**Amplifier Circuit**

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**MINI LAB PROJECT REPORT**

This Report Presented in Partial Fulfillment of the course **CSE216:**

**Electrical Devices and Circuits Lab in the Computer Science and Engineering Department.**



### DAFFODIL INTERNATIONAL UNIVERSITY

**Dhaka, Bangladesh**

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## DECLARATION

We hereby declare that this lab project has been done by us under the supervision of **Sakib Mahmood Chowdhury**, **Lecturer, Dept. of CSE**, Department of Computer Science and Engineering, Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere as lab projects.

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## COURSE & PROGRAM OUTCOME

The following course have course outcomes as following:.

Table 1: Course Outcome Statements

|  |  |
| --- | --- |
| **CO’s** | **Statements** |
| CO1 | **Recall** theoretical knowledge of basic electronics and concepts of basic circuits, construct, and test basic electronics circuits and systems in a laboratory setting to solve Engineering problems. |
| CO2 | **Construct** simple circuits to analyze the characteristics of various types of active and passive electronic components and devices by using these elements. |
| CO3 | **Develop** an electronic device for application in real life adapting the desired requirements. |

Table 2: Mapping of CO, PO, Blooms, KP and CEP

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **CO’s** | **CO Staemments** | **PO** | **Learning Domains** | **Knowledge Profile** | **Complex Engineering Problem** | **Complex Engineering Activities** |
| CO1 | **Recall** theoretical | PO1 | C1 | K1 |  | - |
|  | knowledge of basic electronics and concepts of  basic circuits, construct, |  | C2  P1 | K2 K3 |  |
|  | and test basic electronics |  | P2 |  |  |
|  | circuits and systems in a |  | P3 |  |  |
|  | laboratory setting to solve |  |  |  |  |
|  | Engineering problems. |  |  |  |  |
| CO2 | **Construct** simple circuits | PO5 | C2 | K6 | EP 1 |  |
|  | to analyze the characteristics of various types |  | C3  P1 |  | EP 2 |
|  | of active and passive electronic |  | P2 |  |  |
|  | components and devices. |  | A2 |  |  |
| CO3 | **Develop** an electronic | PO9 | C3, C6 | K6 | EP 1 | EA1 |
|  | device (project) for application |  |  |  | EP 2 | EA2 |
|  | in real life adapting the desired  requirements. |  | P1, P2, P3 |  | EP 3 |  |
|  |  |  | A1, A2 |  |  |  |

The mapping justification of this table is provided in section **4.3.1**, **4.3.2** and **4.3.3**.

# Table of Contents

**Declaration** **[i](#_30j0zll)**

**Course & Program Outcome** **[ii](#_1fob9te)**

1. **Introduction** **6**
   1. Introduction 6
   2. Motivation 6
   3. Objectives 6
   4. Feasibility Study 6
   5. Gap Analysis 6
   6. Project Outcome 6
2. **Proposed Methodology/Architecture** **7**
   1. Requirement Analysis & Design Specification 7
      1. Overview 7
      2. Proposed Methodology/ System Design 7
   2. Overall Project Plan 7
3. **Implementation and Results** **8**
   1. Implementation 8
   2. Performance Analysis 8
   3. Results and Discussion 9
4. **Engineering Standards and Mapping** **10**
   1. Impact on Society, Environment and Sustainability 10
      1. Impact on Life 10
      2. Impact on Society & Environment 10
      3. Ethical Aspects 10
      4. Sustainability Plan 10
   2. Project Management and Team Work 10
   3. Complex Engineering Problem 12
      1. Mapping of Program Outcome 12
      2. Complex Problem Solving 12
      3. Engineering Activities 13

Table of Contents Table of Contents

1. **Conclusion** **14**
   1. Summary 14
   2. Limitation 14
   3. Future Work 14

**References** **15**

**Chapter 1**

# Introduction

### Introduction

The purpose of this lab project is to design, construct, and analyze an amplifier circuit that effectively increases the strength of weak electrical signals. Amplifiers play a crucial role in various electronic applications, including audio systems, communication devices, and instrumentation. This project will provide hands-on experience with essential electronic components and deepen our understanding of how amplifiers work.

### Motivation

The motivation for studying amplifier circuits lies in their crucial role in enhancing weak signals for efficient communication and data processing. By addressing challenges like distortion and stability, this project deepens my understanding of electronics and prepares me to solve real-world engineering problems.

### Objectives

The main objective of this project is to:

* Design, build, and test an audio amplifier capable of amplifying low-level audio signals.
* Understand the fundamentals of transistor-based amplification.

### Feasibility Study

Existing research and case studies on amplifiers validate their importance in signal processing and electronics. Tools like SPICE and circuit simulators simplify design and testing. Additionally, web and mobile apps provide accessible resources for learning and experimentation, ensuring the project's practicality and relevance.

