**COURSE FILE (2019-20 EVEN)**

**Course Title: Analog Circuits Semester: 4**

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**1. Course details**

**1.1 Primary information**

|  |  |  |
| --- | --- | --- |
| 1. | Course Code | 18EC42 |
| 2. | L-T-P | 3-2-0 |
| 3. | Marks (Min/Max)VTU ExamInternal Assessment | 40/10021/6016/40 |
| 4. | Prerequisite | Basic Electronics, Electronic Devices |
| 5. | Teaching Department | Electronics & Communication Engineering |
| 6. | Course Duration | 50 hours |
| 7. | Faculty Handling  | Dr. Balachandra Achar |
| 8. | Course Coordinator | Dr. Balachandra Achar |

**1.2 Course Learning Objectives**

The course will enable the students to:

1. Understand the biasing of BJT and MOSFET amplifier circuits and analyze the amplifier using small-signal model.

2. Obtain the frequency response of amplifiers, and design oscillator circuits.

3. Appreciate the use of negative feedback in amplifiers.

4. Construct various circuits using op-amp and 555 timer ICs.

**1.3 Course Outcomes (COs)**

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

1. Design biasing circuits for BJT and MOSFET amplifiers, and perform DC and AC analysis.

2. Analyze MOSFET amplifiers using small-signal model and high frequency model, and generate sine waves using different oscillator circuits.

3. Understand the different types of feedback amplifiers, and design power amplifiers.

4. Design Op-Amp circuits with and without negative feedback for general applications.

5. Design DAC, ADC, filters and multivibrators using Op-Amp and Timer ICs.

**1.4 Validation of Course Outcomes**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Course Outcomes** | **PO:Level** | **Cognitive Level** |
| CO1 | Design biasing circuits for BJT and MOSFET amplifiers, and perform DC and AC analysis. | PO1:3, PO2:2, PO5:1, PO12:3, PSO1:2 | L3 |
| CO2 | Analyze MOSFET amplifiers using small-signal model and high frequency model, and generate sine waves using different oscillator circuits. | PO1:3, PO2:2, PO5:1, PO12:2, PSO1:2 | L3 |
| CO3 | Understand the different types of feedback amplifiers, and design power amplifiers | PO1:2, PO2:2, PO12:2, PSO1:2 | L3 |
| CO4 | Design Op-Amp circuits with and without negative feedback for general applications | PO1:3, PO2:2, PO3:2, PO5:2, PO12:3, PSO1:2, PSO2:3 | L3 |
| CO5 | Design DAC, ADC, filters and multivibrators using Op-Amp and Timer ICs | PO1:3, PO2:2, PO3:2, PO5:2, PO12:3, PSO1:2, PSO2:3 | L3 |

*POs Mapping Level: 1-Slightly ; 2-Moderately; 3-Highly*

**1.5 Mapping of COs with POs**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** | **PO-6** | **PO-7** | **PO-8** | **PO-9** | **PO-10** | **PO-11** | **PO-12** | **PSO-1** | **PSO-2** |
| **CO1** | 3 | 2 |  |  | 1 |  |  |  |  |  |  | 3 | 2 |  |
| **CO2** | 3 | 2 |  |  | 1 |  |  |  |  |  |  | 2 | 2 |  |
| **CO3** | 2 | 2 |  |  |  |  |  |  |  |  |  | 2 | 2 |  |
| **CO4** | 3 | 2 | 2 |  | 2 |  |  |  |  |  |  | 3 | 2 | 3 |
| **CO5** | 3 | 2 | 2 |  | 2 |  |  |  |  |  |  | 3 | 2 | 3 |

