. Draw its frequency response.

1.10.b Question Bank: Oral

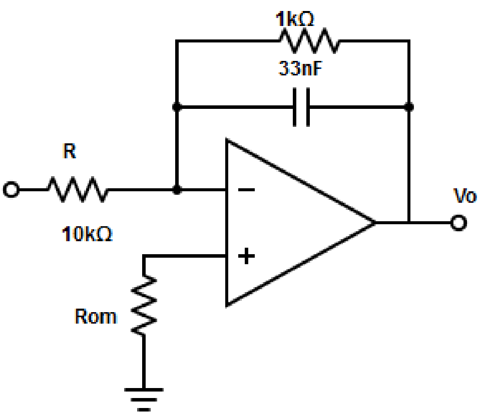
CO3: Identify and Analyze linear applications of Op-Amp.
CO3 mapped to all questions

Sr. No	Questions
Q1	What are the limitations of ideal integrator
Q2	Draw frequency response of a practical and ideal integrator
Q3	Why the gain drops by 20db/decade in integrator
Q4	Draw and explain frequency response of differentiator
Q5	Why the instrumentation amplifier has 3 opamps
Q6	What are the applications of instrumentation amplifier
Q7	What is UGB
Q8	What is break frequency and why the gain drops by -3db at this frequency
Q9	Draw a summing amplifier and prove that its output is addition of all inputs
Q10	Draw inverting and noninverting amplifier
Q11	Draw a subtractor circuit and explain its working
Q12	Why compensation is required for opamp

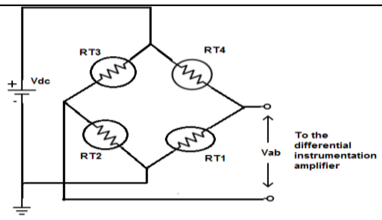
1.10.c Question Bank: MCQ

CO3: Identify and Analyze linear applications of Op-Amp.
CO3 mapped to all questions

Sr.No	Questions
Q1	A certain inverting amplifier has a closed-loop voltage gain of 25. The Op-amp has an open-loop voltage gain of 100,000. If an Op-amp with an open-loop voltage gain of 200,000 is substituted in the arrangement, the closed-loop gain …….. a. doubles b. drops to 12.5 **c. remains at 25** d. increases slightly
Q2	How many op-amps are required to implement this equation $V_o = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right)$ a. 2 b. 3 c. 4 d. **1**
Q3	When a step-input is given to an op-amp integrator, the output will be a. **A ramp.** b. A sinusoidal wave. c. A rectangular wave. d. A triangular wave with dc bias
Q4	Find the output voltage of the integrator **a. $V_o = (1/R\times C_F)\times\int_0^t V_{in}dt+C$** b. $V_o = (R/C_F)\times\int_0^t V_{in}dt+C$ c. $V_o = (C_F/R)\times\int_0^t V_{in}dt+C$ d. $V_o = (R\times C_F)\times\int_0^t V_{in}dt+C$
Q5	The frequency at which gain is 0db for integrator is a. $f=1/(2\pi R_F C_F)$ **b. $f=1/(2\pi R_1 C_F)$** c. $f=1/(2\pi R_1 R_1)$ d. $f=(1/2\pi)\times(R_F/R_1)$
Q6	The frequency at which the gain of the integrator becomes zero is $f=1/(2\pi R_1 C_F)$.

	 a. 43.43kHz **b. 4.82kHz** c. 429.9kHz d. 4.6MHz
Q7	Find the value of capacitor, if the rate of change of voltage across the capacitor is 0.78V/µs and current= 12µA. a. 5µF b. 2µF c. 10µF **d. 15µF**
Q8	Determine the maximum input signal to be applied to an op-amp to get distortion free output. If the op-amp used is an inverting amplifier with a gain of 50 and maximum output amplitude obtained is 4.2V sine wave? a. 159mv **b. 0.168mv** c. 207mv d. 111mv

Q9



R_{T1}, R_{T2}, R_{T3}, R_{T4} are unstrained gage resistance. If the resistance change in each gage is 0.3Ω. Choose the correct option?

1. R_{T1} and R_{T3} increases by 0.3Ω
2. R_{T2} and R_{T4} decreases by 0.3Ω
3. R_{T1} and R_{T3} increases by 0.3Ω
4. R_{T2} and R_{T4} decreases by 0.3Ω

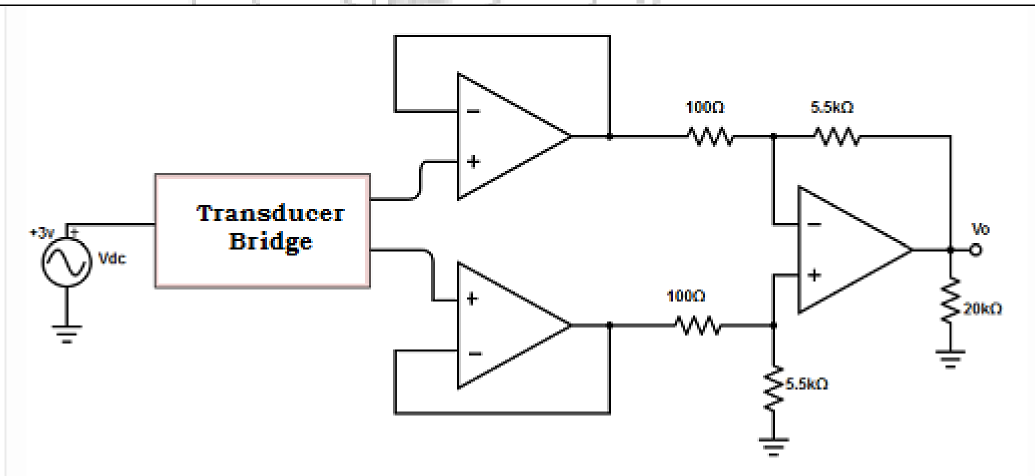
a) 3 and 4
b) 1 and 2
c) 1 and 4
d) 2 and 3

Q10

What will be the resultant circuit, when the thermistor in the bridge transducer is replaced by a strain gage?

