Government of Karnataka

Department of Technical Education
Board of Technical Examinations, Bengaluru

Course Title	: **Analog Electronics Circuits**	Course Code	: **15EC31T**
Semester	: **Third**	Course Group	: **Core**
Teaching Scheme in Hrs (L:T:P): **4:0:0**		Credits	: **4**
Type of course	: **Lecture**	Total Contact Hours	: **52**
CIE	: **25 Marks**	SEE	: **100 Marks**

Prerequisites

Basic principles of electrical and electronics engineering and knowledge of semiconductor theory and devices

Course Objectives

1. Understand the concept and applications of regulated power supplies, SMPS and UPS.
2. Understand the concept of amplification, operating point on DC load line and amplifier applications.
3. Study the working principles of different Op-amp circuits.
4. Construct and verify working of basic wave-shaping circuits such as clipping and clamping circuits.
5. Know the different circuits of sinusoidal oscillators and their applications.

Course Outcomes

On successful completion of the course, the students will be able to attain the following COs

Course Outcome		CL	Linked POs	Teaching Hours
CO1	Construct and analyse sub-circuits of DC regulated power supplies	***R/U/A***	1,2,3,5,6,10	12
CO2	Appraise the applications of SMPS and UPS	***R/U/A***	1,2,3,5,6,10	12
CO3	Realize amplifier applications of BJT	***R/U/A***	1,2,3,10	10
CO4	Construct and analyse the Op-amp application circuits	***R/U/A***	1,2,3,10	07
CO5	Design and analyse active filter circuits	***R/U/A***	1,2,3,10	06
CO6	Select and analyse simple oscillator circuits and wave-shaping circuits	***R/U/A***	1,2,3,10	05
			Total	**52**

Legends: PO-Program Outcome, CO-Course Outcome, CL-Cognitive Level, R-Remember, U-Understand, A-Apply

Course-PO attainment matrix

Course	Programme Outcomes									
	1	2	3	4	5	6	7	8	9	10
Analog Electronics Circuits	**3**	**3**	**3**	**--**	**3**	**3**	**--**	**--**	**--**	**3**

Level 3- Highly Addressed, Level 2-Moderately Addressed, Level 1-Low Addressed.

Method is to relate the level of PO with the number of hours devoted to the COs which address the given PO.
If ≥40% of classroom sessions addressing a particular PO, it is considered that PO is addressed at Level 3
If 25 to 40% of classroom sessions addressing a particular PO, it is considered that PO is addressed at Level 2
If 5 to 25% of classroom sessions addressing a particular PO, it is considered that PO is addressed at Level 1
If < 5% of classroom sessions addressing a particular PO, it is considered that PO is considered not-addressed.

Course content and pattern of marks for SEE

Unit	Unit Name	Teaching Hours	Weightage for CLs in SEE			Marks	Weightage (%)
			R	U	A		
1	Power supplies	12	10	10	10	30	20
2	BJT Biasing and amplifiers	12	10	10	10	30	20
3	OP-AMP and applications	10	05	10	15	30	20
4	Active filters and instrumentation amplifier	07	05	10	10	25	18
5	Wave-shaping circuits	06	05	05	05	15	11
6	Sinusoidal oscillators	05	05	05	05	15	11
	Total	**52**	**40**	**50**	**55**	**145**	**100**

Legend: R-Remember, U-Understand, A-Application

Course Contents

Unit 1: Power supplies 12 Hours

DC regulated power supply: Need and block diagram. **Rectifiers:** Ripple Factor, Ripple Frequency, Efficiency, Peak Inverse Voltage. Circuits, operations and waveforms of half-wave and full-wave (centre-tap transformer and bridge) rectifiers. Expressions for ripple factor and efficiency, simple problems. **Filters: N**eed for filters in power supplies, working of C and PI filter with waveforms. **Regulators:** Need for voltage regulators in power supplies, working of voltage regulator using Zener diode, line and load regulation. **IC voltage regulators:** Features of 78xx, 79xx, LM 317 ICs. **Basic switching regulator**: Definition, working, step-down and step-up configuration, block diagram of SMPS. **UPS:** Block diagram and working principle of on-line and off-line UPS.

Unit 2: BJT biasing and amplifiers 12 Hours

Biasing: principle of transistor as switch and amplifier, need for biasing, operating point, DC load line, stability factor, voltage divider bias for BJT. **Amplifier features**: direct, RC coupled and Transformer coupled; AF and RF amplifiers; and voltage and power amplifiers. **Feedback in amplifiers:** Types of feedback and their features. **Small-signal Amplifier:** Working of common emitter RC coupled amplifier and its frequency response. **Large-signal**

amplifier: Concept of AC load line, classification and principle of power amplifiers, working of Class A–Series-fed amplifier and transformer-coupled amplifier, Class B- Push-pull amplifier and complementary-symmetry push-pull amplifier, expression for output power and maximum power efficiency of class-A and class-B power amplifiers. Working of Class AB and Class C amplifiers. Comparison of power amplifiers. **Multistage amplifiers:** Concept and expression for voltage gain.

Unit 3: OP-amp and applications 10 Hours

Basic differential amplifier: Working principle. **Op-amp:** Block diagram, ideal and practical characteristics. **Op-amp parameters:** Input offset voltage, input offset current, power supply rejection ratio, CMRR, input and output impedance, gain, gain-bandwidth product, slew-rate. **Open-loop configuration:** comparator, disadvantages of open-loop mode. **Closed-loop configuration:** virtual ground, applications - inverting, non-inverting, voltage follower, summing & difference amplifiers, differentiator, integrator, Schmitt trigger, and concept of precision rectifier. Simple problems.