**2. Course Plan**

**2.1 Course Contents, Defining Topic Level Outcomes**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Topic****Title** | **Description** | **Topic Level Outcomes (TLO)** | **Blooms Level****(L1–L6)** | **Dura****tion** |
| **At the end of the topic, the students will be able to** |
| Module-1 | * Biasing in BJT amplifiers
* Small signal operation and models
* Biasing in MOSFET amplifier circuits
* Small signal operation and modelling
 | 1.1 Bias the BJT amplifier circuits | L2 | 16 hrs |
| 1.2 Analyse the BJT amplifier circuit using hybrid-pi model | L3 |
| 1.3 Bias the MOSFET amplifier circuit | L2 |
| 1.4 Analyse the MOSFET amplifier circuit using small-signal model | L3 |
|
| Module-2 | * MOSFET amplifier configurations
* Internal capacitances and high frequency model
* Frequency response of CS amplifier
* Oscillators
 | 2.1 Analyse the common-source and common-drain amplifiers  | L3 | 8 hrs |
| 2.2 Describe the effects of gate and junction capacitances on amplifier performance, and draw the high-frequency model | L2 |
| 2.3 Analyse the frequency response of common-source amplifier | L3 |
| 2.4 Design and analyse FET based oscillator circuits | L3 |
| Module-3 | * Feedback amplifiers
* Output stages and power amplifiers
 | 3.1 List the properties of negative feedback | L2 | 8 hrs |
| 3.2 Perform qualitative analysis of the four basic feedback topologies, and compare the same | L2 |
| 3.3 Analyse class-A and class-B amplifiers and list its applications | L3 |
| 3.4 Analyse class-AB and class-C amplifiers and list their applications | L3 |
| Module-4 | * Op-Amp with negative feedback
* General applications
 | 4.1 Design and analyse inverting and non-inverting amplifiers | L3 | 10hrs |
| 4.2 Design and analyse summing, scaling and averaging amplifiers | L3 |
| 4.3 Describe the instrumentation amplifier and its applications | L2 |
| 4.4 Design and analyse comparator, zero-crossing detector and Schmitt trigger | L3 |
| Module-5 | * Op-Amp circuits
* 555 Timer and its applications
 | 5.1 Describe weighted resistor and R-2R type DAC | L2 | 8 hrs |
| 5.2 Describe the successive approximation type ADC  | L2 |
| 5.3 Explain the small signal or precision rectifier circuits | L2 |
|
| 5.4 Design first and second order filters | L3 |
| 5.5 Construct mono-stable and astable multivibrator circuits using 555 timer | L3 |

***Cognitive levels (Bloom’s levels)***

***L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyse, L5 – Evaluate, L6 – Create***

**2.2 Text Books:**

1. Microelectronic Circuits – Theory and Applications, A S Sedra and K C Smith, 6th edition, Oxford, 2015
2. Op-Amps and Linear Integrated Circuits, R A Gayakwad, 4th edition, Pearson Education, 2000

**2.3 Reference Books:**

1. Electronic Devices and Circuit Theory, R L Boylestad and L Nashelsky, Pearson Education
2. Fundamentals of Microelectronics, B Razavi, 2nd edition, John Wiley
3. Integrated Electronics, J Millman and C C Halkias, 2nd edition, Tata McGraw Hill