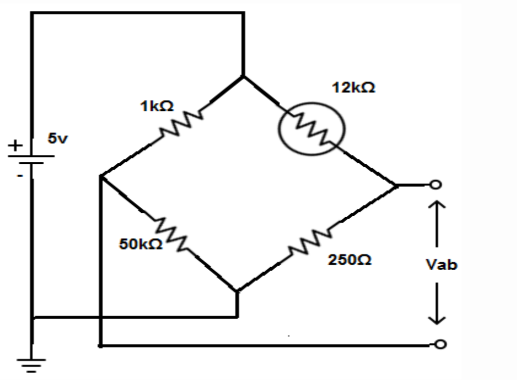
a) Differential input and differential output amplifier
b) Light intensity
c) Analog weight scale
d) None of the mentioned

Q11



Consider the entire resistors in the bridge circuit are equal. The resistance and change in resistance are given as 3kΩ and 30kΩ. Calculate the output voltage of differential instrumentation amplifier?

a) 4.95v
b) 1.65v
c) 8.25v
d) 14.85v

Q12	Consider a thermistor having the following specifications: R_F=150kΩ at a reference temperature of 35°C and temperature coefficient of resistance = 25°C. Determine the change in resistance at 100°C. **a) -1.625MΩ** b) 9.75MΩ c) 4.78MΩ d) None of the mentioned
Q13	Express the equation for transducer bridge, if all the resistor values are equal a) v=-(△R×V_{dc})/(2×R+△R) b) v=-(△R×V_{dc})/2×(R+△R) c) v=-V_{dc}/[2×(2×R+△R)]. **d) v=-(△R×V_{dc})/ [2×(2×R+△R)].**
Q14	a) **V_{ab} = 4.9v** b) V_{ab} = -5.6v c) V_{ab} =1.2v d) V_{ab} =-8.2v 

1.8 a. Unit No.-III

Objectives:-

- Understand nonlinear applications of Op-amp, their circuits and working principle.

Outcomes:-

At the end of the course the Student will be able to:

- Identify and Analyze nonlinear applications of Op-Amp.

Lecture No.	Details of the Topic to be covered	References
18	Comparator, characteristics of comparator, applications of comparator	T1
19	Schmitt trigger (symmetrical/asymmetrical) with numerical	
20	Square wave generator with numerical	
22	Triangular wave generator with numerical	
25	Problems in basic rectifier, Need of precision rectifier, Half wave , Full wave precision rectifiers	
26	Peak detectors, sample and hold circuits.	

1.10. a Question Bank: Theory

CO3: Identify and Analyze nonlinear applications of Op-Amp.

CO3 is mapped with all the questions

Sr.No	Questions
Q. 1	Draw and explain sample and hold circuit using Op-amp.
Q. 2	Draw and explain half wave precision rectifier circuit.
Q. 3	Explain the working of inverting Schmitt trigger. Also derive the equation for the trigger points.
Q. 4	Explain the necessity of precision rectifier with neat circuit diagram. Explain the operation of full wave precision rectifier.
Q. 5	Draw and explain square wave generator using Op-amp.
Q. 6	Design an adder using op-amp to get output expression as: $V_0= - (2V_1 +3V_2 +5V_3)$ where V_1, V_2, V_3 are inputs.
Q. 7	Explain the operation of inverting comparator with appropriate output waveforms.

Q. 8	Design an inverting Schmitt trigger circuit whose V_{UT} and V_{LT} are + or – 5V. Draw input and output waveforms. Assume op-amp saturates at + or – 13.5V.
Q. 9	Explain peak detector using op-amp.
Q.10	State the important characteristics of comparator using op-amp and explain.
Q. 11	Design square wave generator to generate a perfect square wave of 50% duty cycle with an output frequency of 1 kHz. Assume feedback factor to be 0.1. Also draw the output waveform and waveform across the capacitor using op-amp.
Q. 12	Draw and explain zero crossing detectors using op-amp with necessary waveforms.

1.10.b Question Bank: Oral

CO3: Identify and Analyze nonlinear applications of Op-Amp.

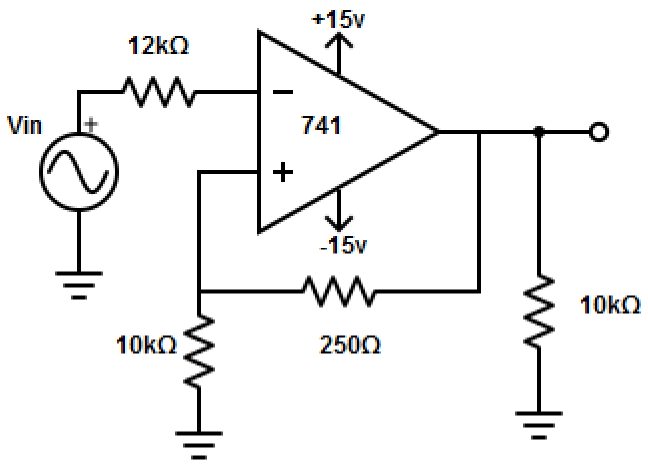
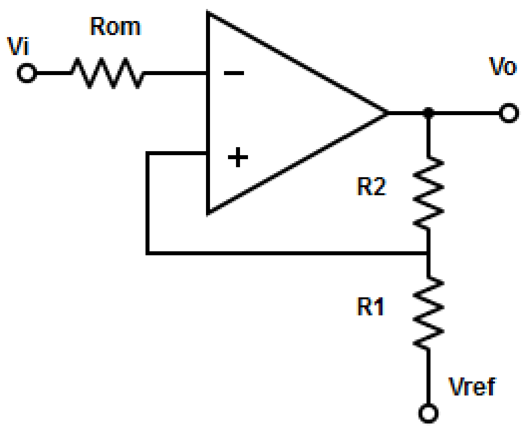
CO3 is mapped with all questions