Unit 4: Active filters and instrumentation amplifier 07 Hours

Active filter: Classification, circuits, working, expressions for cut-off frequencies and frequency response of 1st order Butterworth LPF, HPF, BPF and BEF (No Derivation). Problems to design and analyse 1st order Butterworth filters. Realization of BPF and BEF using LPF and HPF. Mention of applications of active filters. **Instrumentation amplifier:** Need for instrumentation amplifier, working of instrumentation amplifier circuit. **Phase Locked Loop (PLL):** voltage to frequency converter, PLL operation with mention of its applications.

Unit 5: Wave-shaping circuits 06 Hours

RC Circuits: Differentiator and Integrator circuits and their response to sine and square-wave signals. **Clippers:** positive and negative series clippers, positive and negative shunt clippers, combinational clippers and simple problems. **Clampers:** positive and negative clampers. Mention on the applications of clippers and clampers.

Unit 6: Sinusoidal oscillators 05 Hours

Concept of feedback and types, open and closed-loop gains, Barkhausen criteria, LC Tank circuit and stability. Working of Hartley, Collpits and crystal oscillator using BJT. Working of RC phase-shift and Wein-bridge oscillators using Op-amp. Mention on applications and features of these oscillators.

References

1. *Electronic Devices and Circuits*, S. Salivahanan , N. Sereshkumar , McGraw Hill Education (India) Private Limited, ISBN - 9781259051357
2. *Op-amps and linear integrated circuits,* Ramakanth A. Gayakwad, ISBN- 9780132808682
3. *Principles of Electronics*, Rohit Mehta and V K Mehta, S. Chand and Company Publishing, ISBN- 9788121924504
4. *Electronic Devices and Circuits*, David A. Bell, Oxford University Press, ISBN-9780195693409
5. *Fundamentals of Electrical and Electronics Engineering*, B. L. Theraja, S. Chand and Company Publishing. REPRINT 2013, ISBN-8121926602.

6. e-References/URLS:

http://www.allaboutcircuits.com/ http://www.allaboutcircuits.com/videos

Course Delivery

The course will be delivered through lectures, presentations and support of modern tools. Student activities are off-class.

Course Assessment and Evaluation Scheme

Master Scheme

Assessment Method	What		To Whom	Assessment mode /Frequency /timing	Max. Marks	Evidence Collected	Course Outcomes
Direct assessment	CIE	IA	Students	Three tests+	20	Blue Books	1 to 6
				Activity*	05	Activity Sheets	1 to 6
	SEE	End exam		End of the course	100	Answer Scripts at BTE	1 to 6
				Total	125		
Indirect assessment	Student feedback on course		Students	Middle of the Course	Nil	Feedback Forms	1 to 3 Delivery of course
	End of course survey			End of the Course	Nil	Question-naires	1 to 6, Effectiveness of delivery instructions & assessment methods

Legends: CIE-Continuous Internal Evaluation, SEE- Semester End-exam Evaluation

+ Every CIE/IA test shall be conducted for 20 marks. Average of three tests, by rounding off any fractional part thereof to next higher integer, shall be considered for CIE/IA.

***S**tudents should do activity as per the list of suggested activities/ similar activities with prior approval of the teacher. Activity process must be initiated well in advance so that it can be completed well before the end of the term.

Questions for CIE and SEE will be designed to evaluate the various CLs as per the weightage shown in the following table.

Sl. No.	Cognitive Levels (CL)	Weightage (%)
1	Remembering	25
2	Understanding	35
3	Applying	40
	Total	**100**

Continuous internal evaluation (CIE) pattern

(i) Student Activity (5 marks)

The following student activities or similar activities can be assigned for assessing CIE/IA

Sl. No.	Activity
1	Design and construct simple application such as door bell/calling bell, blinking LED, burglar's alarm etc. Prepare a report on its design, function, specifications and

	cost estimation.
2	Collect the technical specifications and price of at least 10 electronic components such as diode, transistor etc. and at least 5 electronics equipments such as RPS, UPS, CRO etc.

Execution Note:

1. Each batch (Maximum of 2 students) should perform the above activities independently. Students can also choose any other two similar activities/related/ innovative activities with prior approval from the concerned teacher.
2. Teacher is expected to observe, follow-up, and record the progress of students' activities
3. Assessment is made based on quality of work as prescribed by the following **rubrics** table.

(ii) Model of rubrics for assessing student activity (For every student)

Dimension	Scale					Marks (Example)
	1 Unsatisfactory	2 Developing	3 Satisfactory	4 Good	5 Exemplary	
1. Research and gathering information	Does not collect information relate to topic	Collects very limited information, some relate to topic	Collects basic information, most refer to the topic	Collects more information, most refer to the topic	Collects a great deals of information, all refer to the topic	3
2. Full-fills team roles and duties	Does not perform any duties assigned to the team role	Performs very little duties	Performs nearly all duties	Performs almost all duties	Performs all duties of assigned team roles	2
3. Shares work equality	Always relies on others to do the work	Rarely does the assigned work, often needs reminding	Usually does the assigned work, rarely needs reminding	Always does the assigned work, rarely needs reminding.	Always does the assigned work, without needing reminding	5
4. Listen to other team mates	Is always talking, never allows anyone to else to speak	Usually does most of the talking, rarely allows others to speak	Listens, but sometimes talk too much,	Listens and talks a little more than needed.	Listens and talks a fare amount	3
					Total marks	ceil(13/4)= 4

(iii) CIE/IA Tests (20 Marks)

Three tests have to be conducted, during specified schedule, in accordance with the test pattern given below and their average-marks shall be considered for CIE/IA.

