

## APPLICATION NOTE 3973

# Maxim's Active-Emissions-Limiting (AEL) Circuitry Demystified

*Abstract: This application note describes the technology Maxim's 3rd-generation Class D audio power amplifiers utilize to enable their "filterless" operation in consumer electronics equipment. Specifically, this article explains how Maxim's new, patent-pending active-emissions-limiting circuitry minimizes radiated emissions without degrading audio performance.*

## Introduction

Maxim's 2nd-generation Class D audio power amplifiers feature a unique, patented, spread-spectrum-modulation mode that flattens wideband spectral components, improving EMI emissions that may be radiated by the speaker and cables. Maxim's 3rd-generation Class D audio power amplifiers employ the same spread-spectrum technology with a new patent-pending active-emissions-limiting (AEL) circuit that further reduces narrow-band spectral components without degrading audio performance. The combination of these two unique technologies allows Maxim's Class D audio power amplifiers, such as the [MAX9705](#), to run 'filterless' with up to 24 inches of unshielded cable and still meet EN55022 electromagnetic-interference (EMI) regulation standards. This article explains the technology Maxim employs in AEL Class D amplifiers to minimize radiated emissions levels, while maintaining the high efficiency expected of Class D amplifiers.

## Maxim's 3rd-Generation Class D Technology

Maxim's 3rd-generation Class D technology features Maxim's spread-spectrum-modulation technology with a new patent-pending active-emissions-limiting circuit that further reduces narrow-band spectral components.<sup>1</sup> AEL circuitry greatly reduces EMI emissions by actively controlling the output-FET gate transitions under all possible transient output-voltage conditions. The edge rate of each gate transition is intelligently controlled such that the near rail-to-rail swing and the fast switching frequency contribution to emissions is reduced with as little impact on amplifier efficiency as possible.

Since the high efficiency of a Class D amplifier is due to its near rail-to-rail swing and the fast on/off transitions of its output FET (**Figure 1**), edge-rate control has the potential to negatively impact the Class D amplifier's efficiency.

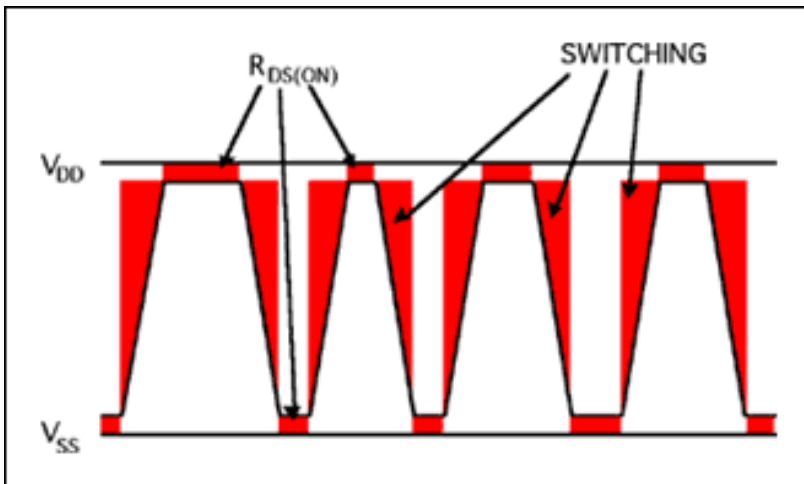
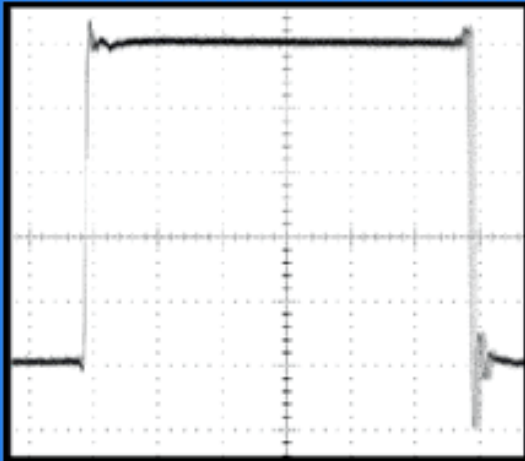