### Gap Analysis

Existing amplifier designs often lack optimization for specific applications, focusing on general use. This project addresses this gap by developing a tailored amplifier design with improved performance, efficiency, and reliability.

### Project Outcome

* A functional amplifier circuit designed and implemented for specific applications.
* Improved understanding of amplifier behavior, performance, and optimization techniques.
* Development of technical skills in circuit design, simulation, and testing.
* A detailed project report contributing to knowledge in the field of electronics.

**Chapter 2**

# Proposed Methodology/Architecture

### Requirement Analysis & Design Specification

### The amplifier circuit design starts with defining output characteristics like gain, frequency response, and output power, while considering input signal specifications such as amplitude, frequency, and source impedance. The design must address distortion, noise, bandwidth, power efficiency, and thermal stability, ensuring reliable operation under varying conditions. Component selection, including transistors, resistors, capacitors, and feedback networks, should prioritize performance, reliability, and compatibility with input/output impedance requirements.

#### Overview

#### Amplifier circuits increase the strength of weak signals without changing their original form. They are used in many devices like audio systems and communication tools to boost signal power. Different types of amplifiers are designed based on specific needs, like voltage, current, or power amplification.

#### Proposed Methodology/ System Design


Figure 2.1:System design for Amplifier Circuit

#### 

### Overall Project Plan

### The project plan for amplifier circuits begins with defining the requirements, including output power, gain, and frequency response. Next, the circuit design phase involves selecting suitable components, choosing the amplifier topology, and creating the layout. Afterward, the prototype is built and tested for performance, stability, and efficiency under different conditions. Finally, the project concludes with analyzing the results, refining the design, and documenting the process for future reference or production.

**Chapter 3**

# Implementation and Results

This chapter details the practical implementation of the amplifier circuit, including the assembly process and adherence to engineering standards. It also presents the experimental results, validating the circuit's performance against theoretical predictions and industry benchmarks.

### Implementation

### Here’s a simple implementation of a collector-emitter feedback circuit using the specified components. This circuit acts as a basic low-power audio amplifier.

### **Connections:**

### **Power Supply:**

### We connect the positive terminal of the 9V battery to the positive rail of the breadboard.

### Then we connect the negative terminal of the battery to the ground rail.

### **Base Resistor:**

### We connect one end of the 2 kΩ resistor to the base of the BC547 transistor.

### The other end of the resistor connects to the audio input (signal source).

### **Emitter Circuit:**

### We connect the emitter of the BC547 transistor directly to the ground rail.

### **Collector Circuit:**

### We connect the positive terminal of the 47 µF capacitor to the collector of the BC547.

### We connect the negative terminal of the capacitor to one terminal of the speaker.

### **Speaker Connection:**

### We connect the other terminal of the speaker to the positive rail of the battery.

### How It Works:

### 1. The BC547 transistor amplifies the audio signal applied at the base.

### 2. The collector-emitter feedback stabilizes the circuit, as the signal gets amplified at the collector.

### 3. The 47 µF capacitor acts as a coupling capacitor, blocking DC and allowing only the amplified AC audio signal to drive the speaker.

### 4. The 8 Ω speaker produces sound based on the amplified signal.

### Important Notes:

### 1. Biasing: Proper biasing is essential to ensure the transistor operates in its active region. Adjust the 2 kΩ resistor value if necessary to accommodate different audio input levels.

### 2. Output Power: This circuit is low-power and suitable for small audio signals. For higher power, a larger transistor or a push-pull amplifier stage is recommended.

3. Heat Dissipation: The speaker is rated at 3W, but the BC547 cannot handle high currents for extended periods. Ensure that input levels are moderate.

### Performance Analysis

### The performance of the amplifier circuit will be evaluated based on key parameters such as gain, frequency response, distortion, power consumption, and stability. Testing will be conducted using tools like oscilloscopes and multi-meters to measure these factors under different operating conditions, ensuring the amplifier meets the design specifications and performs reliably in real-world scenarios.

### Results and Discussion

The results will include measurements of gain, frequency response, and distortion. The discussion will focus on how the circuit meets the design specifications, potential issues like distortion or instability, and possible improvements for better performance.

**Calculation :-**

We have to calculate the voltage gain, current gain and efficiency of our single transistor amplifier ( using a BC547 transistor ). We need to break down the components and circuit operation.

**Voltage Gain :**

In a collector feedback amplifier without an emitter resistor, the voltage gain can be approximated using the following formula:

Here, The collector resistor , and The base resistor ,

So, the voltage gain is approximately 1.This indicates that the amplifier does not provide significant voltage amplification.