(iv) Format of CIE/IA test question paper

CIE Question Paper								
Institution Name and Code								
Course Co-ordinator/Teacher								
Program Name		***Test No.***		*Units*				
Class/Sem		*Date*		*CL*				
Course Name		*Time*		*COs*				
Course Code		*Max. Marks*		*POs*				
Note to students: Answer all questions								
Question No.	**Question**			Marks	**CL**	**CO**	**PO**	
1								
2								
3								
4								

Legends: PO-Program Outcome, CO-Course outcome, CL-Cognitive Level, R-Remember, U-Understand, A-Apply
Note: Internal choice may be given in each CO at the same cognitive level (CL).

(v) Model question paper for CIE

CIE Question Paper					
Institution Name and Code					
Course Co-ordinator/Teacher					
Program Name	Electronics and Communication	***Test No.***	1	*Units*	1 & 2
Class/Sem	3rd Sem	*Date*	1/1/2017	*CL*	R/U/A
Course Name	Analog Electronic Circuits	*Time*	10-11AM	*COs*	1 & 2
Course Code	15EC31T	*Max. Marks*	20	*POs*	1, 2 & 3

Note to students: Answer all questions

No.	Question	Marks	CL	CO	PO
1	Define a) Rectification, b) Ripple Factor, c) Ripple frequency, d) Efficiency, and e) Peak Inverse Voltage as applicable to rectifier	05	U/A	1	1,2,3
2	Explain the operation of full-wave bridge rectifier circuit with waveforms. OR Define line and load regulation and illustrate the difference with examples.	05	R/A	1	1,2
3	Define operating point and explain the DC load line as applicable to BJT amplifier	05	R	2	1,2
4	Write CE mode RC coupled amplifier circuit and sketch a typical frequency response curve with labels. OR Illustrate using circuit how crossover distortion can be overcome in complementary-symmetry power amplifier	05	A	2	1,2

Semester end-exam evaluation (SEE)

(i) End-exam question-paper pattern

Unit	Unit Name	Study Duration (Hrs.)	No. Questions for end-exam	
			PART – A 5 Marks	PART – B 10 Marks
1	Power Supplies	12	02	02
2	BJT Biasing and amplifiers	12	02	02
3	OP-amp and applications	10	02	02
4	Active filters and instrumentation amplifier	07	01	02
5	Wave-shaping circuits	06	01	01
6	Sinusoidal oscillators	05	01	01
	Total	**52**	**09 (45 Marks)**	**10 (100 Marks)**

(ii) Model question paper

Course Title : **ANALOG ELECTRONICS CIRCUITS**
Course Code : **15EC31T** Time : **3 Hrs**
Semester : **Third** Max. Marks: **100**
Instructions: *1. Answer any **SIX** question from **Part A** (5x6=30 Marks)*
*2. Answer any **SEVEN** full questions from **Part B** (7x10=70 Marks)*

Part A

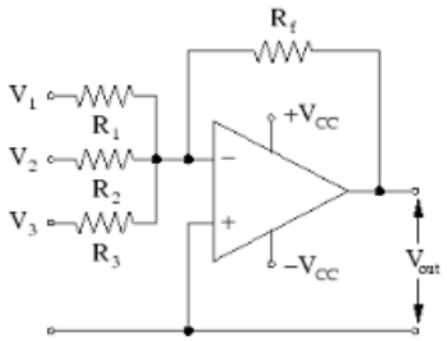
1. Explain the working of Half-wave rectifier with a relevant circuit and waveforms.
2. Identify the rated output voltages of the following regulator ICs.
   a) IC-7805 b) IC-7918 c) IC-7912 d) IC-7815 e) IC-LM317
3. Define biasing and operating point. Match the transistor applications (amplifier, switch-open, switch-close) with different regions on output characteristics of transistor.
4. Explain the working of series-fed class-A amplifier
5. List the ideal and practical characteristics of Op-amp
6. Construct a non-inverting amplifier circuit using Op-amp for a gain of 10
7. Show how to realize BPF using LPF and HPF
8. Construct a shunt clipper circuit to generate a signal having maximum positive amplitude of 2V and negative amplitude of -10V for a sinusoidal input of +10 to -10V.
9. Explain the role of tank circuit in Hartley oscillator; write expression for its frequency of oscillations.

Part B

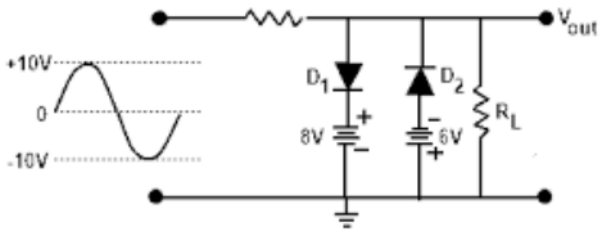
1. Show mathematically that the efficiency of bridge rectifier is 81.2% and ripple factor is 0.48.
2. a) Define filter. Explain the working of C filter in regulated power supply
   b) State the function of UPS. Compare ONLINE and OFFLINE operation of UPS
3. a) In multistage amplifier, illustrate that the overall gain is equal to the product of gains of individual stages

b) Explain the concept of negative feedback and list its disadvantages?