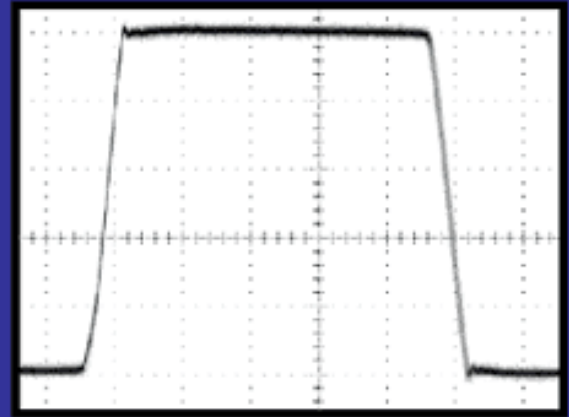
Figure 1. Class D output waveform illustrating regions of loss due to its switching edge rate and transistor  $R_{DS(ON)}$ .

Fast transitions on the output contribute to high efficiency by minimizing loss in rise or fall time. If the on/off transition time is increased, then efficiency decreases. With AEL, the output-FET gate transitions are intelligently controlled so as to maximize Class D efficiency while still achieving excellent emissions performance (**Figure 2**).

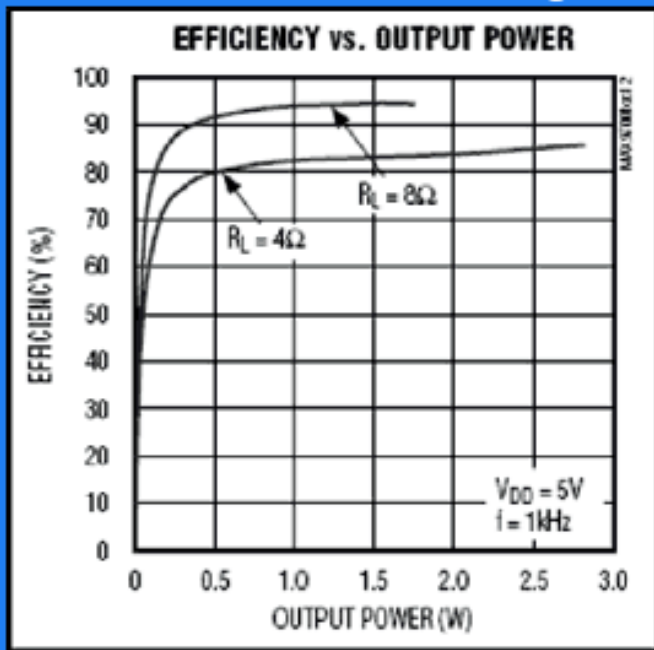
### Maxim Class D Switching Waveform Without Active Emissions Limiting



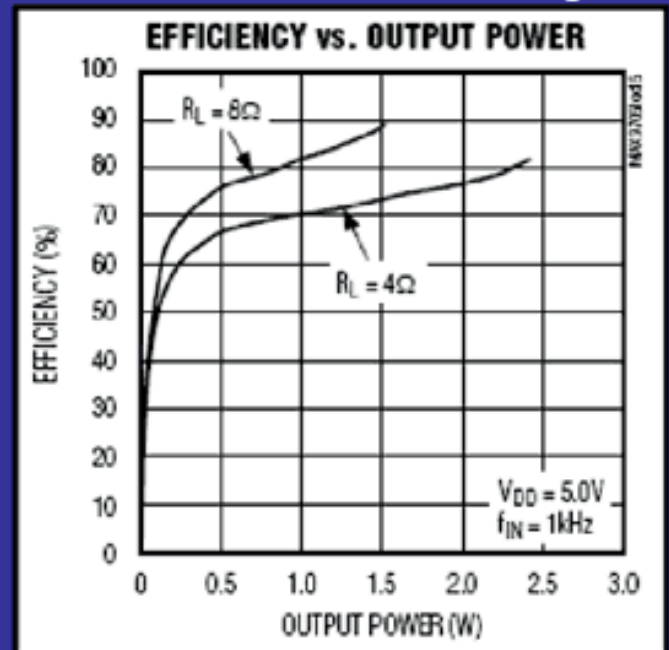
### Maxim Class D Switching Waveform with Active Emissions Limiting



