CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET476	ADVANCED ELECTRONIC DESIGN	PEC	2	1	0	3

Preamble: This course makes a student capable to design a system that senses a physical quantity, condition the sensed signal and digitally measure it.

Prerequisite: EET205 (Analog Electronics), EET303 (Microprocessors and microcontrollers)

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Analyse the frequency response characteristics of op-amps along with its circuit properties.
CO 2	Develop advanced op-amp circuits which serve as building blocks to more complex digital and analog circuits.
CO 3	Design active filters as per situational and system demands.
CO 4	Develop sensor circuits for physical quantity measurements.
CO 5	Design the microcontroller interfacing with analog domain for real world applications.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2		1							
CO 2	3	2	2	1	1							
CO 3	3	2	2	1	1							
CO 4	3	2	2	1	1							
CO 5	3	2	2	1	1							

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	40

Apply	20	20	40
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the frequency response characteristics of an op-amp. (K1, K2, PO1, PO2)

2. Examine the gain frequency relationships of an op-amp. (K1, K2, PO1, PO2)

3. List the non idealities in frequency response resulting in circuit applications. (K1, K2, PO1, PO4)

Course Outcome 2 (CO2)

1. Design precision rectifier circuit and voltage to current conversion circuit after mentioning the assumptions made with respect to inputs and outputs. (K3, PO1, PO2, PO4)

2. Illustrate the working of a PLL using a block diagram. (K2, PO1)

3. List the criteria you consider for designing a sample and hold circuit. (K2, PO1, PO2, PO4)

Course Outcome 3(CO3):

1. List out the benefits of an active filter over a passive filter. (K2, PO1)

2. List out the factors considered for selecting the filter order. (K2, PO1)

3. List out a set of assumptions and design a Butterworth based on your assumptions for the assumed application. (K2, PO1, PO2, PO4).

Course Outcome 4 (CO4):

1. List out the parameters you may consider for selecting a sensor for a particular application (K2, PO1, PO2, PO4).

2. Design a sensor circuit for pressure measurement with proper assumptions (K3, PO1, PO2, PO4).

3. Hall effect sensor can be termed as an isolated sensor, explain why? (K2, PO1, PO2, PO4)

Course Outcome 5 (CO5):

1. Illustrate how an LM 35 temperature sensor is interfaced with Atmega 32 with a block diagram and required coding. (K3, PO1, PO2, PO3, PO4)

2. Conduct a study on parallel vs serial ADC and list out the pros and cons. (K2, PO1, PO4).

3. Analyse the importance of conversion time of an ADC in an embedded system design. (K2, PO1, PO4).

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH AND YEAR

Course Code: EET476

Course Name: Advanced Electronic Design

Max. Marks: 100 Duration: 3 Hours

Note: Certified IC data sheets of relevant ICs may be permitted inside the examination hall. <u>However, application notes of ICs are NOT permitted</u>.

PART A

Answer all questions, each carries 3 marks. Marks

1	List the effects of Op-amp slew-rate in practical circuits.	(3)
2	Draw the high frequency equivalent circuit of an op-amp.	(3)
3	A randomly varying signal whose peak voltage was expected to be in the range -20 V to 35 V. Draw a peak detector circuit that gives the peak voltage value of the signal. What would be the nominal voltage ratings of the components used? Assume a suitable safety factor.	(3)
4	In a classical sample and hold circuit design explain the relevance of acquisition time.	(3)
5	How will the loading effect be affected if you replace a passive filter with an active filter in a measuring circuit? Give proper reasoning for your answer.	(3)

6 How closely is the roll-off rate requirement associated with the order of an active filter? (3)

7 Mr X has designed a current measurement circuit based on hall effect sensor and the design had transient voltage suppressors for surge protection, active filters for noise separation and an isolation transformer for the purpose of isolating the measuring system from high power circuit. If given an opportunity, what corrections will you suggest without changing the sensor and why? (3)

8 List out the relevance of signal conditioning in a circuit that uses MPX2010 pressure sensor. (3)

9 List out any three characteristics of ADC in Atmega 32. (3)

10 What do you understand by the term conversion time in an ADC? (3)

PART B

Answer any two full questions, each question carries 14 marks.

