Class B amplifier has automatic bias

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Class B amplifiers are prone to crossover distortion, which occurs in the output stage in which conduction transfers from one transistor to the other. To prevent crossover distortion, a bias current must flow in both transistors simultaneously. The bias current prevents both transistors from turning off in the transition region. Classic bias circuits keep a constant dc polarization voltage between the bases of the two transistors. Often manually adjusted, it keeps the two transistors on the edge of conduction when there is no signal present. Such a circuit is sensitive to temperature and needs some form of compensation to prevent thermal runaway, which can lead to failure. **Figure 1** shows an approach in which automatic bias eliminates the problem.

In this Class B amplifier, R_1 sets the bias current at idle mode with no signal. Emitter current for Q_3 is $(V_{CC}-V_{BIAS}-V_{BEQ3}-V_{BEQ1})/R_1$, where V_{CC} is the power-supply voltage, V_{BIAS} is the dc voltage on the emitters of Q_1 and Q_2, V_{BEQ3} is the base-to-emitter voltage of Q_3, and V_{BEQ1} is the base-to-emitter voltage of Q_1. Q_1 and Q_2 mirror this current because Q_1 and Q_3 share the same base current, as do Q_2 and Q_4. Assuming that the four transistors are perfectly matched, all of them have the same base current and the same collec-

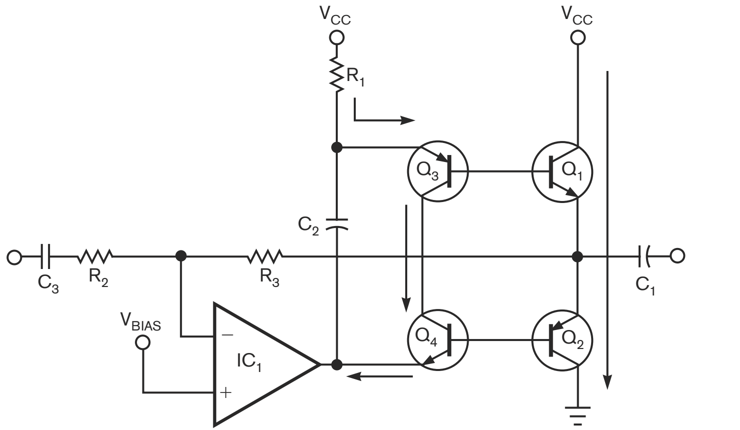

Figure 1 A bias current flows in the transistors that prevents Q_1 and Q_2 from being off simultaneously.

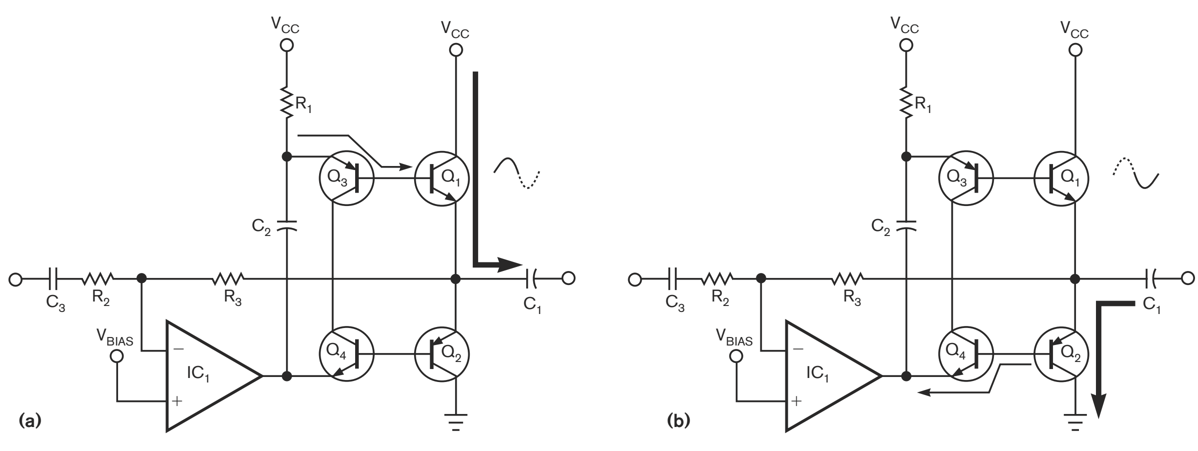

Figure 2 On a positive half-cycle, current flows from Q_1 through C_1 to a load (a). On a negative half-cycle, current flows through Q_2 (b).