4. (a) Compare the relevance of ac load-line and dc load-line as applicable to amplifiers
   (b) Explain the classification of power amplifiers
5. (a) Define any five Op-amp parameters. (b) Construct Schmitt trigger circuit to convert sine wave to square wave
6. (a) In the circuit shown below, if V_1= -1V, V_2=V_3=2V, Supply voltage is ±15V, VR_1=R_2=4KΩ, R_3=2KΩ, and feedback resistance R_f =6KΩ, calculate closed-loop gain and output voltage (6)



   (b) Discuss the effect of slew rate on bandwidth in Op-amp applications (4)
7. Construct a first-order Butterworth LPF and HPF circuit for a gain of 10, cut-off frequency of 160Hz and an input impedance of 10KΩ. Assume relevant data if necessary.
8. Explain the need and working of an instrumentation amplifier
9. Define clamper and clipper. Write the output wave form for the clipper circuit shown below



10. a) Draw Wein-bridge oscillator circuit for the output frequency of 200Hz.
    b) Compare RC phase-shift oscillator with Collpits oscillator.

Institutional activities (No marks)

The following are suggested institutional activities, to be carried out at least one during the semester. The course teacher/coordinator is expected to maintain the relevant record (Containing, Activity name, Resource persons and their details, duration, venue, student feedback, etc) pertaining to Institutional activities.

Sl. No.	Activity
1	Organize seminar, workshop or lecture from experts on the modern trends in analog electronics
2	Organize hands-on practice on design and simulation of analog circuits
3	Motivate students to take case study on different analog electronics-based mini projects (small applications such as applications specified in student activity) to inculcate self and continuous learning

Model Question Bank

Note: The questions in the question bank are indicative but not exhaustive. Sub-questions on different CLs may be combined to frame 10-marks questions or 10-marks questions given here can be splitted into 5-marks questions if necessary keeping weightage of CLs approximately intact and adhering to SEE end-exam pattern.

Unit-1: Power Supplies

Five-mark Questions

REMEMBER

1. State the roles of different sub-circuits of DC regulated power supply
2. Discuss the need for rectifier in DC regulated power supply. Sketch the output waveform of half-wave rectifier for sinusoidal input
3. Define regulator and explain the need for voltage regulators in power supplies
4. Define line and load regulation and discuss the need for quantifying them
5. List any five IC voltage regulators and mention their rated-output voltage levels
6. State the function of filter in DC regulated power supply. Compare PI filter with C filter
7. Differentiate between fixed IC voltage regulators and variable IC voltage regulators
8. List the features of IC-LM 317.

UNDERSTAND

1. Explain the operation of half-wave rectifier circuit with waveforms and circuit
2. Explain the need for filters in power supplies
3. Describe the working of C filter with circuit diagram and waveforms.
4. Explain the working of PI filter with circuit diagram and waveforms
5. Illustrate the need of Zener diode in voltage regulators
6. List the features of switching regulator.
7. Compare LM317 with IC78xx and IC79xx
8. List the components associated with DC regulated power supply
9. Compare online and offline UPS
10. Differentiate DC regulated power supply with SMPS
11. Discuss the need for SMPS and UPS

APPLICATION

1. For the given input V_i=100 *sin* (314t), calculate the ripple frequency in half-wave and full-wave rectifiers.
2. Construct the circuit that has highest efficiency in ac to dc conversion
3. Show mathematically the ripple factor of a bridge rectifier is 0.48
4. Explain when IC-7805 and IC-7912 regulators can be used
5. Construct a circuit that minimizes ripples in the output of a rectifier circuit and briefly explain how it does
6. Construct a simple circuit that keeps the output dc voltage almost constant irrespective of variation in the input voltage above certain level.

Ten-mark Questions

REMEMBER

1. Define a) Rectification, b) Ripple Factor, c) Ripple frequency, d) Efficiency, and e) Peak Inverse Voltage
2. List the different functional blocks and their role in SMPS

3. Define UPS. With a neat block diagram explain the working principle of on-line and offline UPS
4. (a) State the purpose of rectifier, regulator, filter, SMPS and UPS.
   (b) Describe the working of simple voltage regulator employing Zener diode
5. (a) Name the different blocks of DC regulated power supply and state their functions
   (b) Define PIV and describe its role in rectifier circuits
6. Describe the functioning of bridge rectifier circuit with wave forms and identify the differences with centre-tapped transformer full-wave rectifier.

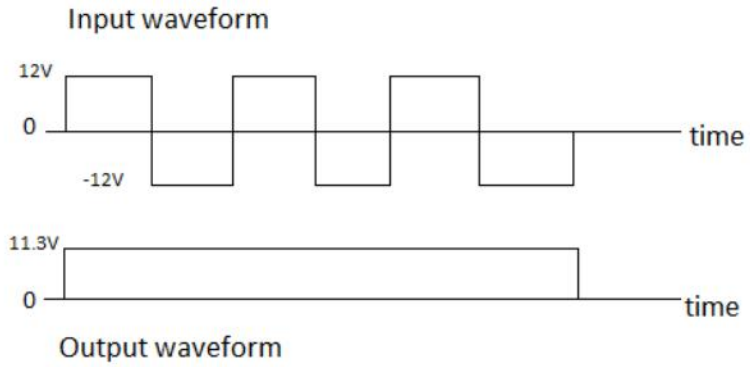
UNDERSTAND

1. Classify the rectifier circuits. Explain the operation of centre-tapped full-wave rectifier circuit with waveforms.
2. (a) Summarize similarities and differences of centre-tapped full-wave rectifier and bridge rectifier.
   (b) Identify the disadvantages of half-wave rectifier
3. (a) Discuss the need for filters and regulators in DC regulated power supplies
   (b) Describe the operation of half-wave rectifier circuit with waveforms
4. (a) Compare the features of IC-LM 317 with IC78XX series.
   (b) Explain briefly the working of step-down and step-up configuration of switching regulator

