Claude in an Electrical Engineering Circuit Analysis Course

## Downloads

* [Download as Word Document (DOCX)](/downloads/teaching/electrical-engineering-claude.docx)

# Case Study: Using Claude for Enhanced Feedback in an Analog Circuit Design Course

## Course Context

**Course:** Analog Electronics Design (EE 3744)
**Level:** Junior
**Enrollment:** 65 students
**Prior Format:** Weekly lab assignments with delayed feedback
**Tools:** Circuit simulation software, breadboarding equipment
**Faculty:** Dr. S, Associate Professor of Electrical Engineering

## Implementation Challenge

Dr. S identified several challenges in her analog circuit design course that AI assistance could potentially address:

1. **Feedback Bottleneck:** Limited time to provide detailed feedback on student circuit designs
2. **Varying Preparation:** Students entered with different levels of electronics background
3. **Troubleshooting Delays:** Students often waited days for help with circuit problems
4. **Self-Assessment Limitations:** Students struggled to diagnose their own design flaws
5. **Documentation Quality:** Technical reports often lacked appropriate detail and clarity

## Implementation Goals

The integration of Claude aimed to:

1. Provide rapid preliminary feedback on circuit designs
2. Develop students’ circuit troubleshooting skills
3. Improve the quality of technical documentation
4. Support varying levels of student preparation
5. Free instructor time for higher-level guidance

## Implementation Process

### Phase 1: Faculty Preparation (Summer before semester)

1. **Tool Selection and Exploration:**
	* Tested multiple AI tools for technical accuracy in electronics domain
	* Selected Claude for its stronger ability to analyze circuit diagrams
	* Created Claude Pro account for advanced features
	* Developed prompt templates for circuit feedback
	* Tested limitations with complex analog circuits
2. **Feedback Framework Development:**
	* Created rubric for distinguishing AI vs. instructor feedback roles
	* Developed circuit-specific prompting guides
	* Created sample circuits with common errors for testing
	* Established process for validating AI feedback accuracy
3. **Integration Planning:**
	* Redesigned lab workflow to incorporate AI feedback steps
	* Created documentation requirements for AI interactions
	* Developed training materials for students
	* Updated grading criteria to include evaluation of AI-assisted revisions

### Phase 2: Student Onboarding (First two weeks)

1. **Introduction Session:**
	* 50-minute workshop on using Claude for circuit analysis
	* Demonstration of uploading circuit diagrams and schematics
	* Example prompts for different types of circuit feedback
	* Discussion of Claude’s limitations with analog circuits
2. **Guided Practice:**
	* Provided sample circuit with intentional errors
	* Students practiced getting and evaluating Claude feedback
	* Instructor-led discussion of response quality and limitations
	* Compared Claude’s feedback with instructor feedback
3. **Feedback Literacy Development:**
	* Trained students to critically evaluate AI feedback
	* Emphasized verification using simulation and first principles
	* Discussed complementary roles of AI and instructor feedback
	* Created guidelines for documenting AI assistance

### Phase 3: Integration Throughout Semester

1. **Structured Feedback Process:**
	* Students submitted initial circuit designs for weekly labs
	* Used Claude to get preliminary feedback before submission
	* Documented Claude’s feedback and their response to it
	* Instructor provided higher-level feedback focusing on areas beyond AI capabilities
2. **Progressive Implementation:**
	* Early labs: Basic amplifier circuits with guided prompts
	* Mid-semester: Filter circuits with student-developed prompts
	* Later labs: Complex systems with integrated troubleshooting
3. **Documentation and Reflection:**
	* Students maintained logs of Claude interactions including:
		+ Circuit design challenges faced
		+ Prompts used (including iterations)
		+ Evaluation of Claude’s feedback
		+ Actions taken based on feedback
		+ Verification methods used

## Implementation Examples

### Example 1: Structured Feedback Workflow

**Lab Assignment Component:** > Before submitting your final amplifier design, complete the following AI-assisted review process: > > 1. Upload your circuit schematic to Claude > 2. Use the “Circuit Analysis Prompt” to get initial feedback > 3. Implement any corrections you agree with and document your changes > 4. If you disagree with any AI feedback, explain why using circuit theory > 5. Include both the original feedback and your revision process in your lab report

**Student Prompt Template:**

I'm an electrical engineering student designing a common-emitter amplifier circuit.
Please analyze this circuit schematic and provide feedback on:

[Student uploads circuit diagram]

1. Biasing stability and operating point analysis
2. Small-signal gain calculation review
3. Potential issues with component values chosen
4. Suggestions for improving performance
5. Any errors you can identify in my circuit topology

For each point, please explain the relevant principles from analog electronics
and cite specific components/connections in my design.

### Example 2: Troubleshooting Assistant

**Troubleshooting Workflow:** 1. Students encountering circuit issues documented symptom 2. Uploaded circuit and measurement results to Claude 3. Used troubleshooting prompt to get diagnostic suggestions 4. Tested suggestions methodically and documented results 5. Reflected on troubleshooting process in lab notebook

**Troubleshooting Prompt Example:**

I'm troubleshooting a two-stage BJT amplifier circuit that isn't working as expected.

