Using an Automotive-Grade, Class-D Audio Amplifier to Improve a Vehicle's E-Call System

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Abstract

According to data from the World Health Organization (WHO), the number of deaths caused by traffic accidents worldwide is increasing every year, while the number of deaths from traffic accidents in Europe is on the decline. [1] Using this information, the study found that there was a causal relationship between how quickly someone is able to receive medical care and their chances of survival.

To further lower mortality rates, intelligent transportation has led to the invention of the emergency call, also called an e-call, function. E-call systems uses mobile phone and satellite positioning functions to establish a phone connection with the nearest rescue center's number after a traffic accident. In addition to voice connection, the onboard e-call system also reports and transmits information about the accident location, accident type, and vehicle.

Note:

1) Source: https://iris.who.int/bitstream/handle/10665/375016/9789240086517-eng.pdf?sequence=1.

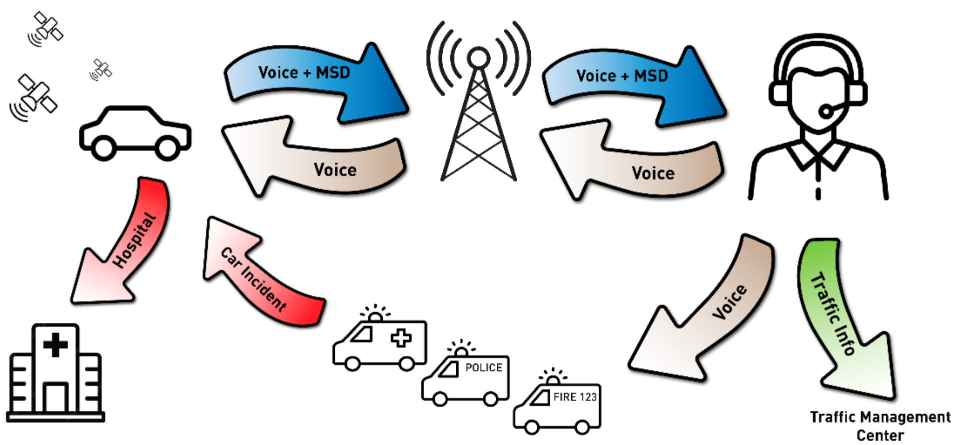

Figure 1: E-Call System

The high efficiency and diagnostic functions required for the vehicle's e-call system result in special requirements for audio systems, such as speaker diagnostics and low power consumption. This article will explore how to improve an e-call system's audio function using the MPQ7795-AEC1, an automotive-grade, Class-D audio amplifier as an example. This audio amplifier is ideal for space-constrained, high-power audio systems.

Automotive E-Call Systems

Figure 2 shows a simplified block diagram of a typical e-call system using the MPQ7795-AEC1.

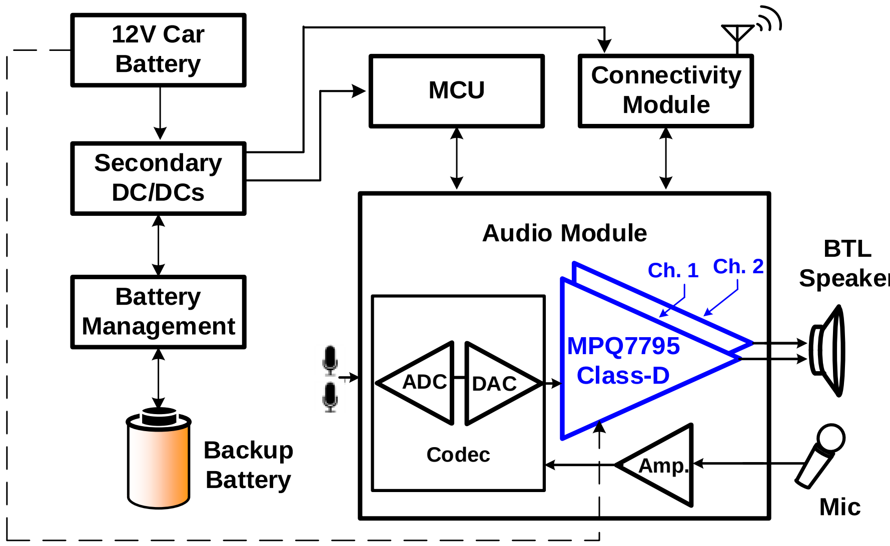

Figure 2: E-Call System (Simplified Block Diagram)

The e-call system operates from a backup battery so that it can operate even if an accident disconnects the car battery from the system.