5. (a) Differentiate SMPS and Regulated power supply
   (b) Explain the functioning of offline UPS with block diagram

APPLICATION

1. (a) Construct a circuit that converts square-wave input to DC output shown in the following figure



   (b) Explain why PIV restricts the dynamic range of the output voltage in rectifier output
2. Write the block diagram of DC regulated power supply and sketch the wave forms at the output of each block.
3. (a) Illustrate how UPS keeps power supply uninterrupted
   (b) List applications of SMPS and DC regulated power supply
4. (a) List the disadvantages of half-wave and centre-tap transformer rectifier
   (b) Calculate the dc output voltage and ripple factor of a full-wave rectifier given input V_i=100 *sin* (2*3.1415*50t)

Unit-2: BJT Biasing and amplifiers

Five-mark Questions

REMEMBER

1. Define amplification, gain, frequency response, bandwidth and input impedance as applicable to amplifiers
2. List the features of RC coupled amplifier
3. Locate the region, on output characteristics plot of BJT, for amplification and switching applications
4. Define biasing of BJT and explain the need for biasing
5. List the differences between Class-A and Class-B power amplifiers

UNDERSTAND

1. Explain the principle of operation of transistor as switch
2. Differentiate between AF and RF amplifiers
3. Differentiate between voltage and power amplifiers
4. Classify the power amplifiers
5. Compare power amplifiers with reference to conduction angle and efficiency
6. Differentiate between small and large-signal amplifiers
7. Explain the principle of operation of transistor as an amplifier
8. Show how individual amplifiers are connected to realise multistage amplifier

APPLICATION

1. Sketch the output of an CE mode RC coupled amplifier having voltage gain of 100 for the given input v_i=0.01 *sin*(31415t)
2. Four RC coupled amplifiers having gains 3, 6, 2, and 5 are available. Illustrate (block diagram level) how some of these amplifiers can be connected to realise an amplifier with a gain of 30.
3. Identify the power amplifier having highest efficiency and substantiate the reason for it.
4. Sketch the frequency response curve of an RC couple amplifier with relevant labels
5. List the pros and cons of negative feedback in amplifiers
6. Modify Class-B push-pull amplifier to overcome cross-over distortion

Ten-mark Questions

REMEMBER

1. (a) Define operating point and describe the role of DC load line to locate it
   (b) List the features of transformer coupled amplifier
2. (a) Describe the working of Class AB amplifier
   (b) List the features of RC coupled amplifier
3. (a) Tabulate the efficiencies and conduction angles of power amplifiers
   (b) List the features of direct coupled amplifier
4. (a) Describe the concept of ac load line and its role in amplifier design
   (b) List various categories of amplifiers and their applications

UNDERSTAND

1. (a) Explain the need for biasing with a brief explanation on voltage-divider bias for BJT amplifier
   (b) Differentiate between large signal and small signal amplifiers
2. (a) Explain the concept of feedback and list various feedback methods in amplifiers
3. (a) Explain the working of common emitter RC coupled amplifier
   (b) Sketch and label frequency response plot of a typical RC coupled amplifier

4. (a) Explain the working of Class-C amplifier
   (b) Relate various power amplifiers with conduction angles and efficiencies
5. (a) Compare the features of Class-B push-pull with Class-AB amplifier
   (b) Demonstrate how multistage amplifier can be realised with using individual amplifiers

APPLICATION

1. (a) Sketch output waveform of an RC coupled amplifier having a gain of 50, given input signal Vi=0.01 sin(3140t).
   (b) Illustrate the use dc load line in amplifier biasing
2. (a) Illustrate how the problems in Class-B push-pull amplifier are solved in complementary symmetry Class B amplifier.
   (b) Apply principle of cascading to realise multistage amplifier and determine the expression for gain in terms of individual gains
3. (a) Establish a relation between gains of individual stages and overall gain in a multistage amplifier
   (b) List the features of RC coupled amplifier
4. Show that the efficiency of class B amplifier is 78.5% and prepare a table comparing its efficiency with other power amplifiers
5. Show that the total gain is equal to the product of gains of individual stages in a multistage amplifier

Unit-3: OP-AMP and applications

Five-mark Questions

REMEMBER

1. Describe the block diagram of Op-amp
2. List the ideal characteristics of Op-amp
3. Enumerate applications of Op-amp and state their functions
4. List advantages and disadvantages of open-loop mode of Op-amp
5. List any five Op-amp parameters and define them
6. State the functions of integrator, summer, inverting, voltage follower and Schmitt trigger applications of Op-amp