Circuit schematic: [Student uploads circuit diagram]

Expected behavior: Output gain of approximately 65dB, bandwidth from 100Hz to 10kHz

Observed behavior: Very low gain (around 20dB) and significant distortion at input
signals above 10mV.

Measurements taken:
- DC voltage at collector of Q1: 1.2V (expected 6V)
- DC voltage at base of Q1: 0.7V
- DC voltage at emitter of Q1: 0.1V
- DC voltage at collector of Q2: 8.4V (expected 6V)

Please:
1. Analyze the potential causes of this behavior
2. Suggest 3-5 specific measurements I should take next
3. Identify likely problem areas in the circuit
4. Explain the relationship between my symptoms and possible causes

### Example 3: Enhanced Technical Documentation

**Documentation Improvement Workflow:** 1. Students drafted technical documentation for labs 2. Used Claude to analyze clarity and completeness 3. Received suggestions for improving technical communication 4. Revised documentation with enhanced descriptions 5. Reflected on improvements to communication skills

**Documentation Enhancement Prompt:**

I've written the Analysis section of my lab report for an active bandpass filter
circuit. Please review my technical writing and provide feedback on:

[Student pastes their technical writing]

1. Clarity of technical explanations
2. Completeness of circuit analysis
3. Appropriate use of technical terminology
4. Logical flow of the analysis
5. Any missing critical information

For each suggestion, explain why it would improve the technical communication.
Focus on helping me communicate circuit behavior more precisely.

## Assessment Strategy

### Evolving Assessment Approach

#### Before AI Integration: Traditional Lab Grading

* Circuit design correctness (40%)
* Circuit performance (25%)
* Technical documentation (25%)
* Lab procedure completion (10%)

#### After AI Integration: Process-Focused Assessment

* Initial circuit design (20%)
* AI feedback evaluation and response (20%)
* Revised circuit quality and performance (25%)
* Technical documentation with process reflection (25%)
* Troubleshooting methodology (10%)

### Evaluation Criteria for AI Use

Dr. S developed specific criteria for evaluating appropriate AI use:

1. **Feedback Quality Assessment:** Ability to distinguish valid vs. questionable AI feedback
2. **Technical Verification:** Use of simulation or calculation to verify AI suggestions
3. **Iterative Improvement:** Strategic refinement of designs based on feedback
4. **Documentation Clarity:** Quality of explanations about design decisions
5. **Process Reflection:** Insights on effective collaboration with AI tools

## Potential Outcomes and Considerations

### Expected Benefits

* More rapid feedback cycles and iterative improvement
* Increased student independence in troubleshooting
* Improved technical communication skills
* More equalized experience for students with varied backgrounds
* Instructor time redirected to complex conceptual guidance
* Better preparation for industry practice

### Potential Challenges

* Risk of over-reliance on AI without verification
* Possible misdiagnosis of subtle analog circuit issues
* Variable student proficiency in prompt engineering
* Additional time required to document AI interactions
* Occasional misunderstandings of complex analog behavior

## Faculty Implementation Considerations

### Key Implementation Strategies

1. **Rapid feedback cycles** to enable more iteration and learning
2. **Critical evaluation** of AI feedback to build stronger circuit intuition
3. **Consistent documentation format** for tracking design decisions
4. **Troubleshooting support** to reduce student frustration
5. **Reallocation of instructor time** to more complex issues

### Important Considerations

1. **Technical validation is essential** - AI can make confident but incorrect analyses
2. **Variable accuracy with analog circuits** - better with digital, less reliable with complex analog
3. **Need for circuit-specific prompt training** - general prompts produced generic responses
4. **Value of intentional limitations** - restricting AI use in some contexts improved learning
5. **Importance of reflection** - metacognitive benefits were as valuable as technical ones

### Future Refinement Directions

If implementing such an approach, consider: 1. Creating a structured prompt library specifically for different circuit topologies 2. Developing validation protocols for analog circuit feedback 3. Incorporating industry perspectives on AI-assisted circuit design 4. Adding comparative exercises contrasting AI and human analysis abilities 5. Creating advanced troubleshooting scenarios that combine AI and traditional methods

## Resources Developed

1. **Circuit-Specific Prompt Library:** Templates for different analog circuits
2. **AI Interaction Documentation Template:** Standard format for recording feedback
3. **Validation Checklist:** Methods to verify AI feedback accuracy
4. **Error Analysis Guide:** Common AI misunderstandings in analog circuit analysis
5. **Technical Writing Enhancement Prompts:** Templates for documentation improvement

## Implementation Advice

### For Faculty Considering Similar Integration:

1. **Start with clearly defined circuit types** where AI performs more reliably
2. **Teach verification methods** alongside AI integration
3. **Use a progressive disclosure approach** to gradually reduce prompting guidance
4. **Leverage AI for first-pass feedback** but maintain instructor final review
5. **Emphasize process documentation** to make learning visible

### Technical Considerations:

1. Claude Pro account provides better image analysis capabilities for circuit diagrams
2. Circuit diagrams should be clear, high-resolution, and properly labeled
3. Complex analog circuits require more careful verification
4. Create a reference library of known circuit types and AI responses
5. Periodically validate AI responses against instructor expertise

*This case study was developed as part of the “Strategies for Integrating Generative AI in Engineering Education” workshop materials in collaboration with Claude-3.7 Sonnet.*