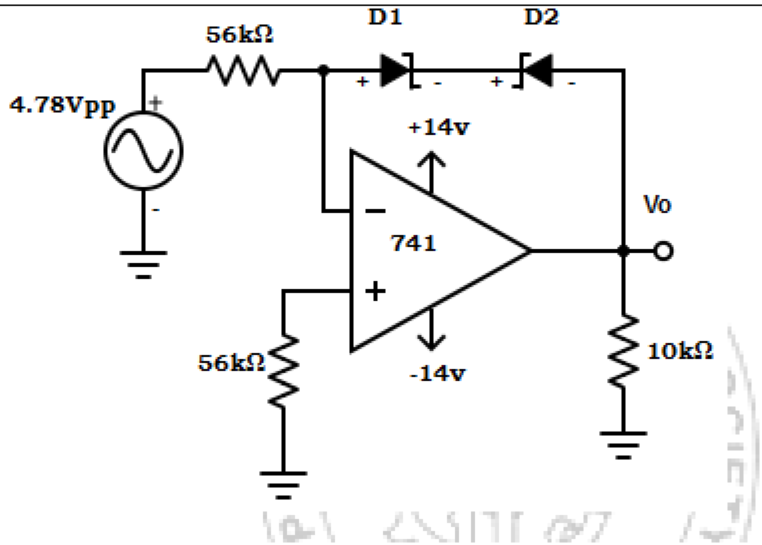
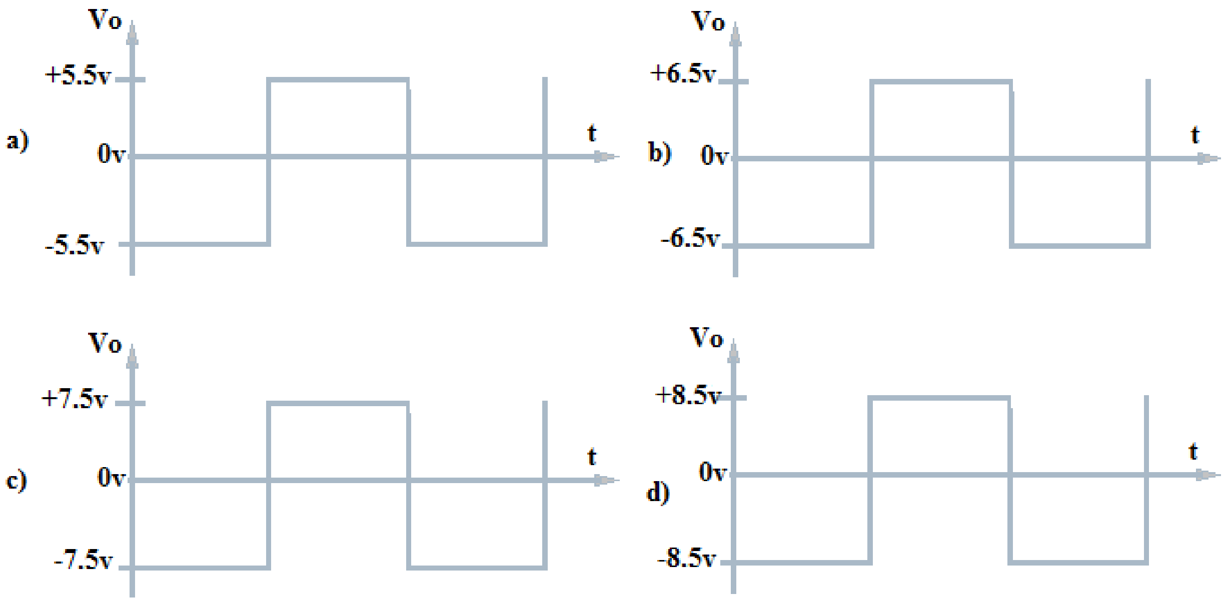
Sr No	Questions
Q1	Why Schmitt trigger is called as regenerative comparator
Q2	Explain working of a Schmitt trigger
Q3	How is hysteresis loop formed
Q4	Draw output of a non- inverting comparator
Q5	Draw an asymmetrical waveform and give it as input to Schmitt trigger and show its output
Q6	How do I limit the voltage at positive or negative side using a comparator
Q7	Draw a square wave generator and explain its working
Q8	Explain significance of capacitor in working of Square wave generator
Q9	Explain the difference between positive and negative feedback
Q10	Why HWR and FWR are called precision rectifiers
Q11	Draw and explain working of inverting and non-inverting HWR and FWR
Q13	Explain application of peak detector
Q14	List applications of sample and hold
Q15	Explain working of a sample and hold circuit with the help of circuit and waveform

