Advances in Class D amplifiers have opened the doors into higher-end apps, but the choice of inductor is crucial toward optimizing their performance.

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Analog Class AB amplifiers have been a staple of the audio industry for decades, and their ability to deliver excellent sound quality has kept them there—despite their inherent bulk and other shortcomings. However, for automotive and battery-powered products, these limitations can no longer be accommodated. Now taking their place is the Class D audio power amplifier. Formerly relegated to low-end applications, these amplifiers, thanks to advances in technology, now can deliver performance equal to that of its Class AB counterpart.

For those not familiar with the Class D amplifier, it uses pulse width modulation (PWM) whereby transistors are operated as switches rather than delivering linear gain as in other amplifier classes. As the switches are either fully on or fully off, power losses are dramatically reduced, which makes it possible to achieve efficiency greater than 90%. This high-efficiency reduces the need for heat sinking, which in turn shrinks size, weight, and cost in comparison to lower amplifier classes.

The input audio signal modulates the PWM signal, which drives the amplifier output devices. At the very end of this signal chain, a low-pass filter removes highly undesirable high-frequency signal content, making it perhaps the most critical component in the entire amplifier.

Dealing with Distortion

One of the traditional problems with Class D amplifiers is their high transient intermodulation distortion (TIM), which results in part from the characteristics of silicon MOSFETs whose switching anomalies, high on-state resistance, and very high stored charge make lowering distortion difficult to achieve. To reduce it, Class D amplifiers use large amounts of feedback to compensate for this mediocre open-loop performance. However, the feedback introduces TIM that degrades output signal to what has been described as harsh, colorless, or bland.

The primary role of the low-pass filter, and parenthetically the inductor within it, is to eliminate these high-frequency signal components above the higher threshold of hearing, which is about 20 kHz. This issue is also addressed through careful design practices and most recently by replacing MOSFETs with gallium-nitride (GaN) FETs, whose performance characteristics in this respect and others is significantly better.

The filter typically has extremely high attenuation to dramatically reduce signal intensity at the unwanted frequencies. In addition to causing distortion, these signals can cause electromagnetic interference to various sources and potentially damage the speaker.

By eliminating distortion products, the filter effectively allows the output signal to be reconstructed to be almost identical to the original. In current Class D amplifier designs, it produces a signal that's virtually indistinguishable from that of a Class AB amplifier. The filter has other benefits as well, one of which is reduced ripple current. Without the filter, the ripple would be superimposed on the audio signal—the filter's action reduces it to a very low level.

Optimizing the performance of a Class D amplifier requires very close attention to the choice of the inductor used in the low-pass filter at the output. For example, the inductor's core should have a current rating higher than that of the amplifier. Otherwise, the core will magnetically saturate, the result of which is increased distortion or possibly having the inductor appear to the output as a short rather than open circuit. This creates a significant spike in current that could potentially damage the speakers following the amplifier.

In addition, selecting the inductance value for the output filter of a Class D audio amplifier is a critical design decision. The latest Class D amplifiers make this even more important, because an inductor with poor electrical properties can severely limit the audio performance. Many other factors should be considered as well, including dc resistance and dc and peak current ratings. In particular, dc resistance directly impacts efficiency by adding to the total load resistance at power supply.

To help choose the proper inductor characteristics, it’s important to discuss the specific amplifier design with the inductor manufacturer that makes this task far easier and ensures a better result. To that end, Coilcraft has created a dc-dc converter inductor selector tool that can be found on its website. The selector makes it possible to specify an inductor without resorting to manual calculations, simply by choosing values. Use of the tool is also described in the “Selecting Inductors to Drive LEDs” application note, which illustrates how it can be used.