By Eric Mendenhall, Director of Audio
and Power Systems

Eric Mendenhall is Director of Audio and Power Systems at Extron Electronics. For over 20 years he has been specializing in the design of power electronics circuits and systems for audio power amplifiers and switch-mode power supplies. Prior to joining Extron, Eric has held positions in several companies including QSC, BGW, Alesis, Gibson and Line 6. Eric received his BSEE at Lehigh University in 1986 and his MSEE at California State University in 1992.

Extron's Patented Ripple Steering Class D Audio Amplifier Technology

Class D Audio Power Amplifiers offer the highest efficiency possible, resulting in cooler running, longer lasting products. They are not without their drawbacks, however, one of these typically being increased EMI - Electromagnetic Interference. Extron's proprietary Ripple Steering technology greatly improves the EMI performance of Class D Audio Power Amplifiers for trouble free application in the most sensitive A/V environments.

A Class D audio power amplifier, also known as a switching amplifier, is essentially a switching power supply with an output that directly reproduces an audio signal at higher power. The basic principle is that the power transistors are rapidly switched on and off at a switching frequency much higher than the audio bandwidth. As a result, very little power is dissipated by the transistors and the efficiency is very high, ideally 100% since the only dissipation occurs due to the use of real-world components rather then their ideal counterparts. This is in contrast to the linear designs that dominated the 1980s and the quasi-linear designs used throughout the 1990s. These had power transistors operating in their linear – or dissipative – regions intentionally and unavoidably, resulting in large power draw and high waste heat.

EMI Emissions from Class D Power Amplifiers

Electromagnetic compatibility constraints are stringent for an audio power amplifier; even units that pass the legally required testing can have problems in the field. Their outputs must often be connected to cables in the 1 to 100 meter range acting as antennae, often in close proximity to AM radios and other sensitive audio, video, and radio equipment. This makes emissions over the 150 kHz – 30 MHz spectrum critical; this is where the switching frequency, or range of switching frequencies, resides. As Class D amplifiers became more widespread, some problems began to arise in the field. Since these amplifiers act like switching power supplies, they had a high level of undesirable output above the audio band, often extending into the AM radio band and beyond. Sensitive A/V environments proved more of a hurdle than laboratory bench testing, and several manufacturers began their quest for lower emission topologies with varying degrees of success. For more information about Class D amplifiers, please refer to the Technically Speaking article by Steve Somers in Issue 12.5, available as a download at www.extron.com.

One approach involved using a variable switching frequency to spread the spectrum of the emissions, theoretically reducing the impact at any one frequency. The benefits of this can be seen in the emissions sweep shown in Figure 1.

Although the emissions are lower at any one frequency than those of a similar fixed frequency design whose output is shown in Figure 2, the variable frequency design manages to cover the entire AM radio band.

Another approach uses interleaving to cancel the switching ripple, but this is only effective at zero output.

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Figure 1 - Variable Frequency Class D Amplifier Output Cable Emissions