11 a) Explain the relevance of unity gain bandwidth for an op-amp. (4)

b) Derive the open loop voltage gain of an op-amp as a function of frequency. (10)

OR

12 a) An inverting amplifier with closed loop gain, A_o = -2 V/V is driven with a square wave of peak values $\pm V_m$ and frequency f. With V_m = 2.5 V. It is observed that the output turns from trapezoidal to triangular when f is raised to 250 kHz. With f = 100 kHz, it is found that slew-rate limiting ceases when V_m is lowered to 0.4 V. If the input is changed to a 3.5 V (rms) ac signal, what is the useful bandwidth of the circuit? (8)

b) How does the frequency response of non-compensated Op-amps differ from compensated Op-amps? (6)

13 a) Describe the operation of a frequency-to-voltage converter with circuit diagrams and waveforms. (7)

b) With a block-diagram, explain how a PLL can be used to implement a frequency multiplier. Use a multiplication factor of 2 for the illustration. (7)

OR

14 (a) For a particular application we need to generate multiple copies of a reference current source. Describe an Op-amp circuit that generates mirror images of the current source which can serve the said purpose. (7)

(b) It is required to design an amplifier for the current signal delivered by a photodetector. Use an Op-amp powered from ±15 V power supply to deliver an output voltage in the range -5 V to +5 V for an input current in the range 0 to 1 A. (7)

15 (a) Design a unity gain second-order low-pass Butterworth filter with a -3 dB frequency of 10 kHz. If input, $V_i(t) = 10\cos(4\pi\, 10^4 t - 90°)$ V, find output $V_o(t)$. (8)

(b) Derive an expression to find the cutoff frequency of a second order low pass Sallen-Key filter. (6)

OR

16 a) Explain the relevance of corner frequencies in filter characteristics. (5)

b) Design a second order Sallen-Key high pass filter with a cutoff frequency of 10 kHz and Q of 1. Assume both resistors to be of equal value and both capacitors to be equal. (9)

17 a) Explain a temperature sensor circuit using the sensor AD590. (6)

b) Design a differential pressure measuring circuit using MPX2010 pressure sensor with switching output. The output should switch at 5 kPa pressure difference. Assume zero offset of the sensor. Assume operating voltage of 10 V, temperature of measurement as 25°C and $P_1 > P_2$. *Hint: use a comparator at the output.* (8)

OR

18 a) To calibrate ADXL202E, the accelerometer's measurement axis is pointed directly at the earth. The 1g reading is saved and the sensor is turned 180° to measure -1g. Let A = accelerometer output with axis oriented to +1g = 55% duty cycle and B = accelerometer output with axis oriented to -1g = 32% duty cycle. What is the sensitivity of the accelerometer? (8)

b) When two or more sensors are mounted close to each other, acoustic interference is possible. Describe the ways in which multiple ultrasonic sensors 873P can be connected. Give the connections for both the analog current and the analog voltage outputs. Assume that the sensors (6) are connected away from an amplifier.

19 a) Differentiate between serial and parallel ADC. (7)

b) What is the relevance of a stable regulated supply voltage in an ADC. List the sampling requirements for successful reproduction in an ADC. (7)

OR

20 It is required to interface the temperature sensor LM35 with Atmega32 for measuring the temperature of an element that varies in the range 0^o C to 120^oC. Draw the interfacing diagram with proper labelling of the Atmega 32 ports. Write an appropriately commented code for the same. (14)

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Syllabus

Module 1: Op-amp Frequency response-compensating networks, frequency response of internally compensated Op-Amps, frequency response of non compensated Op-Amps, High-frequency Op-amp equivalent circuit, open loop voltage gain as a function of frequency, closed loop frequency response, circuit stability, slew rate, slew rate equation, effect of slew rate.

Module 2: Advanced Op-amp applications- Precision rectifier, peak detector and log-converter , antilog amplifier, current mirror, voltage-to-current converters, current-to-voltage converters, voltage-to-frequency and frequency-to-voltage converters, Sample and hold circuit-Basic Circuits, practical sample and hold circuits, performance characteristics. Phase Locked Loop (PLL)- Operating principles, block diagrams, monolithic PLL, IC 565 - PLL applications.

Module 3: Filters- Introduction to basic theory of filters: Filter responses - Active vs passive filters, Low pass, Band-pass, high-pass, band-stop filters and their characteristics - first order vs higher order filters - Realisation of Active filters - Transfer function synthesis, Sallen Key based (VCVS) filters - First order low pass butterworth filter design and frequency scaling, second order low pass butterworth filter design.