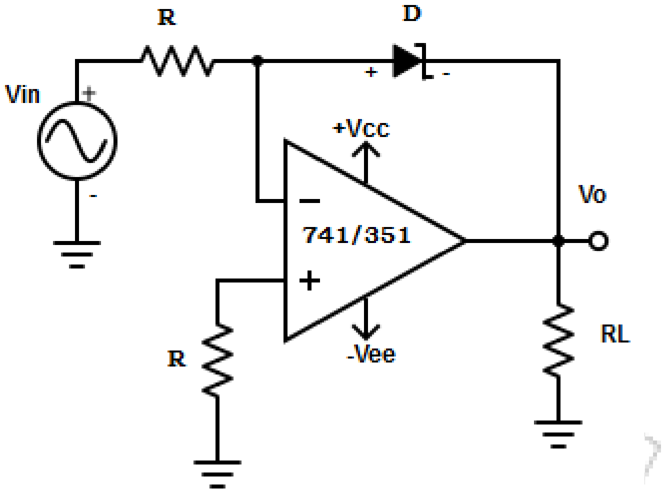
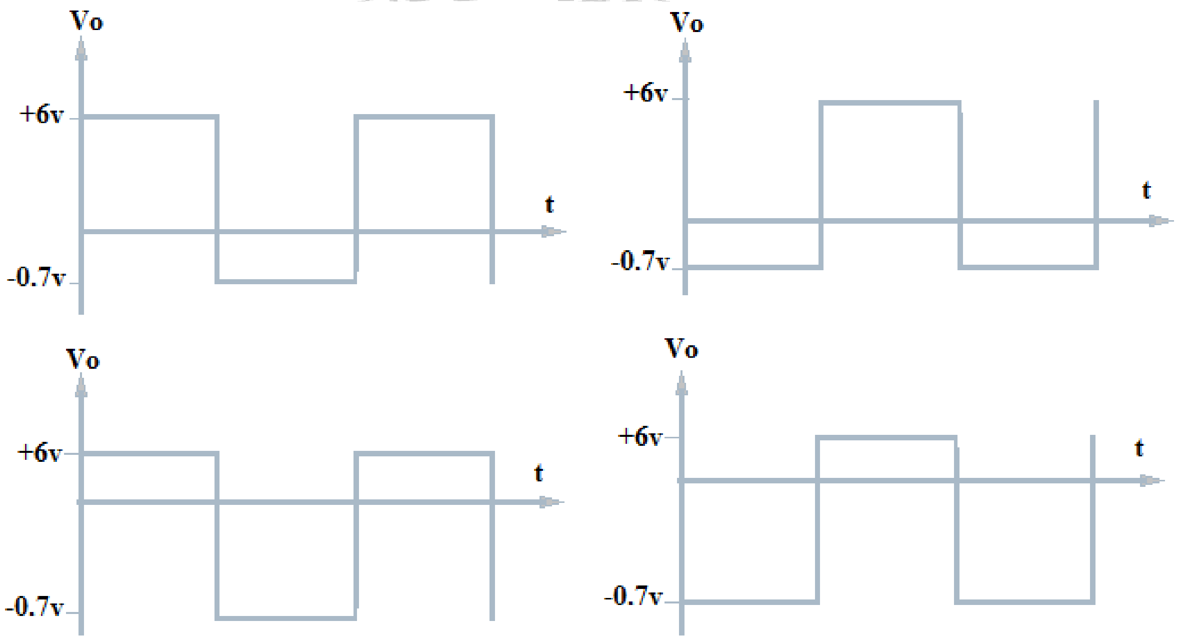
1.10.c Question Bank: MCQ

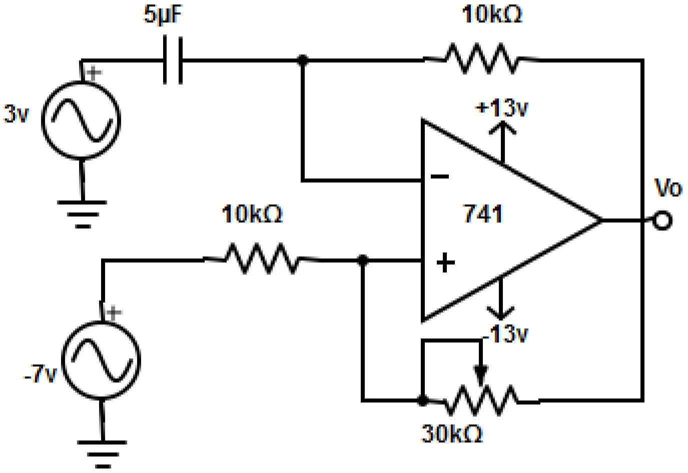
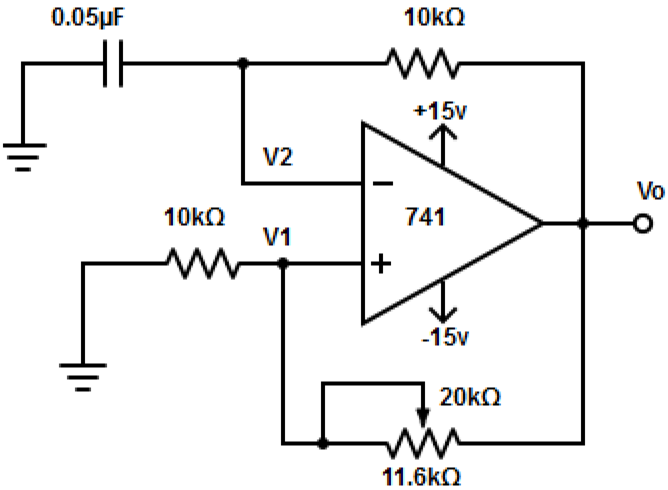
CO3: Identify and Analyze nonlinear applications of Op-Amp.