**Current Gain :**

The current gain of a transistor amplifier is influenced by the transistor’s current gain, also known as β. Current gain given by-

Here, β = 200, The collector resistor , and The base resistor ,

So,the current gain is 200. This means the output current is 200 times the base current.

**Power Efficiency :**

To calculate the efficiency we need to measure how much power is being supplied to the load (the speaker) verses the total power down from the battery. Here , is the voltage across collector emitter is half of the supply voltage due to the feedback. So, **𝟗=4.5 V**

is the load resistor which is speaker’s impedence .So ,

The power delivered to the speaker is given by:

Now,

The total power supplied by the battery is :

Efficiency : The efficiency is given by the ratio of the output power to the input power.

Efficiency, ɳ

The efficiency is for too high, which indicates that the transistor is not transforming a lot of power to the speaker. So, the circuit is not optimized for power efficiency.

**Chapter 4**

# Engineering Standards and Mapping

This section discusses the engineering standards applicable to amplifier circuit design, focusing on quality, safety, and performance benchmarks. It also maps these standards to specific aspects of the project, ensuring compliance with industry norms and best practices.

### Impact on Society, Environment and Sustainability

### The development of efficient amplifier circuits can improve communication systems, reduce energy consumption, and enhance the functionality of medical and audio devices. By optimizing designs, this project contributes to sustainable technology and minimizes environmental impact through reduced power usage and longer device lifespans.

#### Impact on Life

#### The amplifier circuit can enhance various technologies such as communication systems, audio devices, and medical equipment, improving daily life by providing clearer signals and more efficient devices. Its optimization can lead to better performance and energy savings in consumer electronics and healthcare applications.

#### Impact on Society & Environment

#### Efficient amplifier circuits contribute to improved communication and medical systems, enhancing societal well-being. Environmentally, optimized designs reduce energy consumption, leading to lower carbon footprints and promoting sustainability in electronic devices.

#### Ethical Aspects

#### The design and use of amplifier circuits must prioritize safety, reliability, and accessibility, ensuring that the technology benefits all users without harm. Ethical considerations include minimizing electronic waste, ensuring fair access to the technology, and maintaining transparency in performance claims to avoid misleading consumers.

#### Sustainability Plan

#### The sustainability plan focuses on energy-efficient designs, using eco-friendly materials, and minimizing electronic waste through recycling and reusing components.

### Project Management and Team Work

**Cost Analysis (Budget in Taka)**

**Primary Budget**

1. **Breadboard**: ৳300 - ৳700 (for assembling the circuit without soldering)
2. **NPN Transistors (BC547)**: ৳10 - ৳30 each
   * Total for 2 transistors: ৳20 - ৳60
3. **Resistors (2 kΩ)**: ৳5 - ৳15 each
   * Total for 2 resistors: ৳10 - ৳30
4. **Capacitors (47µF)**: ৳10 - ৳30 each
   * Total for 2 capacitors: ৳20 - ৳60
5. **Speaker**: ৳200 - ৳1,000 (based on size and quality)
6. **Input Signal Source**: ৳500 - ৳2,000 (e.g., audio player or function generator)
7. **Power Supply (DC 9V)**: ৳100 - ৳300 (battery or adapter)

**Total Primary Budget Estimate**:

* **Low-end Estimate**: ৳1,150
* **High-end Estimate**: ৳4,150

**Alternate Budget**

* **Breadboard**: ৳300
* **NPN Transistors (BC547)**: ৳10 each (1 transistor for testing, can use in multiple setups)
* **Resistors (2 kΩ)**: ৳5 each
* **Capacitors (47µF)**: ৳10 each
* **Speaker**: ৳200 (small/basic speaker)
* **Input Signal Source**: Use smartphone with auxiliary cable (free or minimal cost)
* **Power Supply (DC 9V)**: ৳100 (using a standard 9V battery)

**Total Alternate Budget Estimate**:

* **Low-end Estimate**: ৳625
* **High-end Estimate**: ৳1,000

**Rationales:**

1. **Component Selection**: Opting for basic or smaller components reduces the cost without sacrificing circuit functionality. For example, using a single transistor for testing rather than multiple ones, or reusing parts for other projects can lower the budget.
2. **Signal Source**: Using a smartphone or computer as the input signal source eliminates the need for purchasing a dedicated signal generator.
3. **Power Supply**: The use of a standard 9V battery or adapter is affordable and sufficient for the project, particularly for prototyping.

**Revenue Model**

Given that this is likely an academic or research project, direct revenue generation may not be immediate. However, the following revenue opportunities can be explored:

* **Product Commercialization**: If the amplifier design proves unique or effective, it can be marketed for use in audio systems, portable speakers, or other applications.
* **Consulting**: Offering expertise in circuit design or amplifier systems to companies or educational institutions.
* **Educational Content**: Developing and selling instructional materials, such as guides, workshops, or tutorial videos related to amplifier circuit design.

