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May 15, 2007

APPLICATION NOTE 4046

# Overview of 2.1 (Satellite/Subwoofer) Speaker Systems

*Abstract: This application note provides an overview of conventional 2.1 audio designs for portable computers, and it considers the ways in which they address the unequal output power requirements of satellite speakers and the subwoofer. The article then details Maxim's highly efficient, low-cost 2.1 solution, which provides 2 × 2W and 1 × 9W of output power from a single 5V power supply.*

## Introduction

Audio designers for portable computers are constantly working on improvements to the sound of the system. In space-constrained designs, one of the better solutions is a 2.1 configuration, which uses stereo satellites for mid and high frequencies (typically 150Hz and above) and a single subwoofer for low frequencies (typically 150Hz and below). This application note leverage's Maxim's expertise in audio and power ICs to implement a 2.1 audio power-amplifier system with 2 × 2W and 1 × 9W of output power from a single 5V power supply.

## Overview of Conventional Solutions

One of the main problems faced by audio system designers has been the unequal output power requirements of the satellite speakers and subwoofer. Typically, the subwoofer requires four to five times more output power for proper sound balance. With only a 5V power supply available, a variety of audio power-amplifier solutions have been employed, each of which has its own disadvantages.

1. The most common solution has been to use two stereo power amplifiers of the same output power level. One of the amplifiers drives the satellites, and the other drives the subwoofer. The satellites use 8Ω speakers, while the subwoofer uses 4Ω speakers. This results in a 2.1 solution with 2 × 1W satellites and a 1 × 2W subwoofer. Although this solution is simple, it does not provide enough power to the subwoofer to produce a substantial amount of bass. Also, using 8Ω speakers for the satellites does not maximize the satellites' sound pressure level (SPL). Consequently, the overall sound level of this approach is limited.
2. By changing the speaker impedances of the above solution, one can use 4Ω speakers for the satellites and 2Ω speakers for the subwoofer. This creates a 2.1 solution with 2 × 2W for the satellites and 1 × 4W for the subwoofer. This solution increases the sound level by doubling the output power; however, sourcing 2Ω speakers and power amplifiers to drive these speakers is difficult and costly. In addition, the supply-current requirements are roughly doubled and the solution's efficiency suffers, resulting in possible thermal-dissipation issues, especially in space-constrained systems.
3. A better solution than the two above is to use a 2 × 2W amplifier for the satellites and a 1 × 9W amplifier for the subwoofer. In this configuration, the satellites are 4Ω and fully utilize the potential of the 5V power supply, while the subwoofer is 8Ω and provides a substantial amount of bass at 9W. However, this 9W subwoofer amplifier requires a 12V power supply, which adds complexity to the solution. With only a 5V power supply available, a 12V power supply needs to be created.

## Analysis of the Conventional Solutions

The advantage of using a 2.1 speaker system is that it provides a "big" sound from a small space. In order to

achieve this, the subwoofer amplifier needs to have at least four to five times more power than the satellites. For 2W satellites, the subwoofer amplifier should have at least 8W to 10W.

Solutions #1 and #2 above are simple to implement since they only require a single 5V supply. However, these solutions do not solve the problem since both lack an adequate amount of power to drive the subwoofer.

Solution #3 would be ideal, if not for the complexity introduced by creating an additional 12V power supply.