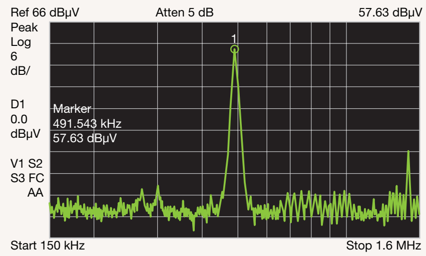

Figure 2 - Fixed Frequency Class D Amplifier Output Cable Emissions

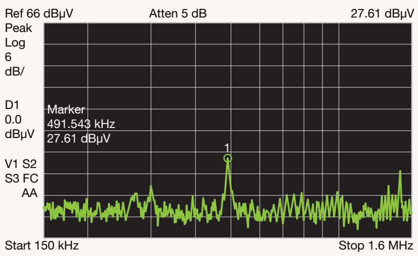

Figure 3 - Ripple Steering Class D Amplifier Output Cable Emissions

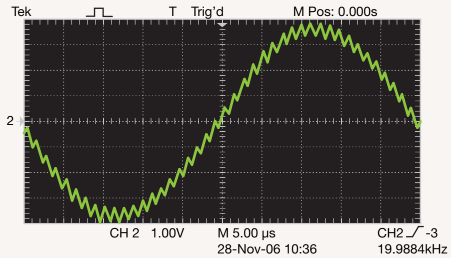

Figure 4 - Audio Output of Class D Amplifier

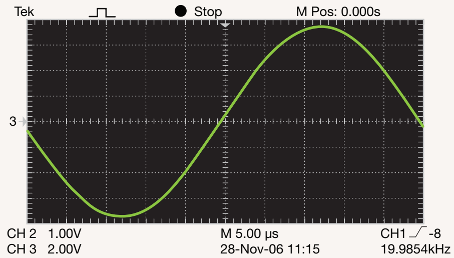

Figure 5 - Audio Output of Ripple Steering Class D Amplifier

As the output voltage increases, the ripple cancellation is less effective, leading to a switching ripple content modulated by the audio, which can be more of a problem than the constant amplitude case.

Extron Ripple Steering for Class D Amplifiers

Extron's proprietary solution uses Ripple Steering to practically eliminate the switching residual. As the name implies, this technique does not eliminate the unavoidable ripple; rather, it simply steers the ripple away from the audio output and towards an internal quarantine area where it can do no harm. With this technique applied the spectrum of Figure 3 results, which is much less objectionable than the prior methods. This experiment showed a 30dB decrease in emissions amplitude, and the constant frequency operation is always well below the AM band.

The audio frequency output waveform of the conventional Class D amplifier shown in Figure 4 is improved considerably when ripple steering is applied as shown in Figure 5. In practice it is difficult to distinguish the output waveform of the Ripple Steering Class D amplifier from that of a linear amplifier.

How is Ripple Steering Achieved?

As noted, the steering of ripple is accomplished by diverting the ripple away from the output that you want to keep clean, and putting it somewhere else. A conventional Class D amplifier is shown in Figure 6, with C1 as the output. Figure 7 shows the same amplifier with Ripple Steering applied. An additional output was constructed

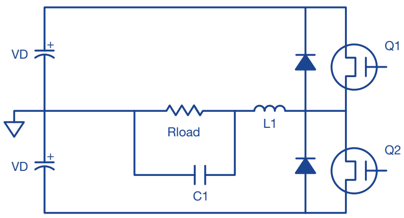

Figure 6 - Conventional Class D Amplifier

with C2, L2, and another winding added to L1. C2 is actually a second audio output that will essentially track the voltage of C1. The difference between the two is that C1 has the loudspeaker and speaker wiring attached to it, represented by Rload, whereas C2 is simply an internal node that goes nowhere. This allows it to be used effectively as a ripple current dump. It's not quite as simple as it appears, however. There are, of course, very particular constraints governing the turns ratio on the coupled inductors, the external uncoupled inductance, and the auxiliary output capacitor. For an expanded technical discussion of the technique, please refer to the Extron white paper: "Class D Amplifier with Zero Switching Ripple," available at www.extron.com.

It has been shown that Extron's use of ripple steering technology results in a Class D amplifier with markedly lower emission of electromagnetic interference reducing the potential negative impact on sensitive A/V systems. Ripple steering technology is currently featured in the PVS 204 PoleVault Switcher and will serve as the basis for future amplifier designs from Extron.

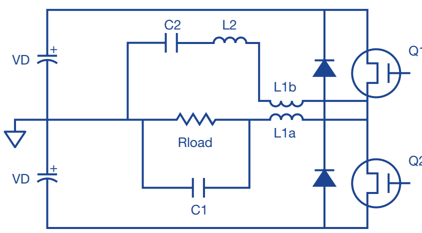

Figure 7 - Ripple Steering Class D Amplifier