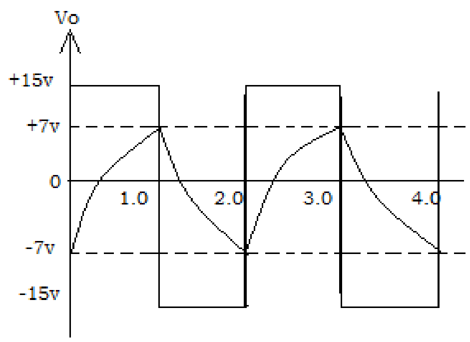
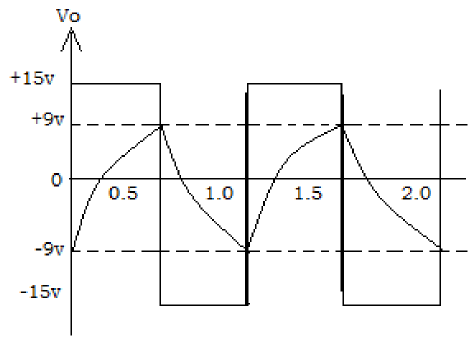
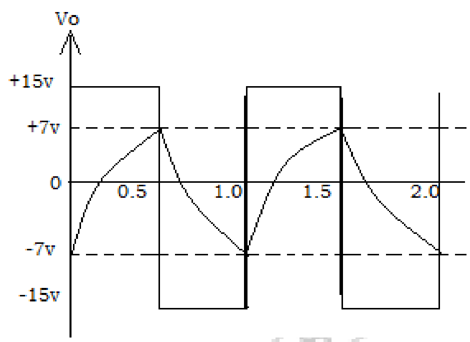
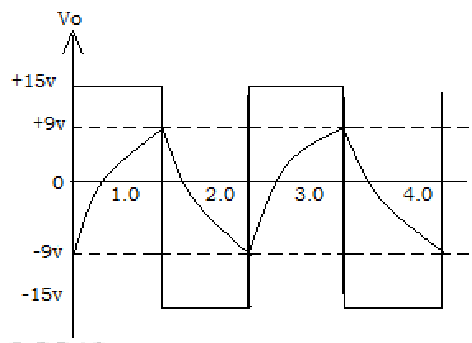
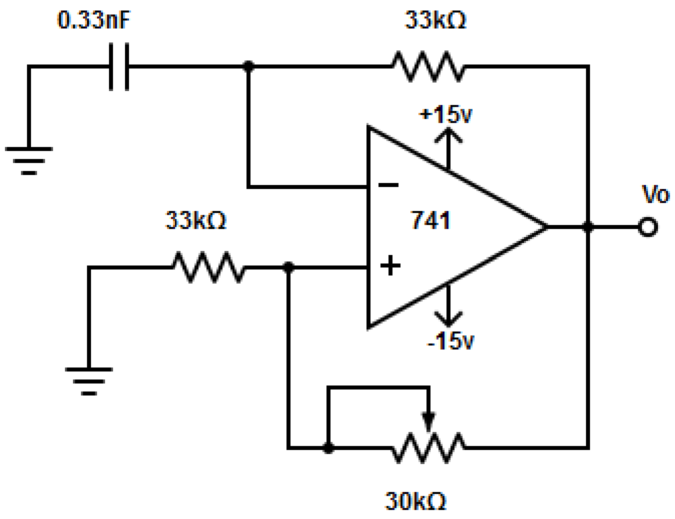
CO3 is mapped with all questions

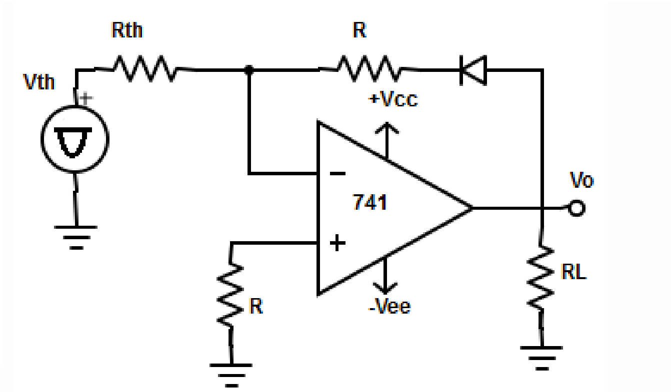
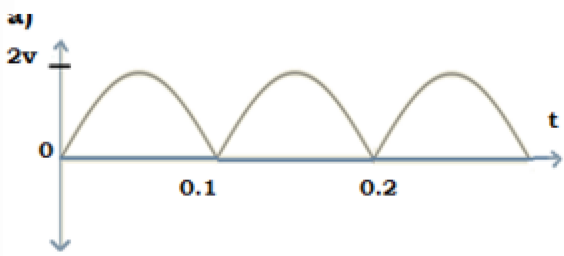
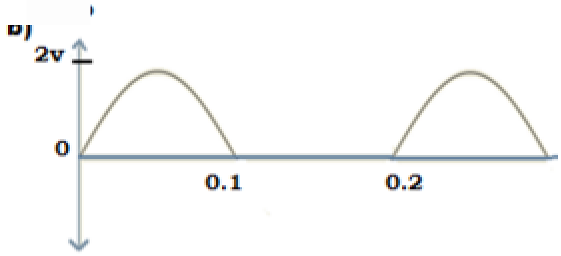
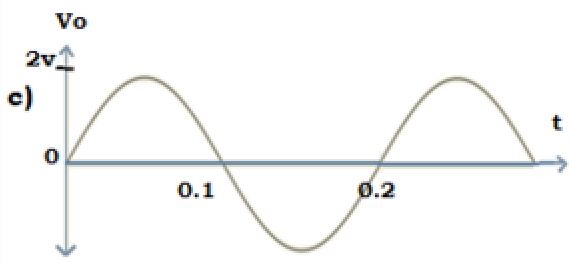
Sr.No	Questions
Q1	Which circuit converts irregularly shaped waveform to regular shaped waveforms? **a) Schmitt trigger** b) Voltage limiter c) Comparator d) None of the mentioned
Q2	. Determine the upper and lower threshold voltage  a) V_{UT} = +14.63v, V_{LT}= +14.63v **b) V_{UT} = -14.63v, V_{LT}= -14.63v** c) V_{UT} = V_{LT}= ±14.63v d) None of the mentioned
Q3	Calculate the hysteresis voltage for the schmitt trigger from the given specification: R_2 =56kΩ , R_1 = 100Ω ,V_{ref} = 0v & V_{sat} = ±14v.  a) 0 mv