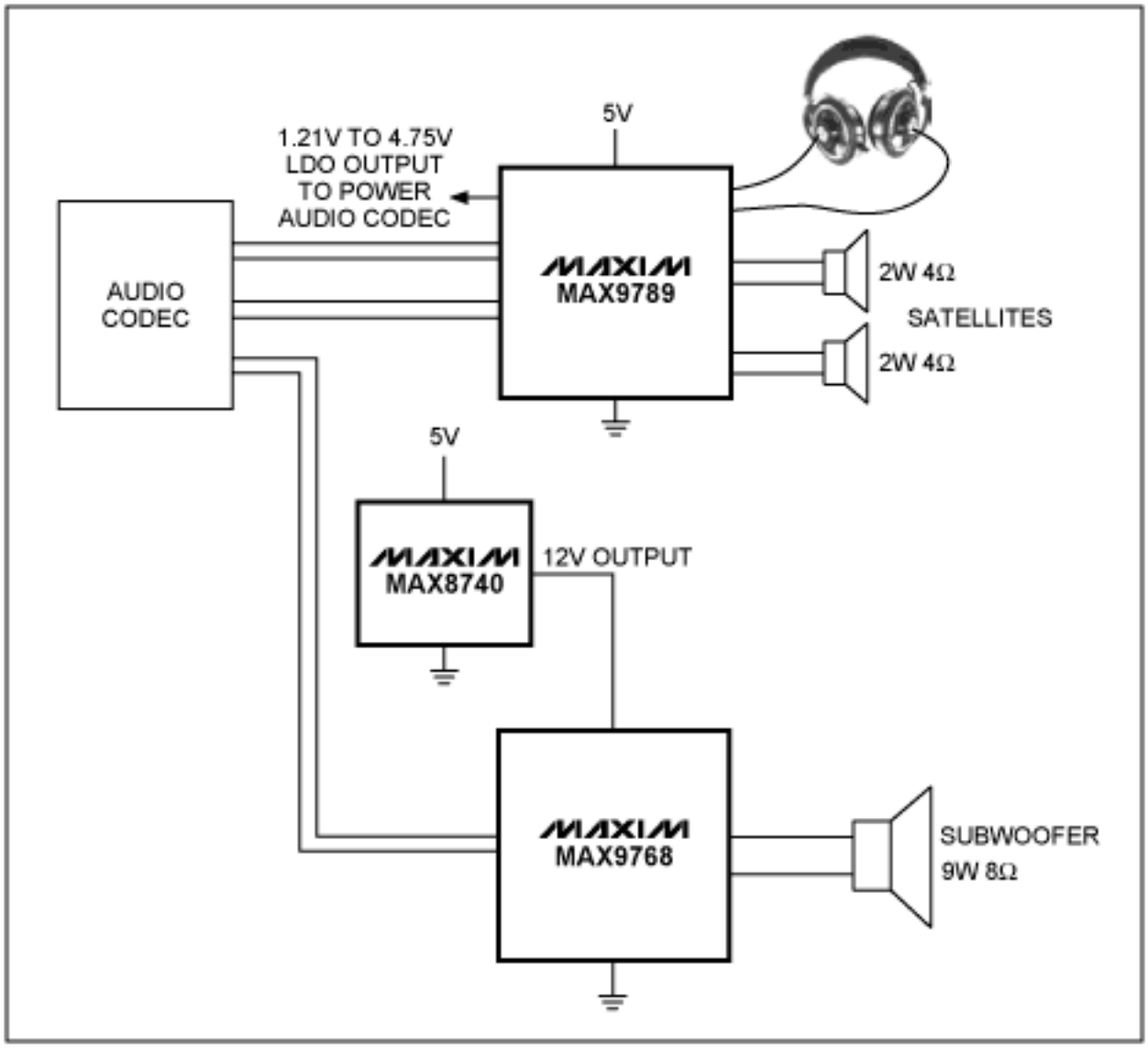


*Figure 1. Maxim's complete solution for 2.1 speaker systems.*

## Maxim's Solution and Its Advantages

**Figure 1** shows Maxim's complete solution for 2.1 speaker systems. This solution uses the MAX9789 Windows Vista®-compliant 2 × 2W stereo amplifier with stereo headphone driver, the MAX9768 1 × 10W mono Class D amplifier, and the MAX8740 low-noise step-up DC-DC converter.

The MAX9789 combines a stereo 2W Class AB speaker amplifier, which drives the satellites in the 2.1 system, and a stereo 100mW DirectDrive™ headphone amplifier into a single device. Designed for use in portable computer systems that use the Windows Vista operating system, the MAX9789 is fully compliant with Windows Vista specifications. The headphone amplifier features Maxim's patented DirectDrive architecture, which produces a ground-referenced output from a single supply, thereby eliminating the need for output-blocking capacitors.[1] This DirectDrive architecture saves cost and board space, reduces component height, and eliminates clicks and pops associated with output-blocking capacitors. Additionally, the MAX9789 integrates a 1.21V to

4.75V variable output LDO to provide a clean supply for an audio codec or other analog circuitry.

The MAX9768 is a filterless output Class D amplifier that provides 9W into 8Ω at 10% THD+N with a 12V power supply. Its Class D modulation scheme does not require output filters to reduce cost and provides an efficient 9W of power for the subwoofer in the 2.1 system. With an efficiency of 87%, the MAX9768 does not require a heatsink. Additionally, its spread-spectrum-modulation scheme allows the device to pass FCC EMI limits with 0.5m cables using only a low-cost ferrite bead and capacitor on each output.[2] (See **Figure 2** below for an FCC emissions scan of the MAX9768 customer evaluation kit using pink noise outputs and 1m cables.) Please note that the output power of the MAX9768 can be reduced if the subwoofer in the system requires less power.

