THE GEORGE WASHINGTON UNIVERSITY

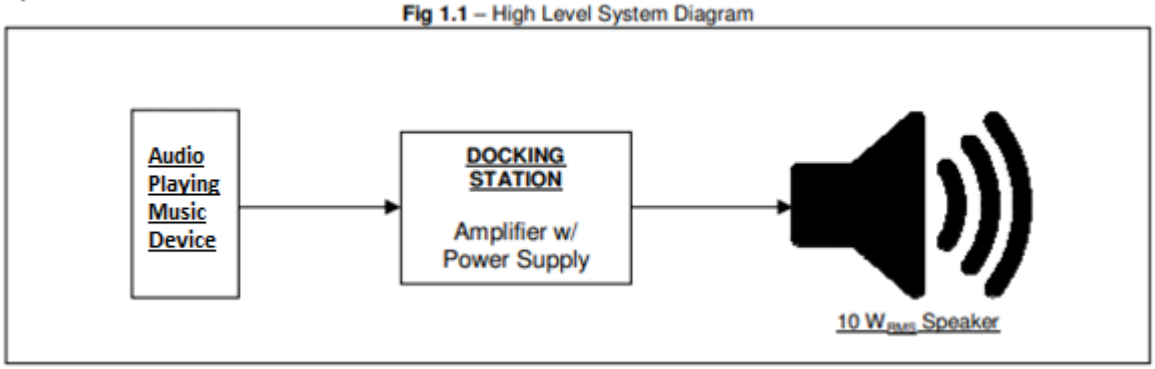
WASHINGTON, DC

School of Engineering and Applied Science
Department of Electrical and Computer Engineering
ECE 2115 - Final Project

Project Description:

You have been hired at Apple Computer Inc. as a summer intern. You have been asked to design an inexpensive music docking station to be sold during the holiday season. Essentially, your task is to design and build a music amplifier, with a power supply, that will meet the specifications below.

Fig 1.1 – High Level System Diagram



Specifications

- Power supply: 120 V_{RMS} at 60 Hz.
- Input Signal (v_{in}, not v_{sig}) = 350mV_{RMS}, frequency: entire audio frequency range
- Load: 8Ω speaker
- Output Power: **10** W_{RMS} +/- 10%
- Volume Control Required
- LED indicator for Power Supply

Requirements

- At minimum, a 2-stage amplifier design must be employed
- A Darlington Configuration for the output stage is suggested to achieve output power requirement

Extra Credit

- FET/BJT Darlington output stage
- Class AB (Push-Pull) output stage
- Class AB (Push-Pull) using Darlington configuration

Due Dates

- (NEW DATE) - Initial Project Calculations & simulations
- (NEW DATE) (tentative) - Project Demonstration, Oral Presentation, Written Report

Project Demonstration

- Circuit will be tested using function generator (Wavegen) set at 350mV_{RMS} at 3 frequencies: 440Hz, 1kHz, 10kHz to verify output power with oscilloscope
- Verification of volume control will be performed
- Amplifier will then be tested using music, grade for clarity of sound will be given.

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Oral Presentation

- 10-minute presentation with 5-minute question and answer period. All presentations must be done using MS Power Point.
  - Recommended structure of oral report is as follows:
    - System Architecture Overview
      - •Discuss the stages of each part of the design
    - Initial Calculations (similar to tutorial #7)
      - •Discuss the Rin/Rout for each stage in the design
      - •Discuss the selection of VCC
      - •Discuss the selection of transistors (using SPEC sheet data)
      - •Discuss the initial output voltage and current swing's you've calculated to reach the specified goals
      - •*You are basically walking viewer through your design process*
    - Design of each stage
      - •Why did you choose the type of output stage you chose?
      - •Hand Calculations (bias voltage/currents, Resistor values, Capacitor values)
      - •SPICE simulations showing bias point and transient simulation to verify simulations
    - Brief discussion on midterm power supply
      - •Treat design as a black box, you have already covered this in midterm project no need to explain each step. Just cover the basics (type of rectifier, input output voltage/current, load/ripple)
  - •Current/Voltage limitations – using SPEC sheet data
    - Implementation
      - •Picture of the final circuit
      - •Discuss measured Rin/Rout of each stage
      - •Discuss measured bias voltages
      - •Discuss/Show output voltage swing for each stage
      - •Discuss gain for each stage
    - Conclusions
      - • % error for measured data vs. hand calculated vs. simulated data
      - •How did your project compare to your calculations?
        - •What would you do differently? How could you improve your design?