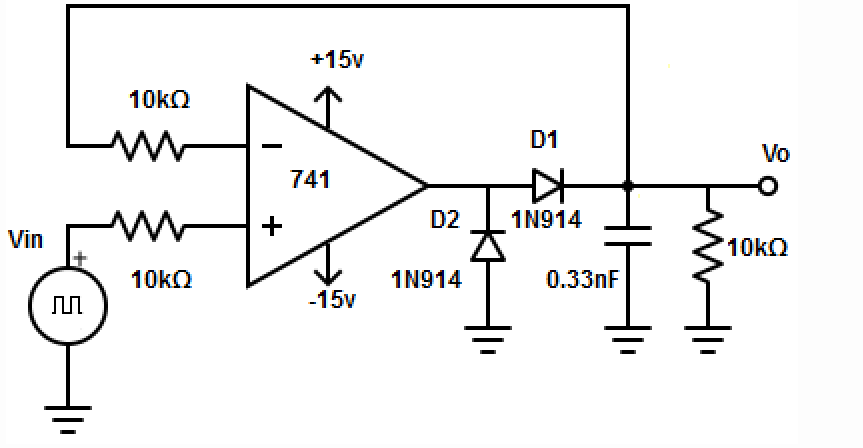
	b) 25 mv **c) 50 mv** d) -25 mv
Q4	How to limit the output voltage swing only to positive direction? a) Combination of two zener diodes **b) Combination of zener and rectifier diode** c) All of the mentioned d) Combination of two rectifier diodes
Q5	 
Q6	A basic op-amp circuit has a zener and rectifier diode connected in the feedback path. Calculate the maximum positive voltage. Where, zener voltage = 5.1 v and voltage drop across the forward biased zener = 0.7v? a) V_O = 5.8v b) V_O = 9.9v c) V_O = 4.7v

	d) V_O = 7.1v
Q7	Use the specification and obtain the output voltage swing for op-amp comparator. Specification: R= 1kΩ; R_L=10kΩ; V_Z=6v; V_{Sat}=±15v (Assume forward bias of zener = 0.7v).  

Q8	The following circuit represents a square wave generator. Determine its output voltage  **a) -13 v** b) +13 v c) ± 13 v d) None of the mentioned
Q9	Determine the expression for time period of a square wave generator a) $T= 2RC \ln\times[(R_1+ R_2) / (R_2)]$. b) $T= 2RC \ln\times[(2R_1+ R_2) / (R_2)]$. c) $T= 2RC \ln\times[(R_1+ 2R_2) / (R_2)]$. d) $T= 2RC \ln\times[(R_1+ R_2) / (2 R_2)]$.
Q10	Determine capacitor voltage waveform for the circuit 

	a)  b)  c)  d) 
Q11	What will be the frequency of output waveform of a square wave generator if $R_2 = 1.16\ R_1$? a) $f_o = (1/2RC)$ **b) $f_o = (ln/2RC)$** c) $f_o = (ln\ /2 \times \sqrt{}RC)$ d) $f_o = (ln/\sqrt{}(2\ RC))$
Q12	Determine the output frequency for the circuit given below  a) 28.77 Hz b) 31.97 Hz c) 35.52 Hz **d) 39.47 Hz**
Q13	

	Determine the output waveform for the circuit     **d) None of the mentioned**
Q14	The resistor in the peak detector are used to a) To maintain proper operation **b) Protect op-amp from damage** c) To get shaped non-sinusoidal waveform d) None of the mentioned
Q15	In the sample and hold circuit, the period during which the voltage across capacitor is equal to input voltage a**) Sample period** b) Hold period c) Delay period d) Charging period
Q16	During which period the op-amps output of sample and hold circuits is processed? a) Delay period b) Sample and hold period c) Sample period **d) Hold period**

Q17	How to detect the negative peaks of input signals in the peak detector given below?  a)Reversing D1 diode **b) Reversing D1 and D2 diodes** c) Reversing D2 diode d) Charging the positions of D1 and D2

1.8 a. Unit No.-IV

Objectives:-

- Introduce some of the Converters and their applications.

Outcomes:-

At the end of the course the Students will be able to:

- **Design** converters, Oscillators and filters using Op-amp.

Lecture No.	Details of the Topic to be covered	References
27,28	V-F converter	T1
29,30	F-V converter	
31	I-V and V-I converter with applications , Current amplifier	
32,33,	DAC: types of DAC, characteristics, specifications, advantages and disadvantages of each type of DAC	
34,35 36	ADC, types of ADC, characteristics, specifications, advantages and disadvantages of each type of ADC	

1.10.a Question Bank: Theory

CO4: Design converters, Oscillators and filters using Op-amp.

CO4 is mapped with all questions

Sr.No	Questions
Q. 1	Explain V2F converter using op-amp with appropriate waveforms.
Q. 2	Explain binary weighted register type of DAC.
Q. 3	With the help of neat diagram explain the operation of Dual slope ADC.
Q. 4	Calculate output voltage of 8 bit DAC for digital input 10000000 and 11011101 with reference voltage of 10 V.
Q. 5	State the specification of ADC. Also explain the application of ADC
Q. 6	Write a short note on flash type ADC.
Q. 7	What are the different types of V to I converter. Explain any one.

Q. 8	What output voltage would be produced by a D/A converter whose output range is 0 to 10 V and input binary number is : i) 10 (for a 2-bit DAC converter) ii) 0110(for a 4-bit DAC) iii) 10111100 (for a 8-bit DAC)
Q. 9	With neat circuit diagram, explain current to voltage converter.
Q. 10	Draw the neat circuit diagram of R-2R ladder DAC and explain its working.
Q. 11	Explain the operation of successive approximation type ADC.
Q. 12	Explain the operation of frequency to voltage converter with neat diagram.

1.10.b Question Bank: Oral

CO4: Design converters, Oscillators and filters using Op-amp.