The audio signal's input front-end and output are combined into a single codec, which includes an analog-to-digital converter (ADC) and a digital-to-analog converter (DAC). Since the audio signal path verbally connects the driver to emergency services via phone, most systems only need one channel that includes the following: one microphone, one ADC, one DAC, one Class-D amplifier, and one speaker.

Because the signal from the DAC has both low-voltage and low-current capabilities, the MPQ7795-AEC1 is an ideal Class-D audio amplifier that provides the signal with the higher voltage and current capabilities to drive the driver in the speaker.

Class-AB Amplifiers and Class-D Audio Amplifiers

Typically, there are two audio amplifiers that can be selected in automotive head-unit systems: Class-AB amplifiers and Class-D amplifiers.

It is simple to implement Class-AB audio amplifiers, which makes them convenient and applicable to many automotive audio systems. These linear amplifiers generate no electromagnetic interference (EMI) and do not require many external electronic components. However, due to their very low efficiency and bad thermal performance, they require passive (or even active) thermal management using heatsinks and fans. These additional external components mean Class-AB audio amplifiers are often more expensive overall than Class-D audio amplifiers.

A Class-D audio amplifier is a switching amplifier. The power stage of Class-D amplifiers is always working in switch mode, minimizing power loss compared to Class-AB amplifiers. In addition, Class-D audio amplifiers are highly efficient switching amplifiers that need very little thermal management; however, they do require output inductors and EMI filters due to EMI concerns. Despite this disadvantage, Class-D audio amplifiers are widely used in automotive e-call systems due to their incredibly high efficiency and small size.

High Efficiency and Excellent EMI Performance

Automotive e-call systems usually require large amounts of power. The MPQ7795-AEC1 can act as a bridge-tied load (BTL) structure for the Class-D amplifier, which makes this device well-suited to meet the power requirements in automotive e-call systems (see Figure 3).

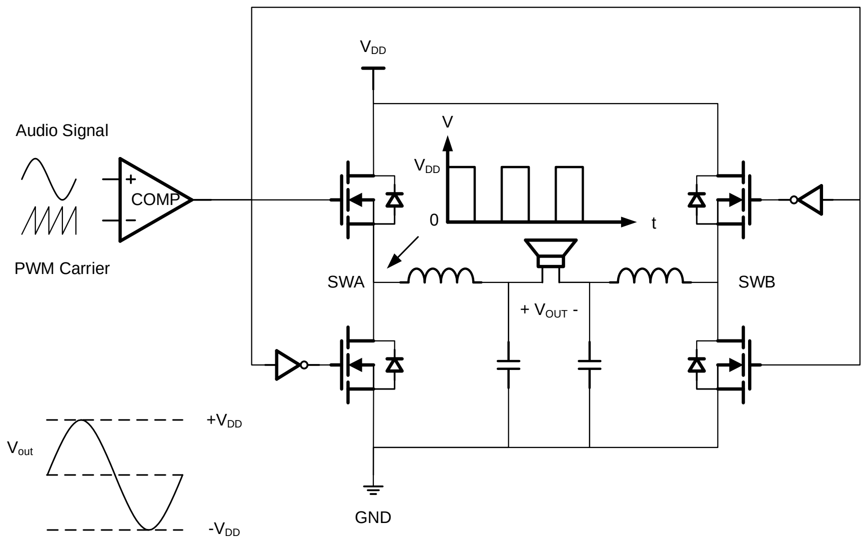

Figure 3: MPQ7795-AEC1 BTL Class-D Amplifier

The BTL amplifier's output signal amplitude (V_{OUT_BTL}) can be as high as the amplifier's supply voltage (V_{DD}). The input audio signal and feedback signal are coupled to the comparator's inverting input, which creates a single-ended circuit. V_{OUT_BTL} can be calculated with Equation (1):

$$V_{OUT\_BTL} = (2D - 1) \times V_{DD} \quad (1)$$

Where D is the duty cycle.

