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TUTORIAL 5590

How to Select the Best Audio Amplifier for Your Design

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Abstract: With the ever changing requirements in the audio market, there have been many advancements in audio amplifier topologies. Knowing the types of audio amplifiers available and the characteristics associated with them is essential in selecting the best audio amp IC for your application.

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Introduction

An audio amplifier increases the amplitude of a small signal to a useful level, all the while maintaining the smaller signal's detail. This is known as linearity. The greater the amplifier linearity, the more the output signal is a true representation of the input.

With the ever-changing performance requirements for amplifiers in the audio market, there have been many advances in audio amplifier topologies. Consequently, designers must know the types of audio amplifiers available and the characteristics associated with each. This is the only way to ensure that you select the best audio amp for an application. In this tutorial, we examine the most important characteristics of each class of audio amp available today: Class A, Class B, Class AB, Class D, Class G, Class DG, and Class H.

Class A Amplifiers

The simplest type of audio amplifiers is Class A. Class A amps have output transistors (**Figure 1**) that conduct (i.e., do not fully turn off), irrespective of the output signal waveform. Class A is the most linear type of audio amp, but it has low efficiency. Consequently, these amps are used in applications that require high linearity and have ample power available.



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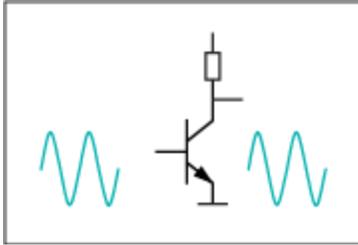


Figure 1. A Class A audio amp is typically associated with high linearity but low efficiency.

Class B Amplifiers

Class B amplifiers use a push-pull amplifier topology. The output of a Class B amp incorporates a positive and negative transistor. To replicate the input, each transistor only conducts during half (180°) of the signal waveform (**Figure 2**). This allows the amp to idle with zero current, thereby increasing efficiency compared to a Class A amp.

There is a trade-off that comes with a Class B amp: the increased efficiency degrades audio quality. This happens because there is a crossover point at which the two transistors transition from the on state to the off state. Class B audio amps are also known to have crossover distortion when handling low-level signals. They are not a good choice for low-power applications.

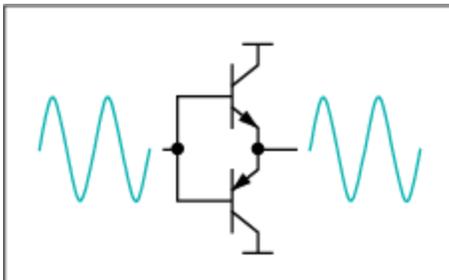


Figure 2. With a Class B audio amp, the output transistors only conduct during half (180°) of the signal waveform. To amplify the entire signal, two transistors are used, one conducting for positive output signals and the other conducting for negative outputs signals.

Class AB Amplifiers

A compromise between Class A and Class B amplifier topologies is the Class AB audio amp. A Class AB amp provides the sound quality of the Class A topology with the efficiency of Class B. This performance is achieved by biasing both transistors to conduct a near zero signal output, i.e., the point where Class B amps introduce nonlinearities (**Figure 3**). For small signals, both transistors are active, thus functioning like a Class A amp. For large-signal excursions, only one transistor is active for each half of the waveform, thereby operating like a Class B amp.

Class AB speaker amps offer high signal-to-noise (SNR), low THD+N, and typically up to 65% efficiency. This makes them ideal choices as high-fidelity speaker drivers. Class AB amps like the [MAX98309](#) and the [MAX98310](#) are used in portable media players, digital cameras, tablets, and e-readers where high fidelity is a must. Some headphone amplifiers use a Class AB topology in a bridge-tied-load configuration. As an example, the [MAX97220A](#) headphone amp offers exceptionally low THD+N throughout the audio band while delivering up to 125mW of power; the MAX97220A is one of the most

widely used Class AB headphone amps in the world today. For other examples, see Maxim's [Class AB amps](#).