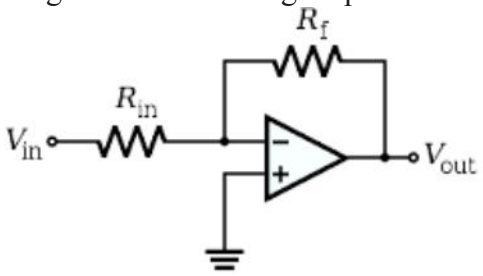
UNDERSTAND

1. Describe the working principle of basic differential amplifier circuit
2. Explain the open-loop configuration of Op-amp as comparator
3. Explain the concept and relevance of virtual ground in Op-amp applications
4. Construct Op-amp circuit having closed-loop gain of -10
5. Sketch the Op-amp circuit that can convert square-wave into pulses with relevant waveforms
6. Discuss the relevance of CMRR and slew-rate on the performance of Op-amp applications
7. Discuss the effect of saturation on the output related to Op-amp applications with example

APPLICATION

1. Sketch an Op-amp circuit that translates sine function into cosine function with the mathematical expression for its output
2. Suggest how voltages can be added and amplified together with the help of Op-amp
3. Sketch the Op-amp voltage follower circuit and mathematically justify its gain is 1
4. Construct an Op-amp circuit that converts square-wave into triangular waveform

5. Construct Op-amp circuit to add two voltages and amplify the sum by 5 times
6. Show mathematically that the gain of an inverting amplifier shown below is $-R_f/R_{in}$



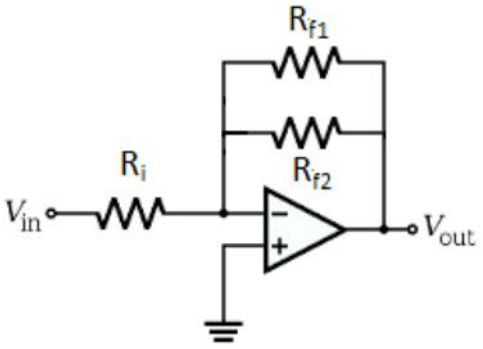
Ten-mark Questions

REMEMBER

1. Define the following terms with reference to Op-amp:
   a) Input offset voltage, b) Input offset current, c) Power Supply Rejection Ratio
   d) CMRR, e) Input impedance, f) Output impedance, g) Gain, h) Gain-bandwidth product, i) Slew-rate, j) Saturation
2. (a) List the applications of Op-amp
   (b) Describe how to use Op-amp to add voltages
3. (a) Define input impedance, output impedance, bandwidth, open-loop gain and closed – loop gain as applicable to Op-amp application
   (b) Name the blocks and their functions of Op-amp
4. (a) Describe how difference amplifier can be realised using Op-amp
   (b) Identify the 741 Op-amp pins and their functions

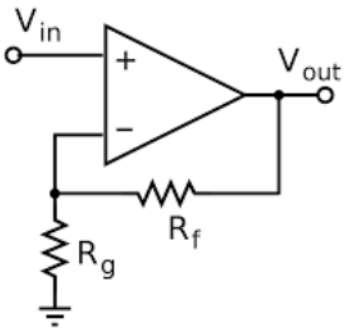
UNDERSTAND

1. Explain the working of Schmitt trigger circuit using Op-amp; also, sketch the hysteresis plot
2. (a) Differentiate integrator and differentiator Op-amp circuits
   (b) List the benefits of using Op-amp as an amplifier as compared to BJT
3. (a) Discuss the concept of precision rectification and its realization using Op-amp
   (b) Construct Op-amp integrator and sketch its response for sinusoidal input
4. (a) Demonstrate how Op-amp can be used as voltage comparator
   (b) Estimate the gain in the following circuit given R_i=1KΩ, R_{f1}=R_{f2}=10KΩ



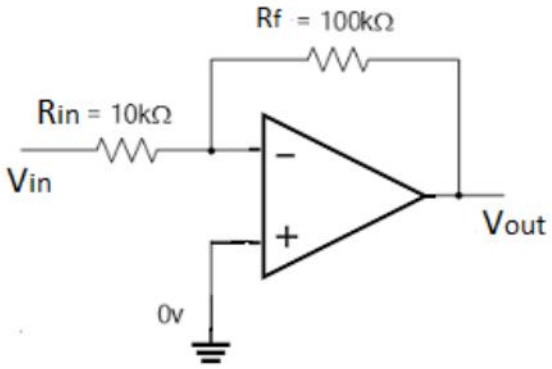
APPLICATION

1. (a) Identify the following Op-amp circuit and justify your identification

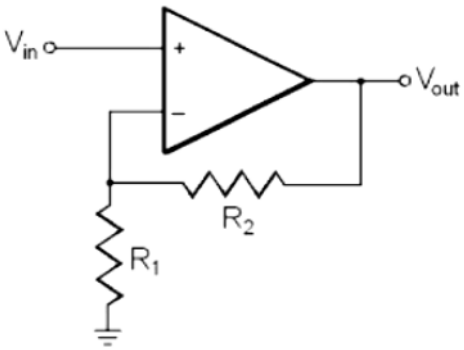


(b) Modify the Op-amp non-inverting amplifier into voltage follower with justification

2. Construct and label an inverting amplifier circuit for a voltage gain of 10 and dynamic output range of -10V to +10V. Sketch its response for the input, *Vi*=15*cos*(314t).
3. If V_{in} = 2V, find the output voltage and voltage gain for the circuit shown below

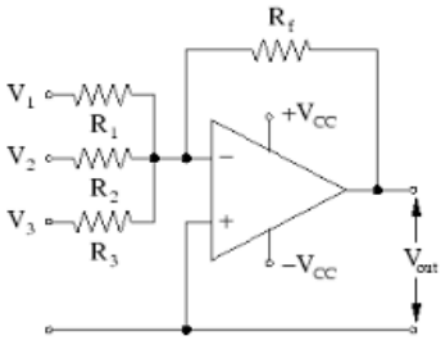


4. (a) If V_{in} = 2V, R_1 = R_2 = 1KΩ, find the output voltage and voltage gain for the below circuit.