The BTL amplifier's maximum output power ($P_{OUT\_BTL\_MAX}$) can be estimated with Equation (2):

$$P_{OUT\_BTL\_MAX} = (V_{DD})^2 / 2R \quad (2)$$

Where R is the speaker's resistance.

One of the important factors of an e-call system is to allow the driver to talk with emergency services as long as possible, which means these systems must be highly efficient. To improve efficiency, the switching frequency (f_{SW}) can be set to 330kHz, 384kHz, 470kHz, or 2.2MHz. The MPQ7795-AEC1's efficiency exceeds 90% during both 470kHz and 2.2MHz operation. Figure 4 shows the efficiency curve vs. the output power with an 8Ω speaker. In addition, the MPQ7795-AEC1 integrates small 150mΩ on resistance ($R_{DS(ON)}$) MOSFETs that improve efficiency.

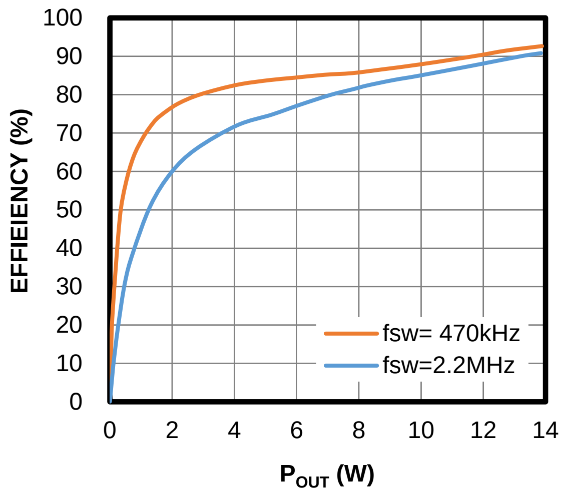

Figure 4: MPQ7795-AEC1 Efficiency Curve

In addition, when 2.2MHz operation is selected, the PCB area can be reduced due to the lower external inductor count. Figure 5 shows the MPQ7795-AEC1's small PCB area.

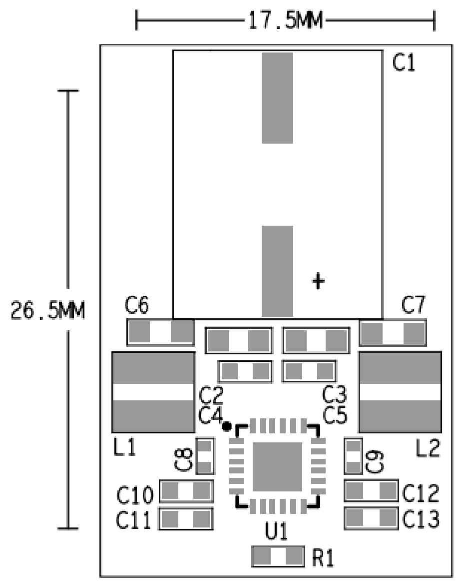

Figure 5: Small PCB Area of the MPQ7795-AEC1

In addition to the benefits of high efficiency and small PCB size, MPQ7795-AEC1 has outstanding EMI performance and can meet CISPR 25 Class 5 standards with a 2m output cable. Figure 6 shows the CISPR 25 Class 5 peak conducted emissions.