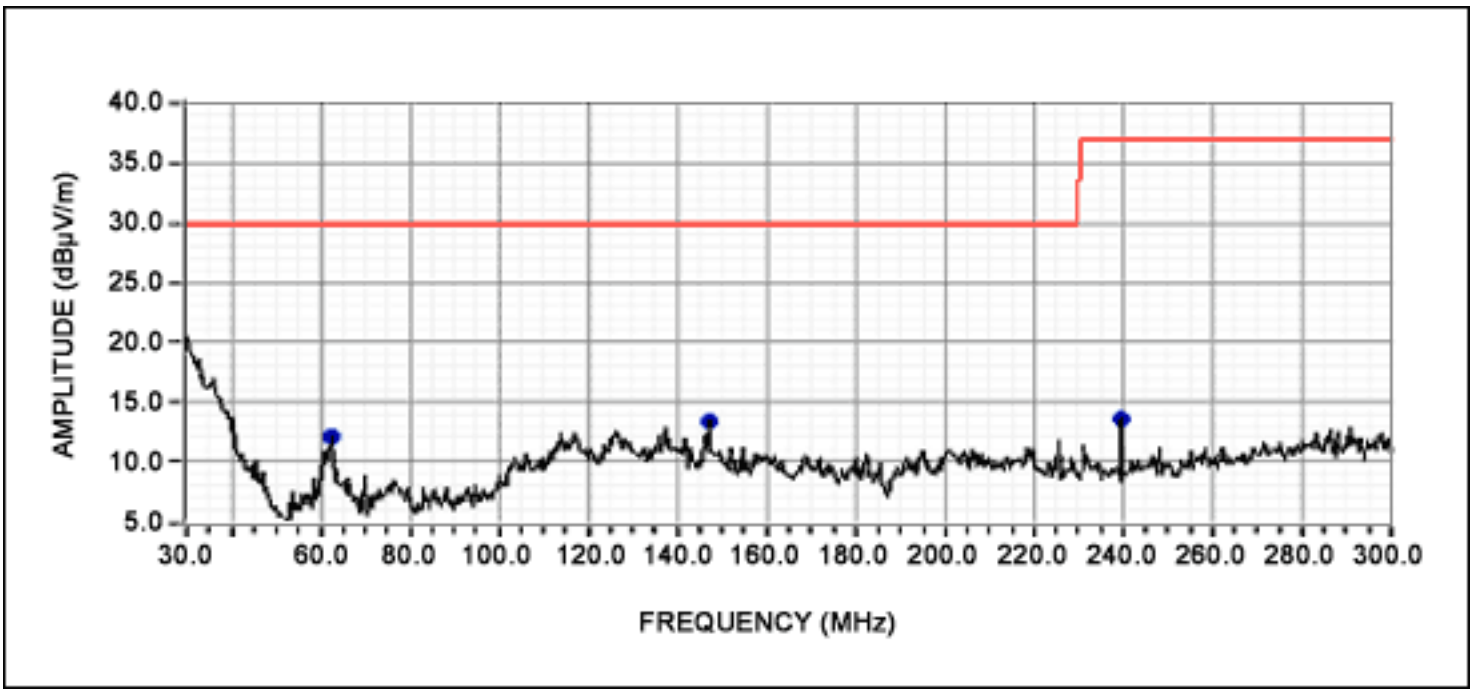


*Figure 2. The MAX9768 filterless EMI measurement using 1m speaker cables.*

The MAX8740 is a fixed-frequency, pulse-width-modulation (PWM) step-up DC-DC converter with an integrated n-channel MOSFET. This part was designed for a wide range of DC-DC conversion applications. For our solution, it is used as a step-up DC-DC converter with a 5V input voltage that generates a 12V DC voltage to power the MAX9768. The MAX8740 is simple to use, requires very few external components, and comes in a µMAX® package. With an efficiency of 90% and a shutdown current of less than 0.1µA the MAX8740 is well suited for portable battery-operated systems.

## Conclusion

This total 2.1 solution for speaker systems takes full advantage of Maxim's expertise in audio and power ICs. The MAX9789 provides a fully integrated audio solution for portable computer systems running Windows Vista. The MAX9768 provides high efficiency and high output power to sufficiently drive the subwoofer in a portable 2.1 system. The MAX8740 completes the system with an easy-to-implement approach to converting the 5V power supply to 12V and powering the subwoofer amplifier with an efficiency of 90%.

[1]For a more detailed description of Maxim's patented DirectDrive architecture, refer to application note 3979, "Overview of DirectDrive Technology."

[2]For more information on the Spread-Spectrum Modulation scheme of the MAX9768, refer to application note 3881, "Spread-Spectrum-Modulation Mode Minimizes Electromagnetic Interference in Class D Amplifiers."

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