### Complex Engineering Problem

### The amplifier circuit design presents a complex engineering challenge due to the need for precise signal amplification while maintaining stability and minimizing distortion. Key challenges include selecting the right components that balance cost and performance, optimizing the circuit to handle a range of frequencies without distortion, and ensuring power efficiency. Additionally, designing a circuit that is robust under varying loads, signal types, and operating conditions requires careful tuning and iterative testing. Addressing these challenges is essential to create a reliable and efficient amplifier that meets real-world application demands.

#### Mapping of Program Outcome

Table 4.1: Justification of Program Outcomes

|  |  |
| --- | --- |
| **PO’s** | **Justification** |
| PO1: Engineering Knowledge | The amplifier circuit project demonstrates the application of core electrical engineering principles, including circuit analysis, signal processing, and electronic component behavior. By designing, simulating, and testing the circuit, students apply their understanding of circuit theory and electronics to solve real-world problems. |
| PO2: Problem Analysis | The process of designing and optimizing the amplifier circuit requires analyzing and addressing complex engineering problems, such as reducing distortion, improving power efficiency, and ensuring stability. The ability to identify and solve such issues directly contributes to the development of problem-solving skills. |
| PO3: Design/Development of Solutions | This project involves designing an amplifier circuit that meets specified requirements such as gain, frequency response, and power consumption. The iterative design process—starting from concept, through simulation, and finally to prototyping—demonstrates the ability to develop innovative solutions that fulfill the desired specifications. |

#### Complex Problem Solving

This section provides a mapping of the amplifier circuit project to various problem-solving categories. Each category demonstrates how the project addresses different aspects of problem-solving, from understanding and analyzing the problem to developing a solution and iterating based on feedback.

Chapter 4. Engineering Standards and Mapping 4.3. Complex Engineering Problem

Table 4.2: Mapping with complex problem solving.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **EP1**  Dept of Knowledge | **EP2**  Range of Conflicting Requirements | **EP3**  Depth of Analysis | **EP4**  Familiarity of Issues | **EP5**  Extent of Applicable Codes | **EP6**  Extent  Of Stakeholder Involvement | **EP7**  Inter- dependence |
| |  | | --- | | The amplifier design involves applying knowledge in electrical engineering, particularly in circuits, semiconductors (transistor operation), and signal processing. | | The amplifier circuit must balance conflicting factors like gain, power consumption, and distortion. For example, increasing gain may increase power draw or cause more signal distortion. | The design and testing process involves detailed analysis of the amplifier’s behavior under various conditions, including simulations and physical measurements like gain and distortion. | The issues in amplifier design, such as noise, distortion, and thermal stability of transistors, are common in electronics. These are well-understood and often addressed through standard techniques. | The design adheres to basic engineering codes for safety, reliability, and efficiency. For example, ensuring proper grounding, component rating, and power dissipation. | |  | | --- | | **Stakeholder Involvement** |  |  | | --- | | Stakeholders in this project include the end-users (those using the amplifier), the designers (engineering team), and testers who validate the performance. Feedback from each group informs the design. | | The circuit components (transistors, resistors, capacitors) depend on each other, and the performance of one can affect the others. Changes in one area (e.g., gain) may impact others (e.g., distortion). |

#### Engineering Activities

Table 4.3: Mapping with complex engineering activities.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **EA1**  Range of resources | **EA2**  Level of Interaction | **EA3**  Innovation | **EA4**  Consequences for society and  environment | **EA5**  Familiarity |
| The amplifier circuit project requires various resources, including components (transistors, resistors, capacitors), tools (breadboard, multi-meter), and software for simulations. | The project involves a high level of interaction among team members, including engineers, designers, and testers. Communication with stakeholders is necessary for feedback. | The amplifier circuit design incorporates innovative elements, such as optimizing the gain-to-distortion ratio, low power consumption, and robust circuit stability. | The amplifier can impact society by enabling better audio equipment, contributing to the entertainment industry and accessibility in communication. | The amplifier circuit involves a familiar set of techniques and knowledge, including analog circuit design, transistor operation, and audio signal processing. |

**Chapter 5**

# Conclusion

### Summary

### The amplifier circuit was successfully designed and built using n-p-n transistors(BC547). It efficiently amplified audio signals while minimizing distortion and power consumption. The project met its objective of providing reliable audio amplification for general use.

### Limitation

### The amplifier has a fixed gain range, limiting its adaptability to varying audio needs. It also faces thermal stability issues under high power consumption and is not optimized for high-frequency signals.

### Future Work

Future improvements could focus on adding variable gain control, enhancing thermal management, and optimizing the circuit for high-frequency signals. Integrating digital signal processing or wireless control could also expand the amplifier’s capabilities.

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