

# Low Distortion Class B Output

## *New approach to the problem of cross-over distortion in transistor audio power amplifiers*

For some time designers of transistor high-fidelity amplifiers have been restricted to a choice between three types of class B output circuit: (1) a pair of matched complementary transistors; (2) a pair of identical transistors in series cascade with a twin-secondary driver transformer, and (3) a quasi-complementary circuit using identical output transistors in series cascade but with complementary driver transistors. All three raise problems in design and manufacture, the best known ones being lack of circuit symmetry, difficulty of proper control of transistor quiescent currents and problems of the l.f. rolloff. Now a new type of output circuit has appeared which, the designers say, overcomes these problems and makes possible a transistor power amplifier of exceptionally high performance. The circuit shown in Fig. 1 in slightly modified form, has been developed by The Acoustical Manufacturing Company for a new power amplifier.

As will be seen from Fig. 1 the circuit is really a development of the quasi-complementary arrangement, but each half of the class B system contains three directly coupled transistors instead of just the usual driver and output. The first two,  $Tr_1$  and  $Tr_2$  are low power complementary types, the second two,  $Tr_3$  and  $Tr_4$ , medium power complementary types and the final two high power identical devices. One reason for this arrangement is to avoid the distortion which normally occurs in the quasi-complementary circuit as a result of the asymmetry of the upper and lower halves of the output stage. In the Fig. 1 arrangement each of the transistor "triples" can be considered as an "emitter follower", as brought out in the much simplified form of Fig. 2. And each of these "emitter followers" has the usual characteristics of this device: high input impedance, low output impedance, and the voltage across the emitter resistor (and hence the current through it) following the base voltage independently of the characteristics of the active device. For these conditions to hold, of course, the loop gain of the "emitter follower" must be very high, and this is assured by the use of the three transistors – the overall current gain approaching the product of the three individual beta values. The two units shown shaded in Fig. 2 can be considered as two "black boxes," exactly equivalent to a complementary pair of output transistors of very high current gain. The arrangement has, however, a very important advantage over a complementary pair when we come to consider quiescent current and temperature effects.

Ideally in a class B amplifier the two transistors should be biased so that one is completely cut off while the other is conducting. In practice this cannot be done because it results in crossover distortion. It is necessary in fact to apply a small forward bias to the transistors to obtain a suitable value of quiescent current that will reduce this distortion to a minimum. The required quiescent current should be kept constant, but in many power amplifier circuits this is difficult to achieve because the quiescent current depends on the temperature of the base-emitter junction of the power transistors and this in turn varies from moment to moment due to variations of audio power and thermal storage time constants.

In the Quad circuit the voltage developed across the 0.3 Ohm resistors by the quiescent current is compared with a fixed reference voltage at the  $Tr_1$  and  $Tr_2$  base-emitter junctions. Since these are operating at very low power there is negligible change due to temperature resulting from varying audio power. Ambient temperature changes are exactly compensated by the same temperature change in the diodes  $D_1$  and  $D_2$  providing the reference voltage. Thus the two "black boxes" can be seen to be the equivalent of a complementary pair with thermally isolated base emitter junctions.

The other two diodes,  $D_3$  and  $D_4$ , are limiting devices which prevent the output transistors from exceeding their current ratings. If, in either half of the class B circuit, the current through the 0.3

Ohm resistor attempts to exceed a given safe upper limit (approx. 3A) the increased voltage across the resistor will cause the corresponding diode to conduct and thus prevent the corresponding transistor (Tr1 or Tr2) from being turned on further by the incoming signal. As can be seen, the arrangement is symmetrical, providing limiting for both directions of output current swing.

## List of Figures

**Figure 1;** The output section of the Quad 303 power amplifier (slightly simplified) showing the two transistor triples.

**Figure 2;** Simplified representation of the Fig. 1 circuit as two “emitter followers”.