THAM 12.4

A 40 W INTEGRATED CAR RADIO AUDIO AMPLIFIER

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ABSTRACT

This paper describes a BTL (Bridge Tied Load) class-H, high -power, high-efficiency audio amplifier for car radio applications. With a supply of 14.4 V, the output power is 40 W into an 8 Ω load; this is not possible using a normal class-B amplifier. Assuming that the music signal at the input has a normal (Gaussian) amplitude distribution, the dissipation is about 50% less than that of a class-B BTL amplifier with the same output power.

INTRODUCTION

A problem in car audio systems is the limited battery voltage of 14.4 V. For a 4 Ω load, this restricts the output power obtainable from single-ended class-B output stage to 6 W, and the output power obtainable from a BTL output stage to 24 W. The output power can be increased by:

- lowering the speaker impedance to 2 Ω, but the dissipation of the amplifier will then be doubled and the power loss in the connection wires will be considerable
- raising the supply voltage by a DC-DC converter (more components)
- using another amplifier configuration

Some high-power car radio boosters uses a separate DC to DC converter. In the amplifier described in this paper, the converter is integrated into the power amplifier stage. It needs only two external capacitors which are charged up to the battery voltage. When momentary high output power is required, the capacitors are connected in series with the battery supply so that the available supply voltage is doubled. This results in the availability of 80 W into a 4 Ω load, or 40 W into an 8 Ω load. Because of the high current (up to 8 A) an application with an 8 Ω load was chosen. The principle of this amplifier is called class-H.

CLASS-H PRINCIPLE

The class-H amplifier consists of a BTL class-B amplifier and a circuit which lifts the internal supply voltage. Since a music amplifier only operates in the extended voltage area for short periods, the average dissipated power is only slightly higher than that for an amplifier without the supply voltage lifting circuit, although the peak output power is substantially increased. However, a circuit for re-charging the capacitors is needed.

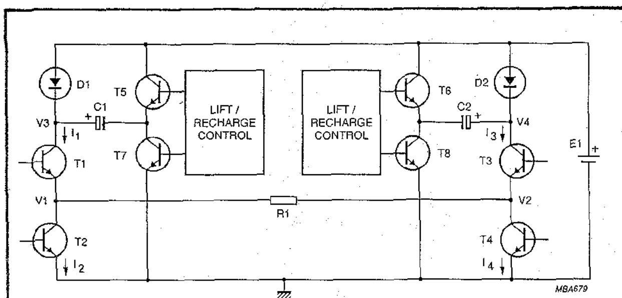

Fig.1 The class-H principle

Figure 1 shows the configuration of the class-H amplifier. T1, T2, T3 and T4 are the output power transistors of the class-B BTL amplifier, and R1 is the load resistor. Controlled current source T7 (T8) charges C1 (C2) to:

$$(V_{C1max} = E_1 - V_{D1} - V_{CEsat}T7)$$

which is about equal to the supply voltage (E1). When voltage V1 (V2) rises and T1 (T3) approaches the saturation area, this is detected by the lift control circuit. Lift transistor T5 (T6) then conducts and the charged capacitor is switched between the collector of T1 (T3) and supply voltage E1. V1 (V2) can increase to about twice the supply voltage. Precautions must be taken in the lift/recharge control circuit to prevent T5 and T7 (T3 and T4) from conducting simultaneously.

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Because the quiescent level of V1 (V2) is half the supply voltage, V1 or V2 can increase to twice the supply voltage, but can only decrease by half the supply voltage. This results in a voltage swing which is asymmetrical with respect to ground at both amplifier outputs. If the supply voltage of one half of the amplifier bridge is increased, the other output clips to ground. This distortion can be eliminated by using a feedback circuit which measures the output voltage across the load (not with reference to ground). Figure 2 shows some waveforms.

