Class D amplifiers have been used in designs where audio performance and EMI are sacrificed for increased efficiency. Today, however, several new techniques have lead to the introduction of ultra-low EMI, high performance Class D amplifiers. The following article describes how system designers can benefit from these new technologies.

As portable, battery-operated devices proliferate; Class D amplifiers continue to gain popularity, due to their inherent efficiency advantages. Most Class D systems now operate above 80% efficiency. In the past, engineers have had to sacrifice audio performance, and increase board space and system cost in order to realize these efficiency gains. Recent advances in Class D technology have addressed the short comings of past architectures, simplifying system design, and reducing solution cost.

Large filters, electromagnetic interference (EMI), or RF interference (RFI) and poor Total Harmonic Distortion + Noise (THD+N) are issues that commonly accompany Class D amplifiers. Recent architectures use the inductive nature of the loudspeaker itself to extract the audio component from the pulse width modulation (PWM) square wave output, eliminating the output filter for audio purposes. However, removing the filter has increased the EMI emitted by this filterless topology. The newest devices have been able to minimizing EMI and improve THD+N, without sacrificing efficiency, as described below.

EMI is important to many designers as it can interfere with ICs and electronic devices elsewhere in the system. Engineers are also challenged with compliance to the standards set forth by governing bodies such as the FCC, CE, Mil-Std-461, and proprietary automotive. The first EMI suppression feature semiconductor suppliers implemented is spread spectrum modulation. Spread spectrum modulation differs from traditional PWM as the switching frequency of the output bridge changes in a band around a center switching frequency. The center frequency, frequency spread and frequency variation method can differ from device to device, but as long as the frequency variation is random, the peak radiated energy will decrease. This is due to the fact that the electromagnetic energy is spread over a wider frequency band. The total high frequency energy remains the same compared to a fixed frequency device, but the peak noise at any one frequency is reduced.

Figure 1 demonstrates near field EMI measurement for a fixed frequency device vs. a spread spectrum device. As the red lines indicate, peak energy is reduced.
Spread spectrum is effective when implemented correctly, and does not adversely affect efficiency or THD. It is now implemented in several devices.

To further reduce the EMI profile of a device, semiconductor manufacturers have implemented edge rate control (ERC). The high frequency energy of a Class D output is contained in the edges of the square wave output. The faster the output rise or fall time, the more high frequency energy the edge contains. Therefore, if the output transition time can be decreased, the amount of high frequency energy released by the system will be reduced.

If not taken into account, decreasing the transition time can also have negative effects on Class D performance. As more time is spent in the active region between states, the output devices dissipate more power, decreasing efficiency. Reducing the rise and fall times also results in a PWM signal that deviates from a perfect square wave, introducing error into the reproduced audio signal and increasing THD+N.

Although edge rate control potentially has a negative impact on the overall performance of a Class D amplifier, the EMI improvement has compelled designers to make marked improvements to ERC technology. When properly implemented, efficiency losses and added THD+N can be minimized.

Devices implement an available enhanced emissions suppression (ES) system. E^2S improves efficiency by slowing the output transition time for only a portion of the edge. In this way, EMI is minimized but power dissipation is also reduced to a level on par with non-ERC Class D amplifiers. PWM audio signal errors introduced by the ERC are corrected by an internal feedback loop, reducing THD+N and improving audio quality.

Performance is shown in Figure 2. The device passed the FCC Class B standard, completely unfiltered, driving a speaker with twenty inches of unshielded, twisted pair cable. Figure 3 shows the same test with a spread spectrum-only device. As illustrated, the E^2S Class D amplifier achieved extremely low EMI, while maintaining audio performance.
While recent advances in Class D technology have substantially reduced EMI generated by Class D amplifiers, proper PCB design is critical in minimizing RF emissions. While this is a vast topic which can cover many articles on its own, it is worth discussing one of the basic practices for minimizing noise issues and EMI: isolating traces that carry switching signals reduces noise coupling into quiet or sensitive portions of the circuit. This practice not only enhances audio performance, but also minimizes the potential for parasitic antennas to be created. To do this requires that you isolate the analog inputs and analog power supplies (which feed input buffers, control, and other sensitive circuitry), as well as their associated bypass capacitors from switching nodes that include device outputs, output bridge power supplies and any external components associated with these nodes.

While many Class D amplifiers have multiple supplies and grounds, one for the low noise, input circuitry, and one for the higher current, noisy output stage, the device may not function as expected if the potential difference between the different supplies or grounds is too great. Ensuring that the device sees the proper voltage potentials while effectively isolating the noisy and quiet portions of the PCB is a challenge. Figure 4 and Figure 5 show the demo board layout, and Figure 6 illustrates how to isolate the signal and power grounds, while still maintaining one uniform potential for the device. This layout is similar to a star ground connection, as the individual ground nodes are all connected to the same copper pour, maintaining the same ground potential at these points. However, the noisy ground and quiet grounds are separated from each other, connected only where ground enters the circuit board. This prevents noise generated by the device outputs from polluting the quiet ground. The same principle is applied to the $V_{DD}$ layer in Figure 7. The left half of the board includes the analog audio inputs, $V_{DD}$ and input coupling capacitors C1 and C2. The right half of the board includes the outputs, PV$_{DD}$ (H-Bridge supply) and bypass cap C3.

The two halves of both the $V_{DD}$ and ground planes are connected only where either power or ground
enters the circuit board. From that point, the two planes split, and the quiet nodes remain isolated from the switching nodes. This technique is effective in keeping switching noise out of areas which can degrade performance or increase EMI.

Figure 4. Top silkscreen of LM48310 demo board

Figure 5. Top layer of LM48310 demo board

Figure 6. GND layer of LM48310 demo board
Due to its high efficiency, the Class D amplifier has become the audio amplifier of choice for portable and power sensitive applications. Improvements to both audio quality and EMI performance, have made designing with Class D amplifiers now much easier. Less stringent PCB layout techniques and fewer external components mean shorter design cycles, lower system size and cost, and longer battery life in portable products—all without sacrificing audio quality.

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