**2.4 Course Delivery Schedule:**

**Section-A**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Lec.****Nos.** | **Topic to be covered** | **TLO** | **Mode of delivery** | **Date on which planned** | **Date on which covered** | **Faculty Sign** | **HOD Sign** |
| 1 | Revision of BJT operation and characteristics | - | Chalk Board | 3/2/2020 |  |  |  |
| 2 | Revision of MOSFET operation and characteristics | - | Chalk Board | 4/2 |  |  |
| 3 | Revision of transistor as an amplifier and as a switch | - | Chalk Board | 5/2 |  |  |
| 4 | **Module-1:** Voltage divider bias | 1.1 | Chalk Board | 8/2 |  |  |
| 5 | Numerical exercises on voltage divider bias | 1.1 | Chalk Board | 10/2 |  |  |
| 6 | Collector to base feedback bias | 1.1 | Chalk Board | 11/2 |  |  |
| 7 | Numerical exercises on collector to base feedback bias | 1.1 | Chalk Board | 12/2 |  |  |
| 8 | Hybrid pi model and derivation of voltage gain | 1.2 | Chalk Board | 15/2 |  |  |
| 9 | Drawing DC and AC equivalent circuits of BJT amplifier | 1.2 | Chalk Board | 17/2 |  |  |
| 10 | Voltage divider bias in MOSFET | 1.3 | Chalk Board | 18/2 |  |  |
| 11 | Numerical exercises on voltage divider bias | 1.3 | Chalk Board | 19/2 |  |  |
| 12 | Drain to Gate feedback bias | 1.3 | Chalk Board | 20/2 |  |  |
| 13 | Numerical exercises on drain to gate feedback bias | 1.3 | Chalk Board | 24/2 |  |  |
| 14 | Small signal model of MOSFET | 1.4 | Chalk Board | 25/2 |  |  |
| 15 | Drawing DC and AC equivalent circuits of MOSFET amplifier | 1.4 | Chalk Board | 27/2 |  |  |
| 16 | Numerical exercises on MOSFET small signal model | 1.4 | Chalk Board | 28/2 |  |  |
| 17 | **Module-2:**CS amplifier with and without source resistance | 2.1 | Chalk Board | 2/3 |  |  |  |
| 18 | CD amplifier or source follower  | 2.1 | Chalk Board | 3/3 |  |  |
| 19 | Numerical exercises on CS and CD amplifiers | 2.1 | Chalk Board | 4/3 |  |  |
| 20 | MOSFET internal capacitances | 2.2 | Chalk Board | 9/3 |  |  |
| 21 | MOSFET high frequency model | 2.2 | Chalk Board | 10/3 |  |  |
| 22 | Frequency response of CS amplifier | 2.3 | Chalk Board | 11/3 |  |  |
| 23 | Basics of oscillator, MOSFET phase-shift oscillator | 2.4 | Chalk Board | 12/3 |  |  |
| 24 | LC and crystal oscillators | 2.4 | Chalk Board | 16/3 |  |  |
| 25 | **Module-4:**Basics of opamp open loop and closed loop | 4.1 | Chalk Board | 17/3 |  |  |  |
| 26 | Inverting and non-inverting amplifiers | 4.1 | Chalk Board | 18/3 |  |  |
| 27 | Numerical exercises on inv and non-inv amplifiers | 4.1 | Chalk Board | 1/4 |  |  |
| 28 | Advantages of feedback, AC and DC amplifiers | 4.2 | Chalk Board | 2/4 |  |  |
| 29 | Summing, scaling and averaging amplifiers | 4.2 | Chalk Board | 4/4 |  |  |
| 30 | Instrumentation amplifiers | 4.3 | Chalk Board | 6/4 |  |  |
| 31 | Numerical examples on op-amp applications | 4.3 | Chalk Board | 7/4 |  |  |
| 32 | Comparators and zero-crossing detectors | 4.4 | Chalk Board | 8/4 |  |  |
| 33 | Inverting and non-inverting Schmitt triggers | 4.4 | Chalk Board | 9/4 |  |  |
| 34 | Numerical exercises on Schmitt trigger | 4.4 | Chalk Board | 13/4 |  |  |
| 35 | **Module-5:**Basics of DAC, weighted resistor DAC | 5.1 | Chalk Board | 16/4 |  |  |  |
| 36 | R-2R ladder DAC | 5.1 | Chalk Board | 20/4 |  |  |
| 37 | Basics of ADC, Successive approximation ADC | 5.2 | Chalk Board | 21/4 |  |  |
| 38 | Precision half-wave rectifier | 5.3 | Chalk Board | 22/4 |  |  |
| 39 | Active filters, First order filters | 5.4 | Chalk Board | 27/4 |  |  |
| 40 | Second order low-pass filters | 5.4 | Chalk Board | 28/4 |  |  |
| 41 | Second order high-pass filters | 5.4 | Chalk Board | 5/5 |  |  |
| 42 | Band-pass and Band-reject filters | 5.4 | Chalk Board | 6/5 |  |  |
| 43 | Basics of 555 timer | 5.5 | Chalk Board | 7/5 |  |  |
| 44 | Monostable and Astable multivibrators using 555 timer.  | 5.5 | Chalk Board | 9/5 |  |  |
| 45 | **Module-3:**Basics of feedback, Properties of negative feedback | 3.1 | Chalk Board | 11/5 |  |  |  |
| 46 | Series-shunt and series-series feedback | 3.2 | Chalk Board | 12/5 |  |  |
| 47 | Shunt-shunt and shunt-series feedback | 3.2 | Chalk Board | 13/5 |  |  |
| 48 | Classification of output stages of amplifier | 3.3 | Chalk Board | 14/5 |  |  |
| 49 | Class-A and Class-B operation operations | 3.3 | Chalk Board | 18/5 |  |  |
| 50 | Transfer characteristics | 3.3 | Chalk Board | 19/5 |  |  |
| 51 | Power dissipation and conversion efficiency | 3.4 | Chalk Board | 20/5 |  |  |
| 52 | Class-AB and Class-C tuned amplifiers | 3.4 | Chalk Board | 21/5 |  |  |

