The Future of Audio Solutions for Cell Phones

After years of anticipation, music capability in cell phones is expected to emerge in a significant percentage. As a result of that, cell phone manufacturers nowadays are paying particular attention to discrete audio amplifier solutions that are able to deliver high power and good sound fidelity through the headphone or speaker of a cell phone design while saving power. **Giampaolo Marino, Intersil, Milpitas, USA**

The goal of an audio amplifier is to reproduce input audio signals into output elements classified as speakers, with the desired volume, power levels, efficiency and low distortion. For a human being, audio frequency ranges between 20Hz and 20kHz, which means the amplifier needs to have a very good frequency response over this range. Power capability varies widely depending upon the end applications, but usually for cell phones, the power levels ranges from milliwatts in headphones to one watt for a loud speaker.

Figure 1: In 2007, the total available market for audio amplifiers alone will be around $200 million, driven by portable devices for the young generation

Towards class D amplifiers

Audio amplifiers for cell phone applications are considered the fastest amplifier growth within its category. It is estimated that, in 2007, the total available market for audio amplifiers alone will be around $200 million, driven by portable devices for the young generation (Figure 1). Today, the total audio amplifier market has been completely dominated by the conventional power-hungry linear amplifiers. As portable electronics consumers demand smaller devices with longer battery life, designers are looking to replace conventional linear amplifier with high-efficiency devices. The world of audio today is divided in two major amplifier classes: class AB, currently retaining 80% of discrete amplifier solutions, and filterless class D amplifiers making up the rest.

This trend is going to invert very rapidly over the next couple of years. Class D amplifiers have an inherent efficiency advantage over the traditional class AB amplifier because class D output stages are always off or on, with no intermediate bias stage necessary. In cell phone applications this all translate to longer battery life.

In a traditional class AB design, the output-stage power dissipation is very large in even the most efficient linear output stage. This difference gives class D great advantages because the lower power dissipation produces less heat, saves circuit board space and cost, and extends battery life.

In a linear amplifier, the output stage is directly connected to the speaker output via a coupling capacitor. Nowadays, the output stages of a typical class AB amplifier are implemented with MOS transistors, as shown in Figure 2.

Often times, even well-designed class AB amplifiers present significant power dissipation due to their midrange output

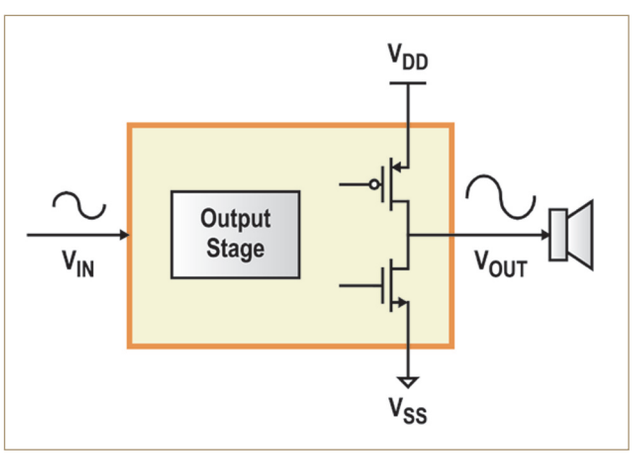

Figure 2: The output stages of a typical class AB amplifier are implemented with MOS transistors

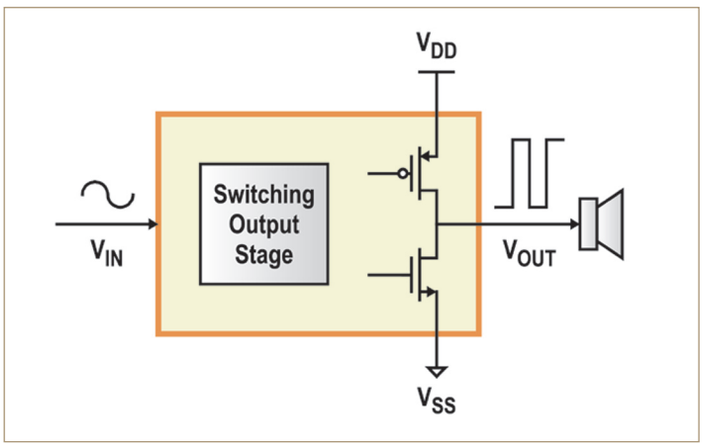

Figure 3: Class D amplifier topologies dissipate much less power than class AB because its output stage switches between the positive and negative power supplies

voltage being significantly far from the positive or negative supply rails. The large drain-source voltage drops produce significant V_{DS} x I_{DS} power dissipation.

Class D amplifier topologies (Figure 3) dissipate much less power than class AB. Its output stage switches between the positive and negative power supplies so as to produce a train of voltage pulses. This waveform helps drastically reduce power dissipation because the output transistors have zero current when not switching and have very low V_{DS} when they are conducting current, thus providing very small V_{DS} x I_{DS} power dissipation.

EMI issues

Of course, class D amplifiers do not come for free. There are several issues that need to be addressed, and the most important issue is their poor EMI performance. Today's cell phones are becoming continuously smaller and lighter, but yet have higher integration contents. Typical EMI problems with cell phone designs usually fall into three different categories: Blatant EMI radiation that exceeds regulatory emission limits during qualification; EMI that although meets regulatory requirements, continues to adversely affect devices in close proximity; and EMI that adversely affects the cell phone through harmonics and spurious signals.

From a class D design perspective, EMI generated through harmonics and spurious signals are of great concern. Those are conducted via speaker and power supply wires. The class D modulation scheme determines a baseline spectrum of components of conducted and radiated EMI. There are different board-level design techniques that can be used to reduce the EMI emitted by class D amplifiers despite its baseline spectrum. Another great challenge for class D amplifier is the ability to achieve good overall sound quality. In fact, several issues must be addressed in order to achieve a sound quality that is comparable with the class AB type. Click and pop noise, which usually occurs when the amplifier turns on or off, can be extremely annoying for the end user. Unfortunately, this particular noise type can be easy introduced into a class D amplifier unless design attention is paid to the modulator stage and output stage timing.

Class D amplifiers can be more design intensive than linear amplifiers, yet the benefit of efficiency justifies a more complicated system when simpler solutions already exist. The theoretical best efficiency for a traditional amplifier output stage is 75%, but linear amplifiers exhibit that efficiency only at their peak output power. The output stage of a class D amplifier delivers a maximum efficiency greater than 90% over its full dynamic range.

Low-power class D amplifiers are intended for portable, battery-powered equipment such as cell phones, PDAs, portable radios, CD players, MP3 players, laptop computers and portable DVD players. Consumers of those products are lured by the promise of portability and how long the device will last on the batteries, not by the expectation of a stunning audio experience. As the market for cell phone devices continues to grow, I am expecting class D amplifiers to gain more acceptance. As the future for cell phones calls for higher levels of functionality, I expect to see class D amplifiers featuring more flexibility and higher levels of integration.