Design Project: Audio power amplifier

Your project is to design and build a Class B audio power amplifier, capable of amplifying the signal from a microphone sufficient to be heard across a room. No integrated circuits are allowed in this project, only discrete componentry! The amplifier must be complete with a power switch and volume control.

Deadlines (set by instructor):

- Project design completed:
- Components purchased:
- Working prototype:
- Finished system:
- Full documentation:

Questions

Question 1

Explain how the microphone in your amplifier works. How, exactly, does it convert waves of air pressure (sound) into electrical signals?

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Question 2

Your amplifier design will almost certainly require more than one stage of transistors to properly match the impedance of the microphone to that of the loudspeaker. Identify the topology of each transistor stage (common-emitter, common-collector, common-base, etc.), and explain what the primary form of gain for each stage is (voltage gain, or current gain).

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Question 3

While Class A amplifier circuits are simpler to design and build, they are rarely used for high-power applications. Why is this? Why are Class B amplifier designs much more popular for high-power applications? Would it be practical for you to build a microphone amplifier such as this using nothing but Class A circuitry?

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Question 4

Explain how you plan to test for and eliminate (if necessary) any *crossover distortion* from your amplifier circuit. Do you suspect crossover distortion will be more noticeable at low volume levels or high volume levels? Explain why.

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Question 5

Sound pressure is often measured in units of dBA. You should be familiar with decibels as a unit of amplifier gain, but what does "db$A$" actually mean? How is 0 dBA objectively defined?

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Answers

Answer 1

The answer to this question depends on what type of microphone you use:

- Condenser: variable capacitance
- Dynamic: electromagnetic induction
- Crystal: piezoelectricity

Answer 2

The answer to this question, of course, will vary with your particular design of circuit.

Answer 3

Class A amplifiers are much less *efficient* than Class B amplifiers: a great deal more of the electrical power energizing the circuit gets wasted in the form of heat.

Answer 4

Crossover distortion is detected by using an oscilloscope to display the output waveform, and is eliminated through proper biasing of the push-pull transistor pair. This type of distortion is generally more noticeable at low volume levels, but I'll let you explain exactly why!

Answer 5

0 dBA = 1 pW/m$^2 \approx$ "Threshold of human hearing"

Notes

Notes 1

Microphones are important devices in the world of electronics, and students are likely to appreciate their function more when building a project that uses one.

Notes 2

A project such as this really brings to life the concepts of gain, and why different transistor amplifier configurations are necessary to achieve different types of gains.

Notes 3

Discuss with your students the practicality of a Class A audio power amplifier for the scope of this project. Just because I made Class B circuitry a requirement of this project does not mean a Class A amplifier design would be completely impractical. One of my goals in writing this design project was to get students experienced with Class B push-pull circuits, which are more challenging to design and build than Class A.

Notes 4

Crossover distortion is the bane of Class B amplifier designs, and may be frustrating for the beginning electronics student to successfully eliminate without causing other problems (such as transistor overheating from excessive Class AB biasing).

Notes 5

Discuss with your students how decibels are an appropriate way to express sound intensity, due to the very nonlinear sensitivity of human hearing. In fact, the very genesis of the decibel scale was early telephone system design, where engineers had to rate signal loss in terms that were meaningful to human users.