CO4 is mapped with all questions

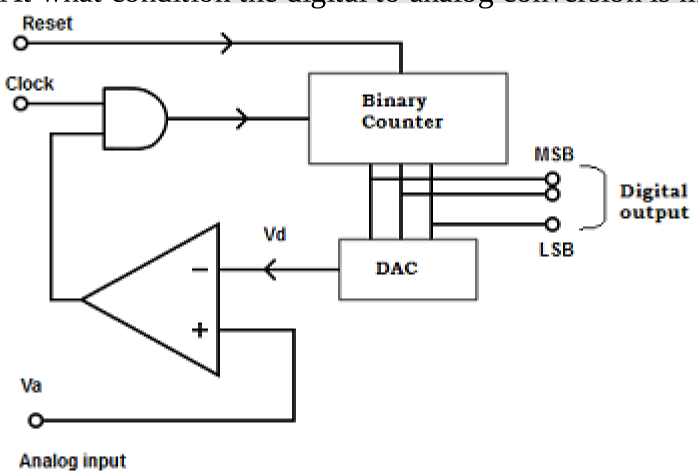
Sr.No	Questions
Q1	What is output of a DAC or ADC ? Draw it in a graph format and show
Q2	Calculate output voltage of 4 bit DAC for digital input 10000000 with reference voltage of 5 V.
Q3	What is difference between DAC and ADC
Q4	List various DAC's
Q5	List Different ADC's
Q6	Explain working of DAC's and ADC's
Q7	What are advantages of R-2R DAC over Binary weighted DAC
Q8	Explain working of V to F and F to V converter

1.10.c Question Bank: MCQ

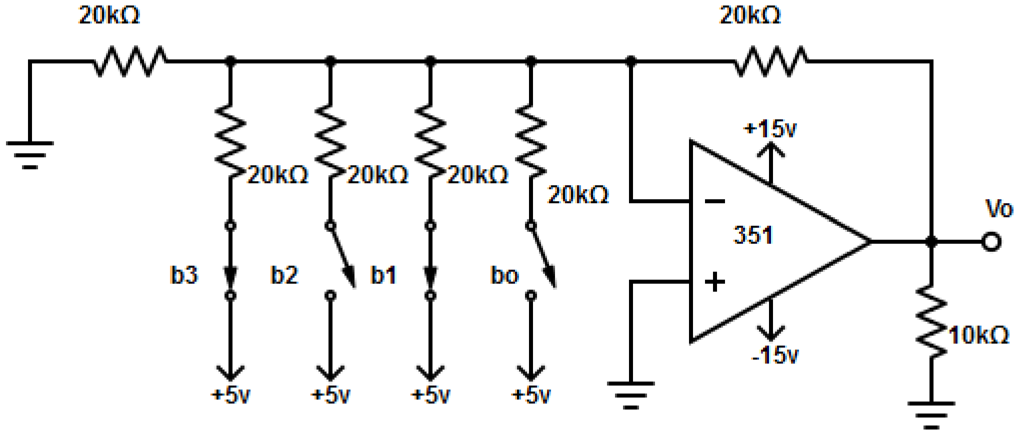
CO4: Design converters, Oscillators and filters using Op-amp.

CO4 is mapped with all questions

Sr.No	Questions
Q1	Find out the resolution of 8 bit DAC/ADC? a) 562 b) 625 c) 256 d) 265

Q2	Non-linearity in the output of converter is expressed in None of the mentioned b) Percentage of reference voltage c) Percentage of resolution d) Percentage of full scale voltage
Q3	A binary input 000 is fed to a 3bit DAC/ADC. The resultant output is 101. Find the type of error? a) Settling error b) Gain error c) Offset error d) Linearity error
Q4	How many equal intervals are present in a 14-bit D-A converter? a) 16383 b) 4095 c) 65535 d) 1023
Q5	Resolution of a 6 bit DAC can be stated as a) Resolution of 1 part in 63 b) 6-bit resolution c) Resolution of 1.568% of full scale d) All of the mentioned
Q6	Find the resolution of a 10-bit AD converter for an input range of 10v? a) 97.7mv b) 9.77mv c) 0.977mv d) 977mv
Q7	The time taken for the output to settle within a specified band of its final value is referred as a) Conversion time b) Settling time c) Take off time d) All of the mentioned
Q8	At what condition the digital to analog conversion is made?  a) $V_a > V_d$ b) $V_a \leq V_d$ c) $V_a \geq V_d$

	d) $V_a \neq V_d$
Q9	The Integrating type converters are used in a) Digital meter b) Panel meter c) Monitoring system d) All of the mentioned
Q10	Which type of ADC is chosen for noisy environment? a) Successive approximation ADC b) Dual slope c) Charge balancing ADC d) All of the mentioned
Q11	How to overcome the drawback of the charge balancing ADC? a) By using precision integrator b) By using Voltage to frequency converter c) By using voltage comparator d) By using dual slope converter
Q12	Which among the following has long conversion time? a) Servo converter b) Dual ramp converter c) Flash converter d) None of the mentioned
Q13	A dual slope has the following specifications: 16bit counter; Clock rate =4 MHz; Input voltage=12v; Output voltage =-7v and Capacitor=0.47µF. If the counters have cycled through 2^n counts, determine the value of resistor in the integrator. a) 60kΩ b) 50kΩ c) 120kΩ d) 100kΩ
Q14	A 12 bit dual ramp generation has a maximum output voltage of +12v. Compute the equivalent digital number for the analog signal of +6v. a) 1000000000 b) 10000000000 c) 1000000000000 d) 100000000000

Q15	For the given circuit find the output voltage?  a) -5.625v b) -3.50v c) -4.375v d) -3.125v
Q16	Calculate the value of LSB and MSB of a 12-bit DAC for 10v? a) LSB =7.8mv, MSB =5v b) LSB =9.3mv, MSB =5v c) LSB =14.3mv, MSB =5v d) LSB =2.4mv, MSB =5v
Q17	A 10-bit D/A converter have an output range from 0-9v. Calculate the output voltage produced when the input binary number is 1110001010. a) ±7.96v b) -7.96v c) 7.96v d) None of the mentioned

1.8 a. Unit No.-V

Objectives:-

- Analyze converters, Oscillators using Op-amp and special purpose IC's like PLL.

