** COMSATS University Islamabad, Lahore Campus**

**Block–B, Department of Electrical Engineering**

**1.5 KM Defence Road, Off Raiwind Road, Lahore**

**COURSE DESCRIPTIVE FILE**

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| **1** | **Course Title** | Electric Circuits Analysis II |
| **2** | **Course Code** | CPE222 |
| **3** | **Credit Hours** | 4(3,1) |
| **4** | **Pre-Requisite** | CPE 121 Electric Circuit Analysis I |
| **5** | **Co-Requisites** | Power Distribution & Utilization System |
| **6** | **Semester** | Fall 2023 |
| **7** | **Resource Persons** | Dr. Mirza Tariq Hamayun |
| **8** | **Supporting Team Members** | Mr. Sarmad Hassan |
| **9** | **Contact Hours (Theory)** | 3 hours per week |
| **10** | **Contact Hours (Lab)** | 3 hours per week |
| **11** | **Office Hours** |  |
| **12** | **Course Catalog Description** | |
| This course provides a comprehensive introduction to sinusoidal Forcing Function ad its characteristics, transient and steady-state response, complex forcing functions, concept of phasors, phasor relationship of R, L and C, concept of Impedance and admittance, lagging/leading currents and voltages, s-domain analysis of electric circuits, network theorem and circuit analysis technique, superposition, source transformation & Thevenin’s Theorem, effective value of current and voltage, instantaneous, average, complex and apparent power, power factor, single phase three-wire systems, three phase Y-Y connection, Delta connection, Frequency Response, Bode Plot, Series and Parallel resonance circuits, half-power frequency and bandwidth and filters. One port & two port networks and circuit analysis using Laplace Transformation technique. | | |
| **13** | **Textbook:** | |
| **Text Book**   * Fundamentals of Electric Circuits (5th Edition) C. K. Alexander, M. N. O. Sadiku, McGraw Hill.   **Reference Books**   * Electric Circuits, J. W. Nilsson, Addison-Wesley (6th edition) * Engineering Circuit Analysis, 8th Edition by W. H. Hayt, J. E. Kemmerly, S. M. Durbin McGraw Hill. | | |
| **14** | **Course Learning Objectives** | |
| After successful completion of this module, the students will be able to demonstrate knowledge and understanding of transformation of the circuits from time domain to frequency and s domain. Student will learn to apply the Kirchhoff laws, Nodal Analysis, Mesh Analysis, Network theorems, Laplace transforms and Bode Plot techniques to the circuit problems in frequency and s domain.  Understand the key concepts of single-phase power systems, three phase power systems, three phase sources, line voltages, line currents, delta, and Y-connected networks. Student will grab the knowledge  Of Frequency response, filters, resonance, Laplace transformation and its application in analyzing the  Circuits. Analysis of two port networks to find impedance, admittance and hybrid parameters. | | |
| **15** | **Course Learning Outcomes (CLOs)** | |
| **Theory CLOs:**  After successfully completing the course, the students will be able to:   1. Solve the single and three phase AC circuits using the concepts of sinusoids, phasors, and basic circuit analysis theorems. (PLO1, C3) 2. Design the AC filters and analyse the two-port networks and LTI systems using the concepts of frequency response and Laplace transformation. (PLO2, C5)   **Lab CLOs:**   1. To design and compute the parameters for single and three phase electric circuits using standard circuit analysis techniques. (C5 – PLO3) 2. To construct the single and three phase electric circuits and measure the required parameters using simulation tool (LTspice), hardware platforms (breadboard, digital multi-meter (DMM) and digital storage oscilloscope (DSO)). (P3 – PLO5) | | |