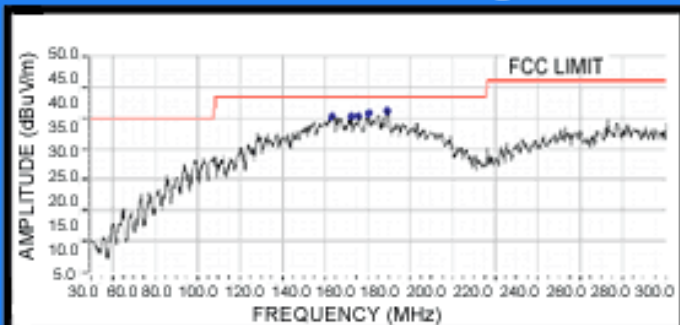
### Maxim Class D Efficiency Without Active Emissions Limiting



### Maxim Class D Efficiency with Active Emissions Limiting



### Maxim Class D Radiated Emissions Without Active Emissions Limiting



### Maxim Class D Radiated Emissions with Active Emissions Limiting

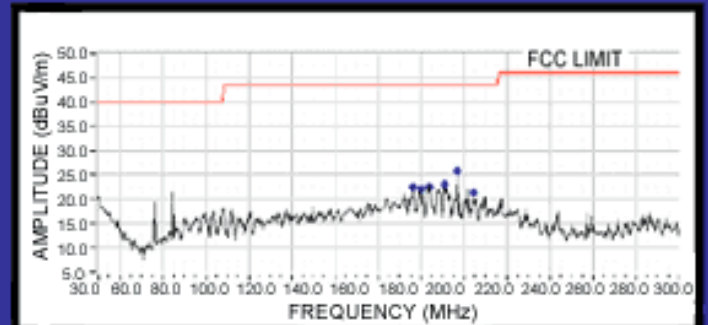


Figure 2. Active-emissions-limiting circuitry intelligently controls the edge rate of the Class D switching waveform and reduces radiated emissions with very little degradation in efficiency.

## The MAX9705 Class D, AEL Amplifier

The MAX9705 is an ultra-low EMI, mono, Class D amplifier featuring Maxim's 3rd-generation Class D technology. Offering efficiencies up to 90%, the MAX9705 boasts of 15.8dB quasi-peaked margin to the FCC limit with 12 inches of unshielded, twisted-pair speaker cable (**Figure 3**). More impressively, the MAX9705 can pass the FCC limit with up to 24 inches of unshielded, twisted-pair speaker cable (**Figure 4**).

