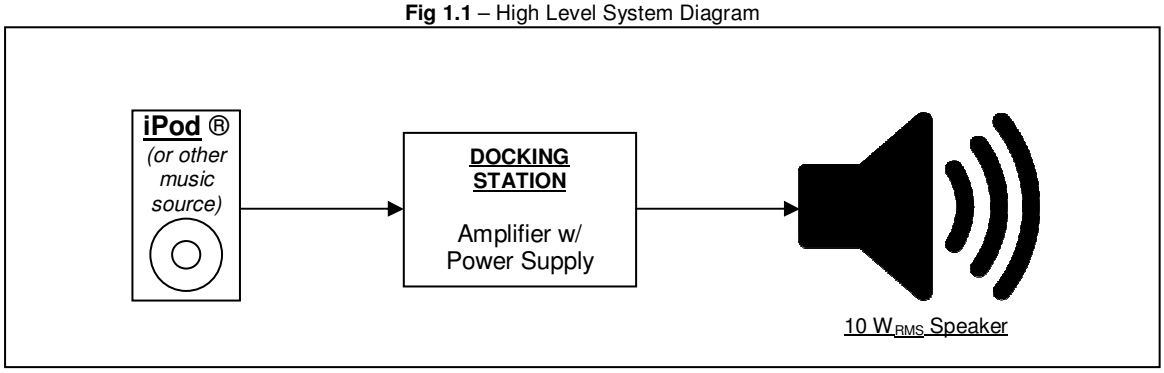
The George Washington University
School of Engineering and Applied Science
Department of Electrical and Computer Engineering
ECE 20 - Final Project

Project Description:

You have been hired at Apple Computer Inc. as a summer intern. You have been asked to design an inexpensive iPod® 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

- 12/4/08 - Initial Project Calculations & simulations
- 12/9/08 (tentative) - Project Demonstration, Oral Presentation, Written Report

Project Demonstration

- Circuit will be tested using function generator 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.

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've 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: iPod, 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 stages 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

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.

The George Washington University
School of Engineering and Applied Science
Department of Electrical and Computer Engineering

ECE 20 - 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) Student is 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 = Lab function generator
____(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 – iPod, 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

=== 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