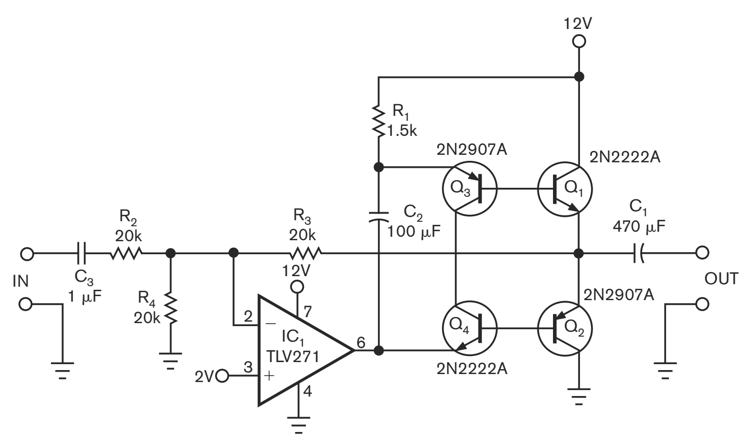

Figure 3 A typical application of this Class B circuit is a headphone amplifier.

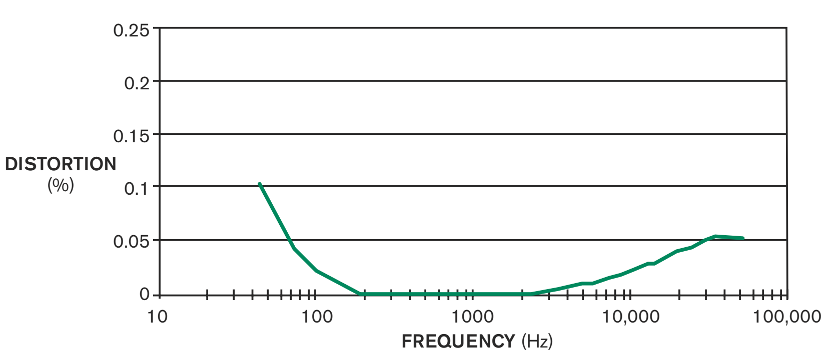

Figure 4 This graph shows distortion as measured on the circuit of Figure 3.

tor current, so the emitters of Q_1 and Q_2 precisely mirror the current in R_1. Transistor matching is unnecessary, however. With unmatched transistors, either Q_3 or Q_4 must operate in saturation, and, because the mirror effect depends on the transistors' current gain, h_{FE}, the difference between Q_1/Q_2 bias current and the current in R_1 can be significant. This circuit automatically adjusts the voltage on C_2 to compensate for temperature and the transistors' characteristics.

When a signal is present, the current gain is the h_{FE} of output transistor Q_1 or Q_2 (the same as for a classic Class B amplifier). On the positive part of the signal, Q_1 carries the load current. Because the base current increases, Q_3 enters saturation. On the negative part of the signal, Q_2 carries the load current and Q_4 saturates.

Figure 2 shows the ac-current path. The maximum average load current is the idle current in R_1 times the current gain of Q_1 times two. The op amp must be able to sink the base current of Q_2 (load current/h_{FE})+(($V_{CC}-V_{BE}\times4$)/R_1). A typical application of this Class B amplifier delivers 0.25W into 8Ω (**Figure 3**). **Figure 4** shows the total harmonic distortion over the 45-Hz to 50-kHz band—that is, 1V rms into 8Ω.EDN