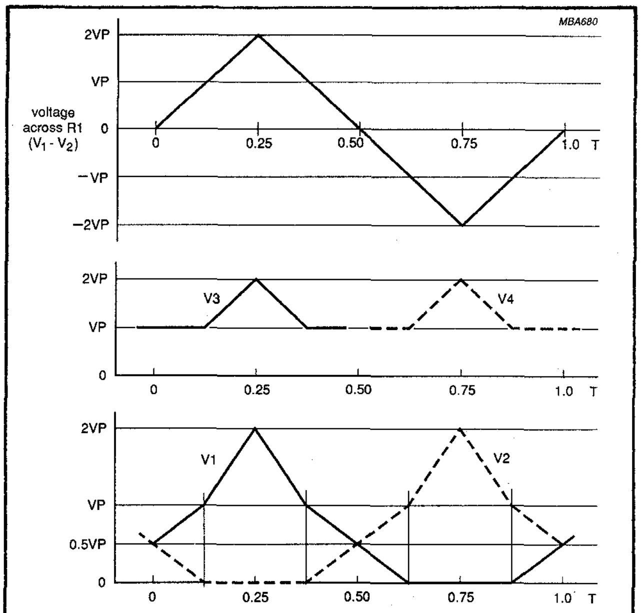

Fig.2 Waveforms of V1, V2, V3 and V4 in Fig.1

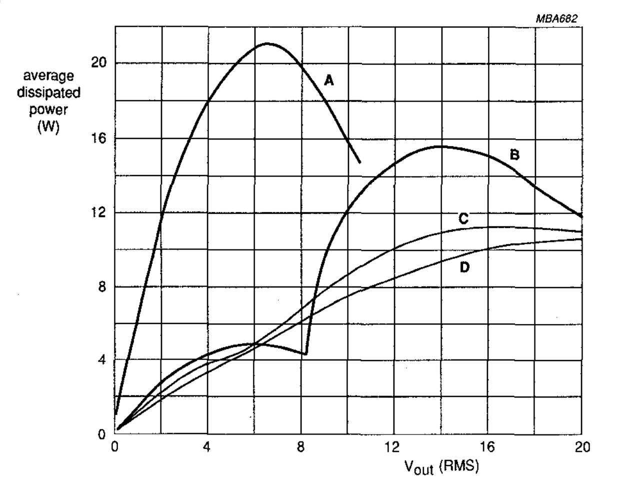

Fig.3 Average power dissipation as a function of RMS output voltage. Curve A: class-B, sinewave, 40 W into 2 Ω. Curve B: class-H, sinewave, 40 W into 8 Ω. Curve C: gaussian. Curve D: exponential

Assuming that the amplifier is driven with a Gaussian distributed signal, like noise or a music, the average dissipated power is low. It can be determined that the average dissipated power in the output stages is about 5 W at a maximum practical listening level. Figure 3 is a curve of the dissipation as a function of output level (sinewave and Gaussian noise). The benefit of the class-H principle is that it allows a much smaller heatsink to be used than would be needed for a 40 W class-B amplifier.

FEATURES

Major features of the amplifier include:

- Differential inputs for high common-mode rejection; a mute facility which operates on the input buffer is controlled by a mode-select-switch pin
- A load impedance sensor (LIS) measures the load before switching on the power amplifiers; in the event of a short-circuit, the output stages remain in the off-state. With a 4 Ω load, the supply lifters remain in the off-state so that too much power cannot be delivered to the load
- Capacitor re-chargers consisting of the power transistor T7 (T8) driven by a controlled current source. By measuring the voltage at the collector of T7 (T8), the current source regulates the dissipation of T7 (T8) to a constant value during recharging of C1 (C2). Transistor T7 (T8) is switched off when C1 (C2) is fully charged
- A global temperature sensor, measuring the package temperature and disables the supply lifters at temperatures above 120 °C; to prevent distortion, the supply lifters are only disabled at the zero crossing of the output signal
- Several protection circuits disable the power stages in case of excessive temperatures (150 °C), load-dump transients on the supply, output current greater than 5 A. The "missing current limiter" compares the current flowing into the load with the current flowing out of it; if there is a difference (due to a short-circuit to ground or supply), the excess current is limited to a safe value to prevent excessive dissipation in the output transistors

IC FABRICATION

A dual-layer metallization 18 V bipolar process, with isolated vertical PNPs, is used to fabricate the IC. Special circuit design techniques are used to prevent breakdown at the internal maximum supply voltage of 36 V. The 19 mm^2 chip is mounted in a 17-pin power SIL package.