

ELEX 3120/3321: Electric Circuits 2

LAB 5 - Instrumentation Amplifier

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Table of Contents

[1 Introduction 3](#_Toc180844478)

[2 Design 3](#_Toc180844479)

[2.1 Instrumentation Amplifier Design Equations 3](#_Toc180844480)

[2.2 Instrumentation Amplifier Circuit Implementation 3](#_Toc180844481)

[2.3 Pre-lab MATLAB Code 4](#_Toc180844482)

[3 Test Amplifier 4](#_Toc180844483)

[4 Calibrate Amplifier for Coins 4](#_Toc180844484)

[5 Verify Operation 4](#_Toc180844485)

[6 Conclusions 5](#_Toc180844486)

Table of Figures

[Figure 1 - Instrumentation Amplifier Circuit LTSpice Schematic 3](#_Toc180844487)

Table of Tables

[Table 1 – Output Voltage Value under Maximum and Minimum Gain 4](#_Toc180844493)

[Table 2 - Voltage Output for Coins Sequence 0-4 5](#_Toc180844494)

# Introduction

This lab involves designing and testing an instrumentation amplifier to read small signals from a load cell in a coin-counting setup. The amplifier, with a target gain of 1000–2000 V/V, uses a Wheatstone bridge configuration to measure voltage changes due to weight variations. Using MATLAB, the amplifier output is processed in real-time to display the corresponding coin count, demonstrating precision amplification and calibration techniques.

# Design

## Instrumentation Amplifier Design Equations

Stage Two:

Stage One:

## Instrumentation Amplifier Circuit Implementation



Figure 1 - Instrumentation Amplifier Circuit LTSpice Schematic

## Pre-lab MATLAB Code

% Initialize DAQ session

daqSession = daq.createSession('ni');

daqSession.addAnalogInputChannel('myDAQ1', 'ai0', 'Voltage');

daqSession.Rate = 10; % set data acquisition rate

% Calibration parameters

calibrationVoltagePerCoin = 0.1; % Voltage equivalent per coin (V)

% Infinite loop to continuously check coin count

while true

voltageReading = daqSession.inputSingleScan(); % Read voltage from DAQ

coinValue = 2 \* round(voltageReading / calibrationVoltagePerCoin); % Calculate number of coins

if coinCount < 0

coinCount = 0; % Ensure no negative coin counts

end

% Display the output

fprintf('Voltage: %.2f V, Coins Value: %d$\n', voltageReading, coinValue);

pause(1); % Pause for specified interval before the next reading

end

# Test Amplifier

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Predicted (equation) | Predicted (equation) | Predicted (LTSpice) | Measured | Measured |
| Av(V/V) | Rg(kΩ) | Vout [V] | Vout [V] | Rg(kΩ) | Vout [V] |
| 1000 | 6.61 | 5 | 4.98 | 6.61 | 6.37 |
| 2000 | 3.305 | 10 | 9.78 | 3.31 | 10.52 |

Table 1 – Output Voltage Value under Maximum and Minimum Gain

% Initialize DAQ session

daqSession = daq.createSession('ni');

daqSession.addAnalogInputChannel('myDAQ1', 'ai0', 'Voltage');

daqSession.Rate = 10; % set data acquisition rate

% Calibration parameters

calibrationVoltagePerCoin = 0.1; % Voltage equivalent per coin (V)

% Infinite loop to continuously check coin count

while true

voltageReading = daqSession.inputSingleScan(); % Read voltage from DAQ

coinValue = 2 \* round(voltageReading / calibrationVoltagePerCoin); % Calculate number of coins

if coinCount < 0

coinCount = 0; % Ensure no negative coin counts

end

% Display the output

fprintf('Voltage: %.2f V, Coins Value: %d$\n', voltageReading, coinValue);

pause(1); % Pause for specified interval before the next reading

end

# Calibrate Amplifier for Coins

voltage: 0.01 V, Coins Value: 0$

Voltage: 0.01 V, Coins Value: 0$

Voltage: -0.02 V, Coins Value: 0$

Voltage: 0.02 V, Coins Value: 0$

Voltage: 0.02 V, Coins Value: 0$

Voltage: 0.04 V, Coins Value: 0$

Voltage: 0.05 V, Coins Value: 2$

Voltage: 0.05 V, Coins Value: 2$

Voltage: 0.07 V, Coins Value: 2$

Voltage: 0.08 V, Coins Value: 2$

Voltage: 0.11 V, Coins Value: 2$

Voltage: 0.10 V, Coins Value: 2$

Voltage: 0.11 V, Coins Value: 2$

Voltage: 0.12 V, Coins Value: 2$

Voltage: 0.15 V, Coins Value: 4$

Voltage: 0.17 V, Coins Value: 4$

Voltage: 0.17 V, Coins Value: 4$

Voltage: 0.17 V, Coins Value: 4$

Voltage: 0.16 V, Coins Value: 4$

Voltage: 0.16 V, Coins Value: 4$

Voltage: 0.17 V, Coins Value: 4$

Voltage: 0.20 V, Coins Value: 4$

Voltage: 0.22 V, Coins Value: 4$

Voltage: 0.25 V, Coins Value: 6$

Voltage: 0.28 V, Coins Value: 6$

Voltage: 0.30 V, Coins Value: 6$

Voltage: 0.30 V, Coins Value: 6$

Voltage: 0.31 V, Coins Value: 6$

Voltage: 0.30 V, Coins Value: 6$

Voltage: 0.31 V, Coins Value: 6$

Voltage: 0.30 V, Coins Value: 6$

Voltage: 0.31 V, Coins Value: 6$

Voltage: 0.34 V, Coins Value: 6$

Voltage: 0.36V, Coins Value: 8$

Voltage: 0.38 V, Coins Value: 8$

Voltage: 0.40 V, Coins Value: 8$

Voltage: 0.42 V, Coins Value: 8$

Voltage: 0.43 V, Coins Value: 8$

Voltage: 0.41 V, Coins Value: 8$

Voltage: 0.40 V, Coins Value: 8$

Voltage: 0.40 V, Coins Value: 8$

Voltage: 0.40 V, Coins Value: 8$

Voltage: 0.40 V, Coins Value: 8$

Voltage: 0.41 V, Coins Value: 8$

# Verify Operation

|  |  |
| --- | --- |
| Coins | Vout[V] |
| 0 | 0.01 |
| 1 | 0.12 |
| 2 | 0.22 |
| 3 | 0.31 |
| 4 | 0.41 |

Table 2 - Voltage Output for Coins Sequence 0-4

# Conclusions The lab successfully implemented an instrumentation amplifier with adjustable gain for precise signal conditioning of a load cell in a coin-counting application. The amplifier output accurately reflected the number of coins, confirming correct design and calibration. This experiment provided practical experience with instrumentation amplifiers, load cells, and real-time data acquisition, crucial for accurate measurement in low-signal applications.