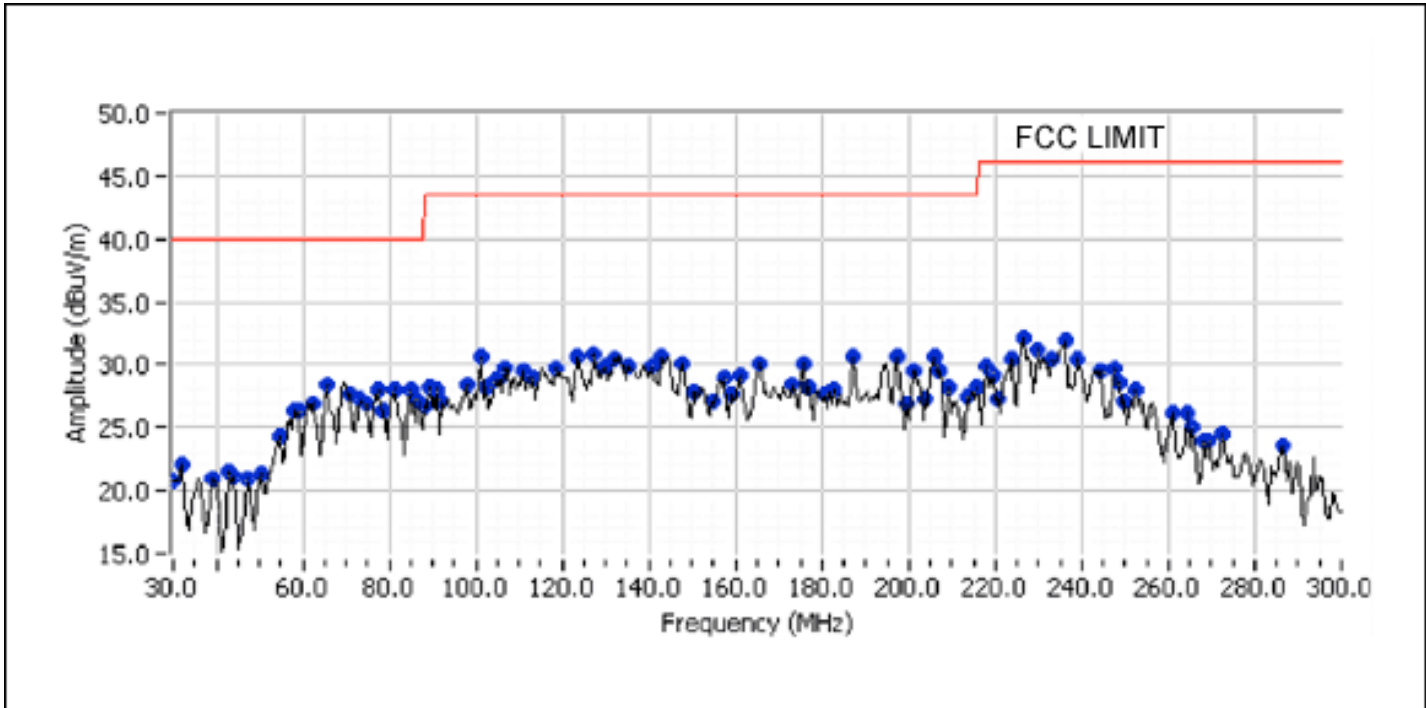


Figure 3. MAX9705 radiated emissions data (MAX9705EVMKit, spread-spectrum-modulation mode, 12 inch, unshielded, twisted-pair speaker cable).