(b) Sketch the output of the Op-amp inverter circuit for *Vin*= 2*sin*(2*pi*50*t) assuming power supply ±12V

5. For a summing amplifier shown below, (a) Find voltage gain if R1=R2=R3=1KΩ and Rf=5KΩ, (a) Estimate the output voltage if V_1=1V, V_2=V_3=2V, R_1=R_2=10KΩ, R_3=5KΩ and R_f=15KΩ, assuming power supply ±15V



Unit-4: Active filters and instrumentation amplifiers

Five-mark Questions

REMEMBER

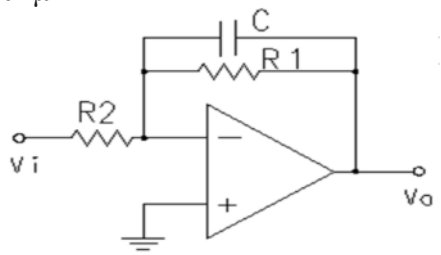
1. Define active filter and mention its **c**lassification
2. List the applications of active filters
3. Describe how BPF can be realised using LPF and HPF
4. Describe PLL
5. Define passive filter, active filter, cut-off frequency, band width and frequency response with reference to filters

UNDERSTAND

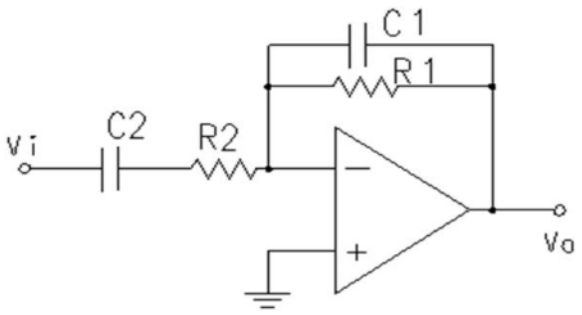
1. Illustrate how BEF can be realized using LPF and HPF
2. Distinguish between LPF and HPF
3. Compare BEF and BPF
4. Identify a circuit that can block low frequency signals and amplify high frequency signals and explain how it does.
5. Explain the need for instrumentation amplifier

APPLICATION

1. Construct first order HPF filter with a cut-off frequency of 1KHz and sketch its frequency response
2. Calculate the cut-off frequency and gain of the following filter circuit given that R1=10KΩ, R2=2KΩ and C=0.01μF



3. Estimate the gain and cut-off frequencies of the following BPF given that C1= 0.01μF, C2 = 1 μF, R1=1K and R2 ≈ 100 Ω



Ten-mark Questions

REMEMBER

1. (a) Define active filter and list different filters based on frequency of filtering
   (b) Describe the function of BEF with block diagram and frequency response plot
2. (a) Describe the operation of PLL
   (b) List the applications of PLL and instrument amplifier

UNDERSTAND

1. (a) Explain the working of instrumentation amplifier circuit
   (b) Describe the working of BPF
2. (a) Explain the operation of PLL and mention its applications
   (b) List the applications of the active filters
3. (a) Explain the working principle and frequency response of 1st order Butterworth LPF

APPLICATION

1. (a) Design a first order Butterworth LPF circuit for a gain of 10, cut-off frequency of 160Hz
   (b) Sketch the frequency response plot and circuit of a typical HPF
2. (a) Modify BPF filter to act as BEF at block diagram level and justify it
   (b) List the advantages and disadvantages of active filters over passive filters

Unit-5: Wave-shaping circuits

Five-mark Questions

REMEMBER

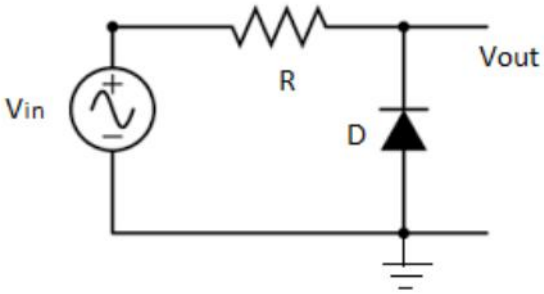
1. List the applications of clippers and clampers
2. Select and write the circuit diagram to generate triggering pulses from square wave
3. Define positive clipper and briefly describe its working with a circuit diagram.
4. Describe how square wave can be converted into triangular wave with the relevant wave shaping circuit
5. Describe how DC level of AC waveform can be increased with a suitable circuit

UNDERSTAND

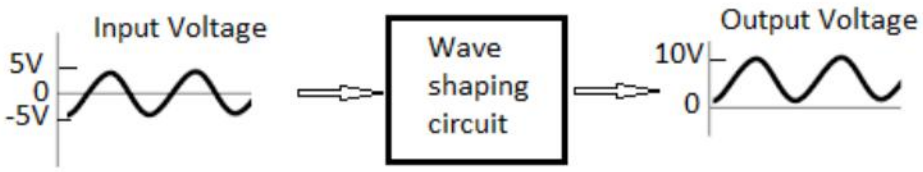
1. Explain positive shunt clipper circuit using diode
2. Sketch and label the combinational clipping circuit
2. Write RC integrator circuit and plot its response for sinusoidal input
3. Compare clipper with clamping circuit
4. Distinguish between RC integrator with RC differentiator circuit