Module 4: IC Sensors- IC sensors for different energy forms, thermal energy sensors, mechanical energy sensors, radiant energy sensors, magnetic energy sensors, chemical energy sensors. MEMS-typical IC sensors, temperature energy sensors- LM35 and AD590, pressure sensors-MPX2010, accelerometer-ADXL202E, ultrasonic sensor-873P, infrared thermometer modules-MLX90601 family, Hall effect direction detection sensor-A3422xka

Module 5: ADC, DAC and sensor interfacing to a typical Microcontroller-Review of ADC and ADC characteristics-resolution, conversion time, parallel versus serial ADC with ADC0848 and MAX1112 examples, sampling requirements, ADC programming / interfacing in Atmega 32, interfacing temperature sensor LM35 with Atmega32, DAC 0808 interfacing with Atmega 32

Text Books

1. L. K. Maheswari, M.M.S Anand, "Analog Electronics", Prentice Hall India Learning Private Limited, 2005.

2. Muhammad Ali Mazidi,Sarmad Naimi, Sepehr Naimi, "The AVR Microcontroller and Embedded Systems: Using Assembly and C", Pearson Education India, 1st Edition, 2013

References

1. Ramakant A Gayakwad, "Op-amps and Linear Integrated Circuits", Pearson Education; Fourth edition, 2015

2. D Roy Choudhury, "Linear Integrated Circuits", New Age International Publishers; Fifth edition, 2018

3. Sergio Franco, "Design with operational amplifier and analog circuits" Third Edition, Mc Graw Hill, 2001

4. Elliot Williams,"Make: AVR Programming-Learning to write software for hardware", First edition, Shroff/Maker Media, 2014.

5. Data sheets and application notes of relevant ICs mentioned in the syllabus

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1: Op-amp frequency response (8 hrs)**	
1.1	Compensating networks,frequency response of internally compensated Op-Amps, frequency response of non compensated Op-Amps,	3 hrs
1.2	High-frequency Op-amp equivalent circuit,.	1 hr
1.3	Open loop voltage gain as a function of frequency, closed loop frequency response, circuit stability,	2 hrs
1.4	Slew rate, slew rate equation, effect of slew rate	2 hrs
2	**Module 2: Advanced Op-amp applications (8 hrs)**	
2.1	Precision rectifier, peak detector and log-converter , antilog amplifier, current mirror, voltage-to-current converters, current-to-voltage converters, voltage-to-frequency and frequency-to-voltage converters,	4 hrs
2.2	Sample and hold circuit- Basic Circuits, practical sample and hold circuits, performance characteristics.	2 hrs
2.3	Phase Locked Loop (PLL)- Operating principles, block diagrams, monolithic PLL, IC 565 PLL applications.	2 hrs
3	**Module 3: Filters (6 hrs)**	
3.1	Introduction to basic theory of filters: Filter responses - Active vs passive filters, Low pass, Band-pass, high-pass, band-stop filters and their characteristics - first order vs higher order filters	2 hr
3.2	Realisation of Active filters - Transfer function synthesis, Sallen	2 hr

	Key based (VCVS) filters	
3.3	First order low pass butterworth filter design and frequency scaling, second order low pass butterworth filter design.	2 hrs
4	**Module 4: IC Sensors (7 hrs)**	
4.1	IC sensors for different energy forms, thermal energy sensors, mechanical energy sensors, radiant energy sensors, magnetic energy sensors, chemical energy sensors.	2 hrs
4.2	MEMS-typical IC sensors, temperature energy sensors- LM35 and AD590, pressure sensors-MPX2010, accelerometer-ADXL202E, ultrasonic sensor-873P, infrared thermometer modules-MLX90601 family, Hall effect direction detection sensor-A3422xka	5 hrs
5	**Module 5: ADC, DAC and sensor interfacing to a typical Microcontroller (7 hrs)**	
5.1	Review of ADC and ADC characteristics-resolution, conversion time, parallel versus serial ADC with ADC0848 and MAX1112 examples, Sampling requirements	4 hrs
5.2	ADC programming / interfacing in Atmega 32, interfacing temperature sensor LM35 with Atmega32, DAC 0808 interfacing with Atmega 32	3 hrs