Outcomes:-

At the end of the course the Students will be able to:

- **Design** converters, Oscillators and filters using Op-amp.
- **Explain** and **Apply** functionalities of PLL.

Lecture No.	Details of the Topic to be covered	References
37,38	Analyze converters, Oscillators using Op-amp and special purpose IC's like PLL.	T1
39,40	Oscillators principle, types and frequency stability, design of Phase shift, Wein bridge, Quadrature, Voltage controlled oscillators.	

1.10.a Question Bank: Theory

Sr.No	Question	CO Mapped
Q. 1	With the help of neat block diagram explain operation of PLL	CO5
Q. 2	Draw and explain circuit of FM demodulator using PLL.	
Q. 3	Write short note on: i) Frequency synthesizer using PLL. ii) Digital phase comparator using PLL.	
Q. 4	Define the following terms with reference to PLL: i) Lock range ii) Capture range iii) Free running frequency iv) Pull-in-time	
Q. 5	Explain graphic equalizer using PLL and define the terms Centre frequency and capture time related to PLL.	
Q. 6	Calculate output frequency f_0, lock range and Capture range of PLL if the timing parameters are C_T = 0.1µf, R_T = 1kΩ. The filter capacitor is 10 µf.	

Q. 7	Give the specifications of PLL IC NE 565 with neat block diagram. Also mention the design equations for the same.	
Q. 8	What is VCO? Give two applications that require a VCO.	CO4
Q. 9	Design a wein bridge oscillator that will oscillate at 2 kHz.	
Q.10	Explain the principle of oscillators, its types and frequency stability.	
Q.11	Design a quadrature oscillator to operate at a frequency of 1.5 kHz.	

1.10.b Question Bank: Oral

Sr.No	Question	CO Mapped
Q1	Explain working of Phase shift oscillator	CO4
Q2	Explain working of Wein bridge oscillator	
Q3	What is meant by VCO	
Q4	What is Frequency stability in oscillators	
Q5	What are different types of oscillators	
Q6	Design an oscillator with given specifications (operating frequency will be given by the examiner)	
Q7	What is Principal and what are applications of oscillators	
Q8	What is PLL? Explain its working of PLL	CO5
Q9	Explain Phase detector	
Q10	Define the following terms with reference to PLL: i) Lock range ii) Capture range iii) Free running frequency iv) Pull-in-time	
Q11	List various applications of PLL	

1.8 a. Unit No.-VI

Objectives:-

- Create Design and learn Frequency scaling of active filters using Op-amp.

Outcomes:-

At the end of the course the Students will be able to:

- **Design** converters, Oscillators and filters using Op-amp.

Lecture No.	Details of the Topic to be covered	References
41,42	Design and frequency scaling of First order and second order Active LP, HP	**T1**
43,44 45	Design and frequency scaling of First order and second order Active BP and wide and narrow band BR Butterworth filters and notch filter. All pass filters.	

1.10.a Question Bank: Theory

CO4: Design converters, Oscillators and filters using Op-amp.

CO4 is mapped with all questions

Sr.No	Questions
Q. 1	State the advantages of active filter. Explain the operation of first order low pass filter with the help of circuit diagram.
Q. 2	Compare active and passive filter.
Q. 3	Design first order wide bandpass filter for the following specifications : Quality factor (Q) = 3 Pass band gain = 5 Centre frequency (Fc) =1 kHz.
Q. 4	Explain the first order active high pass filter with required gain equation. Draw frequency response curve.
Q. 5	With the help of circuit diagram explain the operation of second order high pass filter. Also draw its characteristics.
Q. 6	What is an all pass filter? Where & why it is needed?
Q. 7	Design a wide band-pass filter with f_L = 200Hz, f_H = 1 kHz and a passband gain=4.
Q. 8	Design a 60-Hz active notch filter.
Q. 9	Explain first order low pass butterworth filter.

Q. 10	Using frequency scaling technique, convert the 1 kHz cut-off frequency of the low pass filter to a cut-off frequency of 1.6 kHz with a passband gain=4.

1.10.b Question Bank: Oral

CO4: Design converters, Oscillators and filters using Op-amp.

CO4 is mapped with all questions

Sr.No	**Questions**
Q1	What is need of filter
Q2	List different applications of filters
Q3	Design a filter for the given cutoff frequency
Q4	Draw frequency response for the given filter

1.9 List of Practical

List of Practical's

1. Measure Op-Amp parameters and compare with the specifications.- CO2
   Input bias current, input offset current and input offset voltage. slew rate , CMRR - CO2
   Compare the result with datasheet of corresponding Op-Amp. -
2. Design, build and test integrator for given frequency f_a.- CO3
3. Design, build and test three Op-Amp instrumentation amplifiers for typical application - CO3
4. Design, build and test precision half & full wave rectifier. CO3
5. Design, build and test Schmitt trigger and plot transfer characteristics. CO3
6. Design, build and test PLL. CO5
7. 2 bit DAC and 2 bit ADC. CO4
   A) Design and implement 2bit R-2R ladder DAC.
   B) Design and implement 2bit flash type ADC.
8. Design, build and test square & triangular wave generator. CO3

Optional Experiments:

1. Verify and understand practically virtual ground and virtual short concept in inverting and non-inverting configuration.
2. Plot DC transfer characteristics of emitter coupled differential amplifier.
3. Study effect of emitter resistance and constant current source on figure of merit (CMRR) of emitter coupled differential amplifier.
4. Design and implement V-I converter. CO4
5. Any experiment based on application of Op-Amp.