APPLICATION

1. Write the output waveform of clipper circuit shown below for V_{in} = 10 *sin* (314t) assuming ideal diode



2. Determine and sketch the wave shaping circuit shown in the following block diagram



3. Show how half-wave rectifier can be realised using clipper circuit.

Ten-mark Questions

REMEMBER

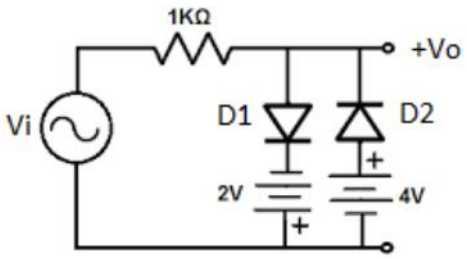
1. Define Clipper. Explain simple positive and negative clipper circuits
2. Define clamper. Explain simple positive and negative clamper circuits
3. (a) List the applications of clippers and clampers
   (b) Describe the working of RC integrator circuit

UNDERSTAND

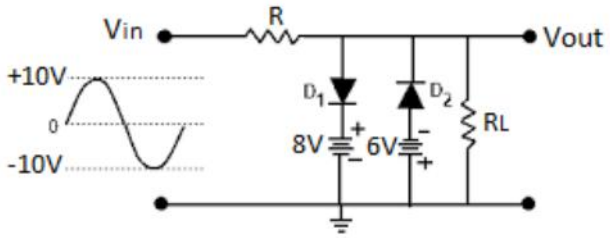
1. Explain positive and negative shunt clipper circuits using diode
2. (a) Differentiate clamper with clipper circuits
   (b) Compare integrator with differentiator circuits
3. Demonstrate (a) Differentiator circuit as triggering pulse generator (b) Integrator as triangular waveform generator

APPLICATION

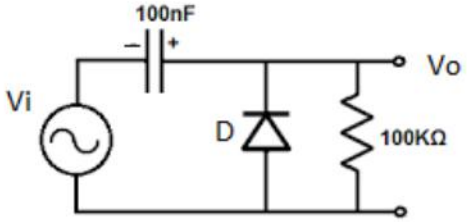
1. Illustrate the operation of RC Differentiator and Integrator circuits with their response to square-wave signal.
2. Construct a clipper circuit to generate a signal having maximum positive amplitude of 2V and negative amplitude of -10V for a sinusoidal input of +10 to -10 V.
3. Write the output waveform of clipper circuit shown below for V_i=10 *sin* (314t)



4. Write the output waveform for the clipper circuit shown below assuming ideal diodes



5. Sketch the output waveforms for the circuit shown below for V_i=10 *sin* (314t) assuming (a) Si diode (cut-in voltage 0.7V) and (b) Germanium diode (cut-in voltage 0.3V)



Unit-6: Sinusoidal oscillators

Five-mark Questions

REMEMBER

1. Define stability, open-loop gain, closed loop-gain, loop phase-shift and feedback as applicable to oscillators.
2. Draw Hartley oscillator circuit that generates 500KHz sine wave.
3. Compare RC oscillators with LC oscillators

UNDERSTAND

1. Discuss the role of tank circuit in oscillator circuit
2. Relate Barkhausen criteria and sustained oscillations
3. Explain the role of RC network in RC phase-shift oscillator and write the expression for frequency of oscillation
4. Identify the oscillator to generate audio frequency oscillations and briefly describe it with circuit.
5. Sketch Wein-bridge oscillator circuit and state the role of bridge

APPLICATION

1. Design LC circuit for Hartley and Collpits oscillators to oscillate at 600KHz
2. Sketch RC phase-shift oscillator circuit to oscillate at 10KHz
3. Explain the relation between sustained oscillations and Barkhausen criteria as applicable to oscillator circuit.
4. Calculate the frequency of oscillations in Hartley oscillator given that L_1=0.03mH, L_2=10μH and C=1μ. Suggest C_1 value to generate same frequency using Collpits oscillator assuming C_2=C and L=L_2

Ten-mark Questions

REMEMBER

1. (a) Draw RC phase-shift oscillator circuit with labelling
   (b) Define loop gain and feedback. Explain the Barkhausen criterion
2. (a) Draw the crystal oscillator circuit with labelling (4)
   (b) Define sustained, over-damped and under damped oscillations as applicable to oscillators (6)

3. (a) List the expressions for oscillating frequencies in Hartley, Collpits, RC phase-shift and Wein-bridge oscillators (8)
   (b) State Barkhausen criterion (2)

UNDERSTAND

1. (a) Explain the concept of positive feedback, open and closed-loop gains (6)
   (b) Select Collpits oscillator tank circuit to oscillate at 500 KHz (4)
2. (a) Explain the working of Hartley oscillator using BJT
   (b) Compare LC oscillators with RC oscillators
3. Compare the crystal oscillator with RC phase-shift and Hartley oscillator

APPLICATION

1. Explain the working of Collpits oscillator using BJT. Illustrate how it can be converted to Hartley oscillator
2. (a) Calculate the operating frequency of a Collpits oscillator circuit, if C_1 = 0.027 μF, C_2 = 0.027 μF, and L_1 = 220 mH
   (b) Illustrate how Collpits oscillator can be converted into Hartley oscillator
3. (a) Construct RC phase-shift oscillator to oscillate at 12KHz
   (b) Compare Wein-bridge and Hartley oscillators

End