Electric Circuits - II Lab

Complex Engineering Activity

FILTERS

1. Objective

The aim of this project is to:

- **Design and implement** an active or passive filter circuit that addresses a real-world signal processing application through effective frequency response control.
- **Evaluate and validate** the designed system using analytical calculations, simulation tools, and hardware testing to compare theoretical and practical performance.
- Address **complex engineering elements** such as multiple constraints, trade-offs, and system integration.
- **Demonstrate engineering judgment and communication skills** by analyzing design constraints, presenting results, and documenting the complete project process.

This is a Complex Engineering Activity and it includes the following Washington Accord (WA) attributes:

Code	Activity Characteristic
EA1	Range of Resources – Use of diverse, possibly specialized, resources.
EA5	Familiarity – activities involve unpredictability and require judgment and responsibility

2. Description

This project aims to engage students in solving a **Complex Engineering Problem (CEP)** by designing, implementing, and analyzing a **hardware-based filter circuit** that demonstrates a **real-world application**. Students will apply their understanding of circuit theory, frequency response, and filter characteristics to create a functional prototype and evaluate its performance.

Projects should go beyond textbook examples and demonstrate critical thinking, creativity, and integration of multiple circuit concepts.

3. Deliverables

The expectations from the project are that students develop a system based on application of filters keeping the following deliverables in mind:

1. **Identify a real-world problem** that can be addressed through a filter-based circuit (e.g., signal conditioning, noise suppression, audio enhancement, biomedical filtering, sensor interfacing, etc.).

2. **Design and Calculations:** Select the type of filter that fits your problem — low-pass (allows low frequencies), high-pass (allows high frequencies), band-pass (allows a range), or band-stop (blocks a range). Decide whether it should be passive (using only resistors, capacitors, inductors) or active (using op-amps for amplification or control). . Perform the **necessary design calculations** to determine component values such as resistors, capacitors, and inductors based on your target **cutoff frequency**, **gain**, and **bandwidth**. Use standard filter design formulas or equations derived from circuit analysis to justify your choices.

3. **Simulation**: Simulate the circuit on PSpice (or any equivalent tool) to verify your calculations, visualize the frequency response, and confirm that the design meets your specifications before moving to hardware implementation.

4. **Implementation:** Build your designed filter circuit on hardware using a breadboard, Veroboard, or PCB. Ensure neat wiring, correct component placement, and proper grounding. Once assembled, test the circuit's performance using lab instruments such as a function generator and oscilloscope.

   Record important parameters including **cutoff frequency**, **gain**, **attenuation**, and **bandwidth**. *Compare these measured results with your theoretical and simulated values to evaluate the circuit's accuracy and performance and document it.*

5. **Challenges and Troubleshooting:** Lastly, discuss what challenges were faced during the design process and how were they resolved.

6. **Report:** Prepare a clear **written report.** Highlight your problem, design choices, results, comparisons, analysis and what you learned. Refer to the report format.

4. Project Timeline and Submission

i. Week 10: **Milestone 0-Project Proposal** Submission
ii. Week 14: **Milestone 1-Pre-evaluation**
- Report 1: Submission of simulations

iii. Week 15**: Milestone-II Final Evaluation:**
- Project Demonstration
- Viva
- Report 2: Complete project report submission

5. Instructions

- Project work will be carried out in a group of maximum 03 students.
- Groups will be formed in lab sections and must be approved by the corresponding Lab RA/Instructor.
- Basic components & breadboard will be provided to each group 1 time.
- The breadboard provided will be returned back on the day of Final Evaluation.

6. Project Proposal Requirement

The proposal document must contain the following sections:

- Title Page
- Objective
- Introduction
- Block Diagram
- Proposed Schematic
- List of Components
- Expected Outcomes
- Planning of task division

7. Report Requirement

The proposal document must contain the following sections:

- Title Page
- Objective
- Introduction
- Block Diagram
- Schematic
- Simulation
- Calculations
- Complex Engineering Activity-Challenges[1]
- Results
- Group members' Contribution
- References

8. Weightage

The project is worth 22 percent of the lab grade. Out of 100% of the total CEA score the milestones weightages are:

1. Milestone 0 Proposal Submission – 10%.
2. Milestone 1- Simulation – 30%
3. Milestone – 2 – Final Evaluation - 60%

[1] Address **complex engineering elements** such as multiple constraints, trade-offs, and system integration. Refer to appendix for further clarification.

CEA Rubrics for Electric Circuits II Lab

Proposal - 10 points

	Learning Outcomes
CLO 4	LR9 – Report

Milestone 01 - Weightage = 30 points

	Learning Outcomes
CLO 2	LR2 – Simulation, LR3 – Troubleshooting
	LR6 – Calculations LR11- Design

Milestone 02 - Weightage = 60 points

	Learning Outcomes
CLO 2	LR1 – Circuit Layout LR3 – Troubleshooting
	LR6 – Calculations LR11 – Design LR4 – Data Collection
CLO 4	LR7 – Viva
CLO 4	LR9 – Report
CLO 2	LR10 – Analysis LR5 – Results and Plots

Consolidated

Milestone	CLO	EAs	CLO 2	CLO 4
Milestone 1	Proposal		-	/10
Milestone 2	Simulation		/10	-
	Calculation	EA2	/10	-
	Design	EA5	/10	-
Milestone 3	Organization & Presentation		/15	-
	Design Functionality	EA2	/20	-
	Viva			/10
	Final Report	EA2	-	/15
	Total		/65	/35

Appendix

Complex Engineering Activity

1. **Multiple constraints:**
   You must consider **practical limitations** — for example:

   - Limited component availability or cost
   - Power supply restrictions (48 V input)
   - Space on the breadboard or PCB
   - Safety, noise, and reliability issues
   - Performance targets (like gain, cutoff frequency, stability)

2. **Trade-offs:**
   Engineers often have to **balance competing factors** — improving one thing can worsen another. For example:

   - Increasing gain may also increase noise.
   - Using higher-order filters improves sharpness but makes the circuit more complex and costly.
   - Choosing smaller capacitors may save space but affect frequency response accuracy.

3. **System integration:**
   Your filter circuit should be seen as part of a **larger system**, not in isolation — for instance:

   - Interfacing the filter with a sensor, amplifier, or controller
   - Ensuring output levels match the next stage's input
   - Making sure grounding and power distribution work with other components.

4. **Range of Resources (EA1):**
   This project involves using multiple engineering tools and resources at different stages. For example:

   - Simulation software such as Multisim, PSpice, LTSpice or Proteus for design verification.
   - Analytical tools for manual calculations and frequency response prediction.
   - Hardware components like op-amps, capacitors, resistors, and regulated power supplies.
   - Measurement equipment (oscilloscope, function generator, multimeter) for testing performance.

5. **Unfamiliar and Unpredictable Situations (EA5):**

   During testing, you may encounter real-world conditions that differ from simulations. For example:

- Component tolerances or wiring issues causing deviation from expected results.
- Noise interference or instability in the actual circuit
- Difficulty achieving exact cutoff frequency or gain values

You are expected to analyze these issues, apply engineering judgment, and suggest corrective actions.

6. Technical Communication and Documentation:

Clear reporting and presentation are essential to demonstrate your engineering process. For example:

- Documenting circuit design, simulation results, and hardware testing steps
- Comparing theoretical, simulated, and experimental results
- Explaining observed deviations and possible improvements
- Presenting findings effectively during the final evaluation