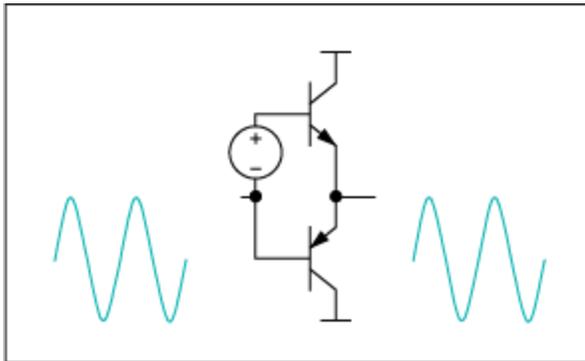


Figure 3. A Class AB amp biases both transistors so that they conduct when the signal is close to zero. Thus, these amps provide more efficiency than Class A, with lower distortion than Class B.

Class D Amplifiers

The popularity of handheld mobile audio devices, such as smartphones, MP3 players, and portable docking stations, brings power consumption into greater focus. Now it is necessary to reduce power consumption to increase battery life. Class D amplifiers use pulse-width modulation (PWM) to produce a rail-to-rail digital output signal with a variable duty cycle to approximate the analog input signal (**Figure 4**). These amps are highly efficient (often up to 90% or higher) because the output transistors are either fully turned on or fully turned off during operation. This approach completely eliminates the use of the linear region of the transistor that is responsible for the inefficiency of other amplifier types. Modern Class D amps also achieve fidelity comparable to Class AB amps. With its high efficiency, Class D switching amplifiers, such as the [MAX98304](#) and the [MAX98400A](#), are widely used in portable applications. For other examples, see Maxim's [Class D amps](#).

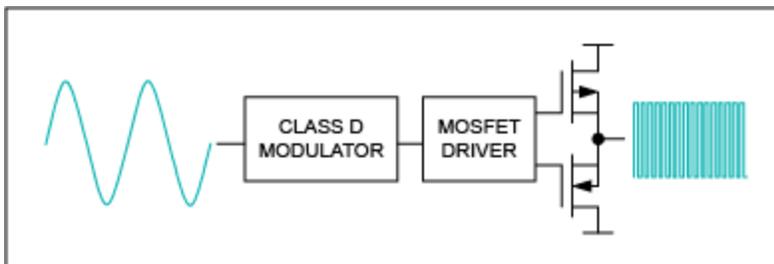


Figure 4. A Class D audio amp outputs a switching waveform at a frequency far higher than the highest audio signal that needs to be reproduced. These amps are highly efficient because the output transistors are either fully turned on or fully turned off during operation.

Class G Amplifiers

Class G amplifiers are similar to Class AB amps, except that they use two or more supply voltages. When operating at low signal levels, Class G amps select a low supply voltage. As the signal level increases, these amps automatically select the appropriate supply voltage (**Figure 5**). Class G amps are more efficient than Class AB amps because they use the maximum supply voltage *only* when required; in contrast, Class AB amps always use the maximum supply voltage.

There is a common problem in portable audio applications: the limited supply voltage available to the speaker amp. Class G power amps solve this supply voltage problem by using a charge pump to boost the supply voltage. As examples, the [MAX9730](#) speaker amp is optimized for traditional dynamic speakers, while the [MAX9788](#) speaker amp is designed for ceramic speakers. For other examples, see Maxim's [Class G amps](#).

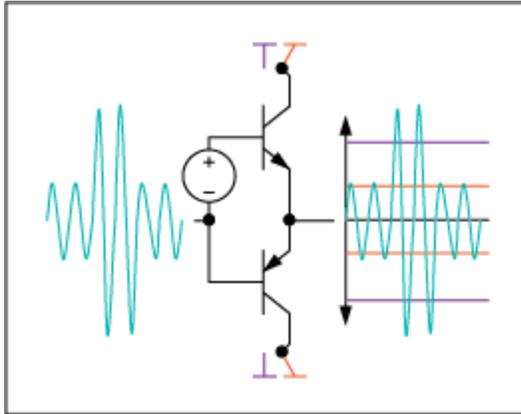


Figure 5. A Class G amp is more efficient than a Class AB amp because it uses the maximum supply voltage only when required.