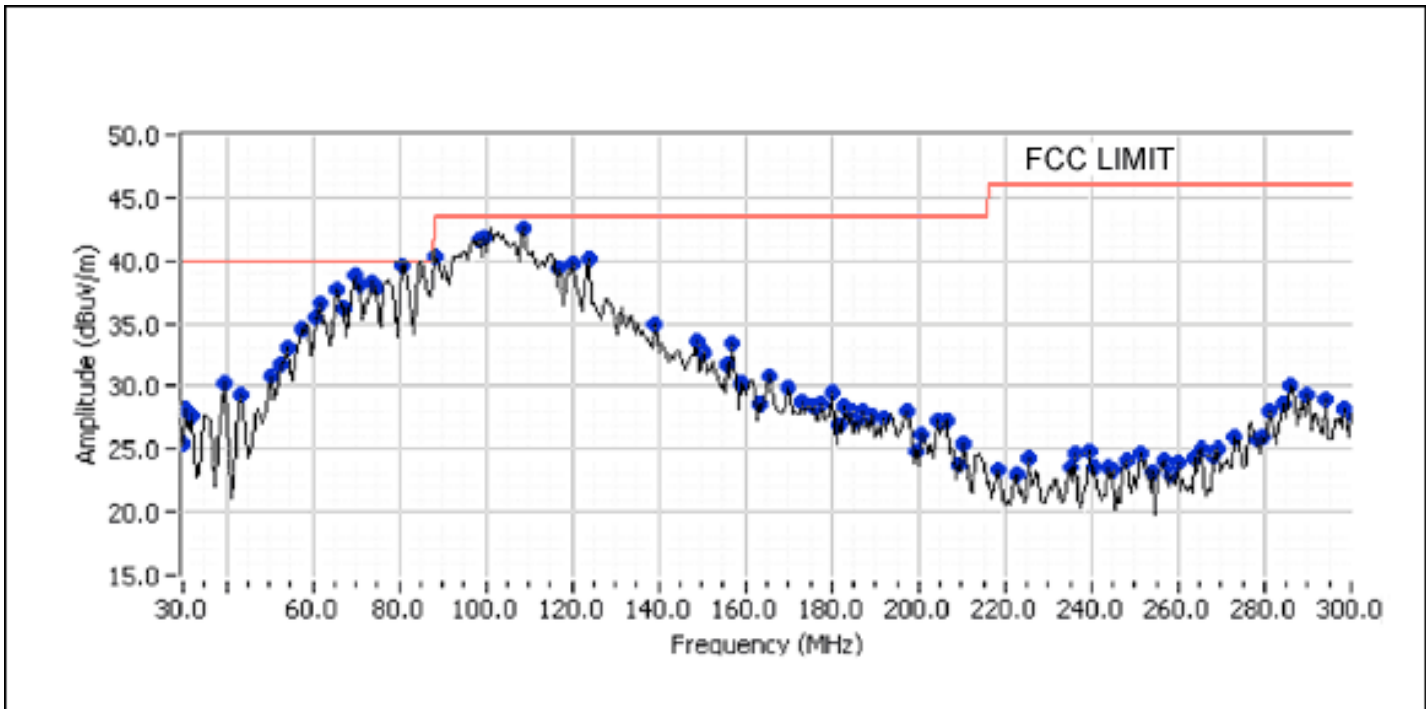


Figure 4. MAX9705 radiated emissions data (MAX9705EVMKit, spread-spectrum-modulation mode, 24 inch, unshielded, twisted-pair speaker cable).

In addition to excellent EMI performance, the MAX9705 IC features a low 0.02% THD+N, a high 75dB PSRR, and a low-power 0.3 $\mu$ A shutdown mode. The MAX9705 is available in 10-pin TDFN (3mm x 3mm x 0.8mm), 10-pin  $\mu$ MAX<sup>®</sup>, and 12-bump UCSP<sup>™</sup> (1.5mm x 2mm x 0.6mm) packages. For more a more detailed description and additional specifications, refer to the [MAX9705 data sheet](#).

## Conclusion

The emissions performance of Maxim's 3rd-generation Class D amplifiers enables the truly 'filterless' operation of Class D amplifiers in consumer electronic equipment. In this way, spread-spectrum modulation and active-emissions-limiting circuitry reduce component count, extend battery life, and enable Maxim's 3rd-generation Class D amplifiers to provide Class AB performance without sacrificing efficiency. Consequently, this 'filterless' technology allows for smaller, more cost-effective solutions, making these amplifiers ideal for cellular-phone, MP3, PDA, and notebook applications.

<sup>1</sup>For a detailed discussion of Maxim's patented spread-spectrum-modulation technology, refer to application note 3881, "[Spread-Spectrum-Modulation Mode Minimizes Electromagnetic Interference in Class D Amplifiers](#)."

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Application Note 3973: [www.maxim-ic.com/an3973](http://www.maxim-ic.com/an3973)

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