


# ECE 215/S – Principles of Electronic Cyber Warfare

## Block 2: Signal Processing

## Lesson 19: Analog Filter Lab

Department of Electrical and Computer Engineering
United States Air Force Academy

Fall 2026

# Lab Goal and Deliverable

Today you **build** the filters you analyzed at Lesson 17 — plus one circuit that goes past them — and measure whether they behave the way the math said they would.

- Work through the lab handout **with your lab partner (groups of 2)**
- **Submit the completed handout to Gradescope by the end of the lab period** — it is worth **1 project point**
- Scored on the same 1 / 0 basis as every other project item

**Midterm is due today. Turn it in before you pick up a probe.**

# Authorized Resources

- Lab equipment, your laptop, and the lab handout
- Course slides, readings, and practice problems
- Your ECE 215 equation sheet
- EI from ECE instructors during the period
- GenAI **only up to Level 3** — use of GenAI as a feedback tool on student-generated work, as defined in the AW GenAI Policy
- You may **not** use materials from previous semesters

Document any collaboration or GenAI use on the handout.

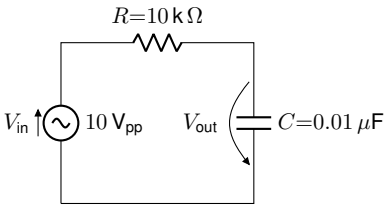
# Good Lab Practice

Before you energize anything:

- Keep the **function generator's output off** while you change the circuit
- **Check every connection** before turning the output back on
- **Analyze first** — compute what you expect, so you notice immediately when the measurement disagrees
- Keep food and drink away from the equipment

**A measurement that disagrees with your prediction is data.**
**A measurement with no prediction behind it is confusion.**

# Parts 1–3: Set Up, Build, Configure




4 kHz sine, **High Z**

1. **Part 1:** program the generator with the values shown — sine, **High Z**
2. **Part 2:** build the R-C circuit and, **before you power it**, compute and record the predicted cutoff:

   $$f_{\mathrm{cutoff}} = \frac{1}{2\pi RC}$$

   Probe $V_{\mathrm{in}}$ on CH1 and $V_{\mathrm{out}}$ on CH2 — *then* turn the output on
3. **Part 3:** both channels on and scaled, then **Measure** → Peak-to-Peak on each, and Time Measurements → Phase with **Source 1 = CH2, Source 2 = CH1**

# Part 4: Measure the Frequency Response

1. Set the function generator to a known amplitude and a **low** frequency, well below your predicted $f_{\text{cutoff}}$
2. Record $V_{\text{in}}$ and $V_{\text{out}}$, and compute the gain $|V_{\text{out}}/V_{\text{in}}|$
3. **Sweep the frequency** across the range in the handout, recording gain at each point
4. Keep $V_{\text{in}}$ constant as you sweep — generators can sag under load, so **re-check it at every point**
5. Plot gain versus frequency **on the grid on the handout's last page (page 6)** — the percent difference goes in the blank below it

**Measure $V_{\text{in}}$ at every frequency.**
**Assuming it stayed put is the classic lab error.**

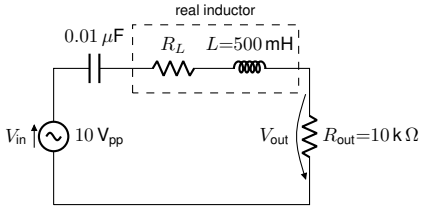
# Parts 4–6: Find the Cutoff, Then Explain It

- **Part 4:** find the frequency where the gain falls to **0.707** of its passband value — the $-3$ dB point — then **compute the percent difference** against your Part 2 prediction:

$$\%\ \text{difference} = \frac{|f_{\text{measured}} - f_{\text{predicted}}|}{f_{\text{predicted}}} \times 100$$

- At the cutoff the phase should read $\approx -45°$ ($\approx +45°$ for the Part 5 high-pass) — a second, independent confirmation that you found the right frequency
- **Part 5:** swap $R$ and $C$, take the output across the resistor, identify the filter, and find its cutoff by sweeping $100$ Hz–$10$ kHz — same $R$ and same $C$, so it should land on the *same* cutoff
- **Part 6:** measure the real $R$ and $C$ on the **ZLCR meter** and recompute the cutoff
- Expect a discrepancy — a $\pm 10\%$ capacitor moves the cutoff by roughly $\pm 10\%$, and the scope probe and breadboard add stray capacitance of their own
- **A disagreement you can explain is a good result.** One you cannot explain means keep looking

# Part 7: Hypothesize, Then Measure




1. **Hypothesize the filter type** (LPF, HPF, BPF, BSF/BRF) *before* you sweep
2. Build it with the values shown. $R_L$ is the inductor's own resistance — nothing to add
3. Sweep $100$ Hz–$10$ kHz at a **fixed** $10$ $V_{pp}$ input and find the **frequency of peak gain** (1–5 kHz)
4. Record whether the measurement **confirmed or corrected** your hypothesis

**An inductor *and* a capacitor — past Objective 2.4's one-element filters. Commit to an answer, then let the bench settle it.**

# Submission Checklist

Before you leave:

- ☐ Predicted $f_{\text{cutoff}}$ computed and recorded **before** measuring
- ☐ Gain versus frequency table filled in across the full sweep
- ☐ Response plotted with the $-3$ dB point marked, and the percent difference shown — on the grid and in the blank on the last page of the handout (page 6)
- ☐ Part 5 filter type identified and its cutoff found
- ☐ Components measured and the cutoff recalculated
- ☐ Part 7 filter type hypothesized before the sweep, peak-gain frequency recorded, hypothesis confirmed or corrected
- ☐ A sentence explaining any discrepancy
- ☐ Documentation statement
- ☐ Equipment powered off and packed up
- ☐ Handout submitted to Gradescope by the end of the lab period

# Wrap-Up

- You built three circuits, measured their responses, and found two cutoffs and one peak — the cutoffs are exactly what Objective 2.4 asks you to compute
- Predicting first and measuring second is the habit worth taking from today

Due today:

- Both to Gradescope: the **Midterm** (Objectives 1.1–1.7, 2.1–2.3) and **this lab handout**

Next lesson:

- **Lesson 20 — Objective 2.5: Analog-to-Digital Conversion.** Turning that analog voltage into numbers