Written Report

- A discussion of system architecture (the big picture), design decisions, Rin/Rout, should be discussed up-front
- Each stage of the project: Music Playing Audio Device, CE, CC, speaker, power supply should be given its own sub-section, show hand calculations, SPICE simulations, measured data for each component
- The entire amplifier should then be given a sub-section. Show expected input/output voltage/current swings, SPICE simulations, measured data for entire system
- Discuss the % error between hand/SPICE/measurements in each stage sub-section
- Discuss difficulties encountered, changes you'd make, lessons learned in the conclusion
- All hand calculations must be submitted as an appendix to your report

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Grading

- 50% Demonstration
- 25% Oral Report
- 25% Written Report

Extra Credit Criteria

- Extra Credit will be performed if and only if the following criteria have been met:
  - Advanced output stages (class AB, etc.) have successfully been implemented in the final project and are verified during demonstration.
  - Hand calculations, SPICE simulations, and demonstration have been performed.
  - Student can answer any and all questions regarding basic operation, and discuss calculations during oral presentation
- The reward for extra credit will be:
  - Dropping of lowest quiz grade
  - Dropping of two lowest lab report grades
- Students are forewarned from using output stage configurations that they do not fully understand; putting something together and it just "works" is unacceptable and will hurt your final grade.

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ECE 2115 - Final Project Grading Sheet

Student's Name: _____

=== CIRCUIT DEMONSTRATION (100pts total) ===

(student must have each item with circuit to show TA during demonstration)

Architecture/Setup

____(5pts) Students are able to discuss architecture (CE – CC, type of output stage etc.)

____(5pts) Student has characterized music source output impedance and speaker impedance

____(5pts) Student is able to explain (calculation/spice) output voltage (Vpeak) necessary to achieve $10Watt_{RMS}$ goal

Complete Amplifier

____(2.5pts) Student explains value v_{sig} must be to obtain $v_{in} = 350mV_{RMS}$ using function generator (in context to Rin of input stage of amplifier)

____(2.5pts) Student explains value v_{sig} must be to obtain $v_{in} = 350mV_{RMS}$ using music source (in context to Rin of input stage of amplifier)

Using VCC: Agilent E3631A DC Power Supply & Vsig = AD2 function generator (Wavegen)

____(5pts) Scope verifies target Vpeak across speaker for $v_{in} = 350mV_{RMS}$, 440Hz Tone

____(5pts) Scope verifies target Vpeak across speaker for $v_{in} = 350mV_{RMS}$, 1KHz Tone

____(5pts) Scope verifies target Vpeak across speaker for $v_{in} = 350mV_{RMS}$, 10KHz Tone

Using VCC: Agilent E3631A DC Power Supply & Vsig = Music Source – computer, etc.

____(5pts) Student explains what value v_{sig} must be to obtain $v_{in} = 350mV_{RMS}$ (in context to Rin of input stage of amplifier)

____(5pts) Scope verifies target Vpeak across speaker for $v_{in} = 350mV_{RMS}$, all 3 tones

____(5pts) Scope verifies target Vpeak across speaker for $v_{in} = 350mV_{RMS}$, tone = music

____(5pts) Music Clarity (distortion free, no clipping, etc.)

Using VCC: Midterm Power Supply & Vsig = any source

____(5pts) Scope verifies VCC = 12V/-12V, ripple at minimum

____(5pts) Scope verifies target Vpeak across speaker for $v_{in} = 350mV_{RMS}$, all 3 tones & music

____(5pts) If ripple too high to produce distortion free music, student explains why

Input Stage

____(5pts) Scope verifies that gain matches student calculation

____(5pts) Rin/Rout measured/verified

____(5pts) Quiescent Current verified/matches calculations

Output Stage

____(5pts) Scope verifies that gain matches student calculation

____(5pts) Rin/Rout measured/verified

____(5pts) Quiescent Current verified/matches calculation

____(Y/N) Extra Credit Attempted

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=== ORAL PRESENTATION (100 pts total) ===

System Architecture Overview

____(5pts) Discuss the stages of each part of the design Initial Calculations (similar to tutorial #7)

____(5pts) Discuss the Rin/Rout for each stage in the design

____(5pts) Discuss the selection of VCC

____(5pts) Discuss the selection of transistors (using SPEC sheet data)

____(5pts) Discuss the initial output voltage and current swing's you've calculated to reach the specified goals

Design of each stage

____(5pts) Why did you choose the type of output stage you chose?

____(5pts) Hand Calculations (bias voltage/currents, Resistor values, Capacitor values)

____(5pts) SPICE simulations showing bias point and transient simulation to verify simulations

Brief discussion on midterm power supply

____(5pts) Just cover the basics (type of rectifier, input output voltage/current, load/ripple)

____(5pts) Current/Voltage limitations – using SPEC sheet data

____(5pts) Ripple recalculated for Amplifier as load

Implementation

____(2.5pts) Picture of the final circuit

____(5pts) Discuss measured Rin/Rout of each stage

____(5pts) Discuss measured bias voltages

____(5pts) Discuss/Show output voltage swing for each stage

____(5pts) Discuss gain for each stage

Conclusions

____(5pts) % error for measured data vs. hand calculated vs. simulated data

____(5pts) How did your project compare to your calculations?

____(2.5pts) What would you do differently? How could you improve your design?

____(10pts) Students Overall Understanding of what he/she has designed and built

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