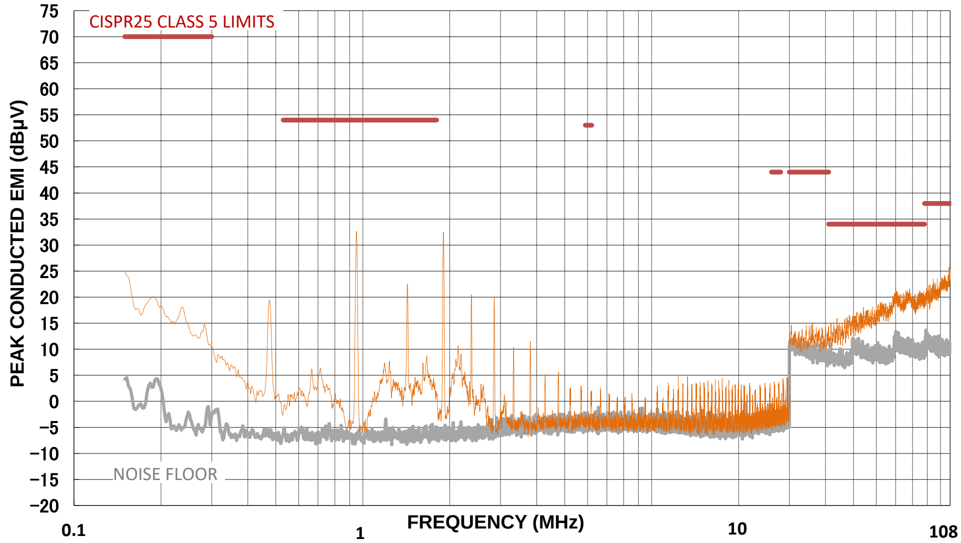

Figure 6: EMI Results for CISPR 25 Class 5 Peak Conducted Emissions

Figure 7 shows the CISPR 25 Class 5 peak average conducted emissions.

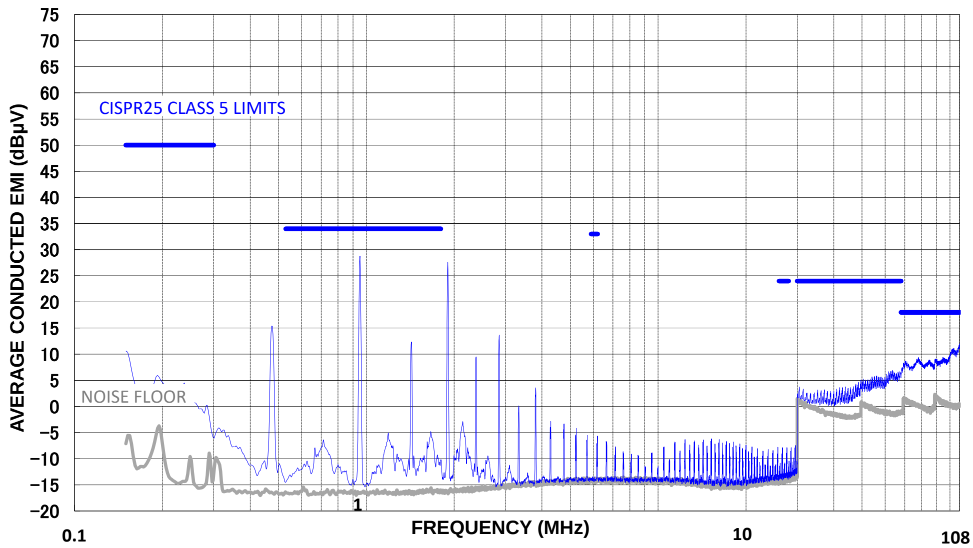

Figure 7: EMI Results for CISPR 25 Class 5 Average Conducted Emissions

Load Detection Function for Audio Amplifiers

For automotive e-call systems, it is critical that the system remains functional after a serious accident. Therefore, the Class-D audio amplifier must have integrated detection communication so that the amplifier can convey the results of these detections to the processor. If an accident occurs, the detection system helps confirm that the speaker can still facilitate communication between the driver and emergency services.

The MPQ7795-AEC1's load detection feature can detect open load, short load, output short to VDD, and output short to ground conditions. When the device is enabled, the load diagnostics run before the part starts switching, or before entering a fault state. During diagnostics, the output is in a high-impedance (Hi-Z) state. Load detection typically takes 480ms. If any fault condition mentioned above is detected, the MPQ7795-AEC1 can report the fault status to the microcontroller (MCU). At the same time, there is no pop noise during load detection for the MPQ7795-AEC1.

Conclusion

To reduce the mortality rate for automotive accidents, it is vital to have a reliable e-call system so that emergency services can be deployed as quickly as possible. Ideally, a driver will never need to use their e-call system, but in the event of an accident, it is imperative to have a Class-D audio amplifier that can effectively facilitate communication between the driver or passenger and emergency services.

The MPQ7795-AEC1 is an automotive-grade Class-D audio amplifier that provides load detection to ensure fault-tolerant operation and high output power in a tiny package. Visit the MPS website to see additional Class-D audio amplifiers that can be used to meet your automotive design needs.

References

1) World Health Organization (WHO). (n.d.). Global status report on road safety 2023. Geneva. License: CC BY-NC-SA 3.0 IGO.