Class DG Amplifiers

The Class DG amplifier uses PWM to produce a rail-to-rail digital output signal with a variable duty cycle. In this respect, a Class DG amp is the same as a Class D amp. The Class DG amp, however, also uses a multilevel output stage to sense the magnitude of the output signal (**Figure 6**). It then switches the supply rails, as needed, to supply the required signal power more efficiently. A Class DG amp, such as the [MAX98308](#), uses the same dual-power concept as a switching Class D topology for even higher efficiency. For other examples, see Maxim's [Class DG amps](#).

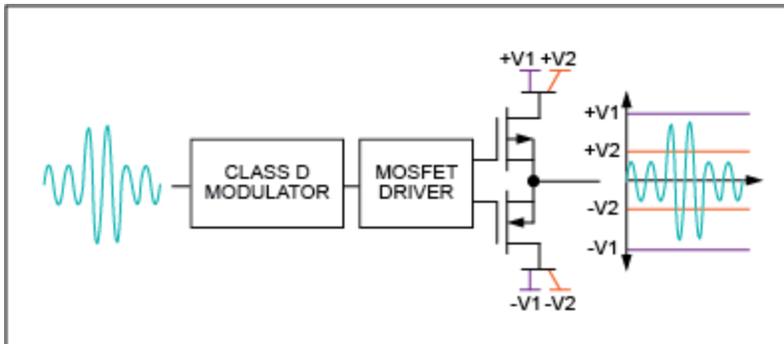


Figure 6. A Class DG amplifier senses the magnitude of the output signal and then switches the supply rails, as needed, to supply the required signal power more efficiently.

Class H Amplifiers

Class H amplifiers modulate their supply voltage to minimize the voltage drop across the output stage. Implementations range from using multiple discrete voltages to an infinitely adjustable supply. Though

similar to the Class G technique of reducing dissipation across output devices, the Class H topology does not require multiple power supplies (**Figure 7**).

Class H amps are generally more complex than other audio amplifier designs. These amps require extra control circuitry to predict and control the supply voltage. Audio codec ICs, such as the [MAX98090](#) and the [MAX98091](#), integrate a Class AB headphone amp with a Class H power structure to provide a very low-power, complete audio solution. For other examples, see Maxim's [Class H amps](#).

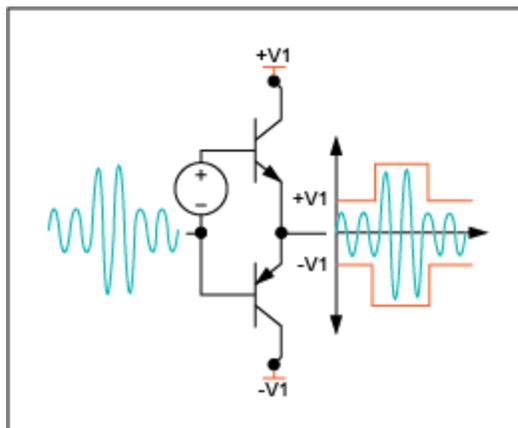


Figure 7. A Class H audio amp reduces dissipation across the output devices connected to that supply. This allows the amp to operate with an optimized Class AB efficiency, regardless of output power level.

Summary

This has been a brief survey of the many types of audio amplifiers commonly used in designs today. Clearly, when designing an audio circuit for any type of device, care should be taken in determining the audio amplifier topology best suited to the application. A good understanding of these different classes of audio amps will help you choose the best audio amp for your design.

Part Selection Links

[Speaker Amplifier ICs](#)

[Headphone Amplifier ICs](#)

[Integrated Audio Subsystem ICs](#)

Related Parts

MAX97220A	Differential Input DirectDrive Line Drivers/Headphone Amplifiers	Free Samples
MAX9730	2.4W, Single-Supply Class G Power Amplifier	Free Samples
MAX9788	14V _{P-P} , Class G Ceramic Speaker Driver	Free Samples
MAX98090	Ultra-Low Power Stereo Audio Codec	Free Samples

MAX98091	Ultra-Low Power Stereo Audio Codec	
MAX98304	Mono 3.2W Class D Amplifier	Free Samples
MAX98308	3.3W, Mono Class DG Multilevel Speaker Amplifiers	Free Samples
MAX98309	Mono 1.4W Class AB Audio Amplifiers	Free Samples
MAX98310	Mono 1.4W Class AB Audio Amplifiers	Free Samples
MAX98400A	Stereo, High-Power, Class D Amplifier	Free Samples

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