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**Faculty-1 Faculty-2 HOD**

**2.5 Topics Covered Beyond Syllabus**

**3. Assessment of COs**

**3.1 Assessment Schedule:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Date** | **Assessment Tool used** | **TLOs Assessed** | **Average Cognitive Level** |
| 28/3/2020 | IA Test-1 | 1.1, 1.2, 1.3, 1.4, 2.1, 2.2 |  |
| 30/4/2020 | IA Test-2 | 2.3, 2.4, 4.1, 4.2, 4.3, 4.4 |  |
| 23/5/2020 | IA Test-3 | 5.1, 5.2, 5.3, 5.4, 5.5, 3.1, 3.2 |  |
| 18/3/2020 | Assignment-1 | 1.1, 1.2, 1.3, 1.4, 2.1, 2.2 |  |
| 22/4/2020 | Assignment-2 | 2.3, 2.4, 4.1, 4.2, 4.3, 4.4 |  |
| 16/5/2020 | Assignment-3 | 5.1, 5.2, 5.3, 5.4, 5.5, 3.1, 3.2 |   |
| 30/5/2020 | Quiz | 3.3, 3.4 |  |

**3.2 Measuring CO Attainment:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **TLO** | **Attained Level of Bloom's Taxonomy** | **Assess-ment Tool Used** | **Weightage** | **Attainment Level** | **Contribution to CO Attainment** | **Attainment Goal** |
| **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
| 1.1 |  |  |  |  |  |  |  |  |  |  |
| 1.2 |  |  |  |  |  |  |  |  |  |  |
| 1.3 |  |  |  |  |  |  |  |  |  |  |
| 1.4 |  |  |  |  |  |  |  |  |  |  |
| 2.1 |  |  |  |  |  |  |  |  |  |  |
| 2.2 |  |  |  |  |  |  |  |  |  |  |
| 2.3 |  |  |  |  |  |  |  |  |  |  |
| 2.4 |  |  |  |  |  |  |  |  |  |  |
| 3.1 |  |  |  |  |  |  |  |  |  |  |
| 3.2 |  |  |  |  |  |  |  |  |  |  |
| 3.3 |  |  |  |  |  |  |  |  |  |  |
| 3.4 |  |  |  |  |  |  |  |  |  |  |
| 4.1 |  |  |  |  |  |  |  |  |  |  |
| 4.2 |  |  |  |  |  |  |  |  |  |  |
| 4.3 |  |  |  |  |  |  |  |  |  |  |
| 4.4 |  |  |  |  |  |  |  |  |  |  |
| 5.1 |  |  |  |  |  |  |  |  |  |  |
| 5.2 |  |  |  |  |  |  |  |  |  |  |
| 5.3 |  |  |  |  |  |  |  |  |  |  |
| 5.4 |  |  |  |  |  |  |  |  |  |  |
| 5.5 |  |  |  |  |  |  |  |  |  |  |
| **Total Attainment of CO1** |  |  |  |  |  |  |
| **Total Attainment of CO2** |  |  |  |  |  |  |
| **Total Attainment of CO3** |  |  |  |  |  |  |
| **Total Attainment of CO4** |  |  |  |  |  |  |
| **Total Attainment of CO5** |  |  |  |  |  |  |

**3.3 Other Information:**

|  |  |  |
| --- | --- | --- |
|  | **Section - A** | **Section - B** |
| Total number of classes held |  |  |
| Number of numerical classes held |  |  |
| Number of seminars held |  |  |
| Portion coverage |  |  |
| Students’ feedback |  |  |
| No. of students having attendance shortage |  |  |
| University result |  |  |
| Use of various teaching methods |  |  |

**3.4 Remarks:**

|  |
| --- |
| Faculty:Signature |
| Course Coordinator:Signature |
| Module Coordinator:Signature |
| HOD:Signature |