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| **16** | **Tentative Lecture Plan** | | | | | | | | |
| **Week** | **Topic** | **CLO** | **Specific Outcome** | **Contact Hours** | **Students Learning Hours** | **Assessment** | **Bloom Taxonomy** | |
| 1-2 | Sinusoid, Complex numbers, Phasors, Phasor relationships of circuit elements, Impedance and Admittance | **CLO1** | Distinguish the Lead/Lag between two sinusoids and the time domain to frequency domain conversion using the basic concepts of complex numbers and phasors. | **6** | **6** | Assignment 1, Quiz1,  Midterm | **C2** |
| 3-5 | Application of KCL, KVL, current and voltage divider in frequency domain, Nodal and mesh analysis, superposition theorem, Source transformation, Thevenin and Norton equivalent circuits. | Solve the single-phase ac circuits to compute the unknown parameters using various circuit analysis techniques. | **9** | **9** | **C3** |
| 6-7 | Instantaneous and average power, Effective or RMS value, Maximum Power Transfer Theorem, Apparent power and Power factor, complex power, conservation of ac power, power factor correction. | Compute and distinguish the instantaneous, effective, complex, real and apparent power in ac circuits using power triangle. | **4.5** | **6** | Assignment 2,  Quiz 2,  Midterm | **C3** |
| 7-8 | Three-phase circuits: balanced three-phase voltages, balanced wye-wye connection, balanced wye-delta connection, balanced delta-delta connection, balanced delta-wye connection, power in a balanced system. | Solve the three-phase balanced ac circuits using the concept of wye-delta transformation. | **4.5** | **6** | **C3** |
| 9-10 | Frequency response, transfer function, Bode plots, series resonance, parallel resonance, filters: low-pass filter, high-pass filter, band-pass filter, band-stop filter. | **CLO2** | Analyze the frequency response of ac circuits and design the filters using their transfer functions and bode plots. | **6** | **6** | Assignment 3, Quiz 3, Terminal | **C5** |
| 11 | Laplace transformation, properties of the Laplace transform | Analyze the linear systems in s-domain using Laplace transformation | **3** | **3** | Assignment 4, Quiz 4, Terminal | **C4** |
| 12 | Inverse Laplace transform, simple poles, repeated poles, complex poles | Analyze the linear systems in time domain using Inverse Laplace transformation | **3** | **3** | **C4** |
| 13-14 | Applications of the Laplace transform: circuit element models, circuit analysis, transfer functions, and state-variables. | Analyze the LTI systems in time and frequency domain using their transfer functions and state variables. | **6** | **6** | **C4** |
| 15 | Two-port networks: impedance, admittance, hybrid and transmission parameters. | Analyze the two port networks using their impedance, admittance, hybrid and transmission parameters. | **3** | **3** | Terminal | **C4** |

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| **17** | **Assessment Plan** |
| |  |  |  |  | | --- | --- | --- | --- | | Quizzes (minimum 4) | | 15% | | | Homework assignments (minimum 4) | | 10% | | | Midterm exam (1.5 hours) | | 25% | | | Terminal exam (3 hours) | | 50% | | | **Total (theory)** | **100%** | |   **Theory**  **Lab**   |  |  |  |  | | --- | --- | --- | --- | | Lab manual | | 25% | | | Lab Midterm exam | | 25% | | | Lab project and terminal exam | | 50% | | | **Total (lab)** | **100%** | |  |  |  | | --- | --- | | **Final marks** | Theory marks \* 0.75 + Lab marks \* 0.25 | | |

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| **18** | **Course Learning Outcomes (CLOs) and Assessment Plan** |
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| **19** | **Laboratory Experiences** | |
| There is a Laboratory component in all 3+1 credit courses taught at the department. Lab work consists of a minimum of 14 experiments and 03 related assignments, which constitute 25% of the overall course-grade. The laboratory experiments include hands-on exercises as well as computer analysis of the concepts taught in class. This course familiarizes the students with P Spice and MATLAB analysis and design software tool, which is a part of most laboratory experiments. | | |
| **20** | **Laboratory Resources** | |
| The relevant laboratory is equipped with workbenches and computers to facilitate the experiments outlined in the lab handbook(s) that are periodically updated. A current list of the 14 lab experiments performed in this course is provided as Annexure-II. The list of software and equipment available is also posted in all labs and is managed by staff dedicated for this purpose. | | |
| **21** | **Computer Resources** | |
| For the purposes of this course the P Spice design and MATLAB analysis is used throughout the course. | | |
| **22** | | **Mapping of CLOs to PLOs** |
| PLO 1 **Engineering Knowledge:** An ability to apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. **(Cognitive)**  PLO 2 **Problem Analysis:** An ability to identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences. **(Cognitive)**  PLO 3 **Design/Development of Solutions:** An ability to design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. **(Cognitive)**  PLO 4 **Investigation:** An ability to investigate complex engineering problems in a methodical way including literature survey, design and conduct of experiments, analysis and interpretation of experimental data, and synthesis of information to derive valid conclusions. **(Cognitive, Psychomotor)**  PLO 5 **Modern Tool Usage:** An ability to create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities, with an understanding of the limitations. **(Psychomotor)**  PLO 6 **The Engineer and Society:** An ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solution to complex engineering problems. **( Cognitive)**  PLO 7 **Environment and Sustainability:** An ability to understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development. **(Cognitive)**  PLO 8 **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice. **(Affective)**  PLO 9 **Individual and Team Work:** An ability to work effectively, as an individual or in a team, on multifaceted and /or multidisciplinary settings. **(Affective)**  PLO 10 **Communication:** An ability to communicate effectively, orally as well as in writing, on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. **(Affective)**  PLO 11 **Project Management:** An ability to demonstrate management skills and apply engineering principles to one’s own work, as a member and/or leader in a team, to manage projects in a multidisciplinary environment. **(Affective)**  PLO 12 **Lifelong Learning:** Anability to recognize importance of, and pursue lifelong learning in the broader context of innovation and technological developments. **(Affective)** | | |

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| **23** | **PLOs Coverage Explanation** |
| PLO 1 **Engineering Knowledge:**  The homework, exams, and laboratory experiments require direct application of mathematics and engineering knowledge to successfully complete this course. Students learn how fundamental mathematical concepts are used to understand, analyze and design basic electric circuits in both time and frequency domains.  PLO 2 **Problem Analysis:**  Analysis of circuit in phasor domain using circuit laws and network theorems for the evaluation of circuit behavior and finding various parameters. Single and Three Phase circuit analysis is performed for various power outcomes. Time Domain Problems are also converted to s domain via Laplace Transformation for doing better problem analysis. Analysis of circuits to find various parameters.  PLO 3 **Design/ Development of Solutions:**  Laboratory experiments and simulation exercises give students experience in studying the behavior of the circuit with different excitations and corresponding responses, manipulating measurements and interpreting the results.  PLO 5 **Modern Tool Usage:**  Using experimental equipment in lab, students study and observe various attributes and parameters of an Electric circuit in software such as P spice and MATLAB.  PLO 10 **Communication:**  Through problem analysis and design of solutions in assessments reports and evaluation during lab work trains a student to affectively use communication skills to explain their understanding and results in formal manner.  **PLO 4, 6-9, 11-12:** These PLOs are not directly addressed in this course. | |

**ANNEXURE-I**

**List of Experiments:**

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| **Lab #** | **Details** |
| 1 | To explain the procedure for generation and display of AC signal using hardware tool  Objectives   * To explain the procedure for generating the arbitrary waveforms using function generator. * To explain the basic understanding of viewing a time varying voltage waveform and various control knobs using digital oscilloscope. |
| 2 | To explain natural and step response of parallel RLC circuits using software tool  Objectives   * To explain the basic understanding of LTspice software * To explain the DC bias point and Transient Analysis using LTspice. * To explain the Natural and Step response of RLC circuits using LTspice. * To explain the concepts of overshoot, settling time and rise time using LTspice. |
| 3 | To Display the Sinusoidal Steady State Response of RC and RL circuits using hardware & software tools  Objectives   * To Display the behavior of capacitor and inductor under time varying signal. * To Explain the experimental verification of capacitor and inductor’s impedance expression. |
| 4 | To Reproduce the circuits in Ltspice and Show the Network theorems in phasor domain using software tool  Objectives   * To Show the network theorems of electric circuits in Phasor domain using Ltspice |
| 5 | To Reproduce the circuit and show the Power (Active, Reactive and Apparent) and Power Factor Correction using software tool  Objectives   * To show the parameters for AC power analysis using LTspice * To compute active, reactive and apparent power using standard circuit formulas * To reproduce the circuit for computing power factor and its correction using LTspice |
| 6 | To reproduce three phase circuits using software tool  Objectives   * To reproduce the three phase circuits with wye and delta configuration using LTspice * To display the output waveform for three phase circuits with wye and delta configuration using LTspice * To show the line currents and compute the active power dissipated in the delta connected circuit using   LTspice. |
| 7 | To reproduce RC Low and High pass Filter by selecting appropriate components using hardware & software tools  Objectives   * To reproduce the series RC low pass and high pass filters to display its cutoff frequency using Ltspice. To design a simple RC low and high pass filter for cut off frequency of 4.8kHz using Ltspice.. * To trace the Bode plot for low and high pass RL filters using graphical techniques. |
| 8 | To reproduce RL Low and High pass Filter by selecting appropriate components using hardware & software tools  Objectives   * To reproduce the series RL low pass and high pass filters to display its cutoff frequency. * To design a simple RL low and high pass filter for cut off frequency of 4.8kHz * To trace the Bode plot for low and high pass RL filters using graphical techniques. |
| 9 | To reproduce Passive filters (Band pass, Band stop) by selecting appropriate components using software tool  Objectives   * To design band-pass and band-stop filters for given specified center frequency using standard design criteria. * To reproduce the designed circuit and show the parameters for computing center frequency using LTspice. * To show the difference of measured center frequency with calculated value using LTspice and sketch   its frequency response. |
| 10 | To reproduce series and parallel resonance RLC circuit using software tool  Objectives   * To compute the resonant frequency of series and parallel RLC circuit using standard circuit technique. * To show the resonant frequency of series and parallel RLC circuit and LTSpice * To design a series and parallel resonance circuit for desired resonant frequency using standard circuit technique. * To reproduce the response of a series and parallel resonance circuit for desired resonant frequency using LTSpice * To show the difference of the measured resonant frequency with calculated value of a series and parallel resonance circuit using LTSpice and sketch its frequency response. |
| 11 | To reproduce the circuit and show the impedance, admittance and hybrid parameter for unknown two port network using software tool  Objectives  To show the impedance, admittance and hybrid parameter for unknown two port network using LTspice |
| 12 | To reproduce second and third order RC low pass filter circuits using hardware & software tool  Objectives   * To design second and third order low pass RC filters for desired cut-off frequency using standard design criteria * To reproduce the designed circuit and show the parameters for computing cut-off frequency using trainer board, digital oscilloscope, function generator and LTspice * To show the difference of the measured cut-off frequency with calculated value. |