An Ultra-Low Distortion Direct-Current Amplifier

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A high-power complementary symmetry emitter-follower output amplifier is described which can drive loads in the impedance range of 4 to 16 ohm, providing distortion of less than 0.2% in the range from 20 to 20,000 Hz. Performance measurements on the amplifier are presented and discussed.

INTRODUCTION Although NPN silicon power transistors have been used in commercial audio amplifiers for several years, it is only recently that high-power, high-beta, high-voltage, high-frequency silicon PNP transistors have been available. The commercial appearance of these devices has made possible the design of high-power complementary symmetry emitter-follower output amplifiers capable of driving loudspeakers or other loads in the impedance range from 4 to 16 ohm, with very low distortion and excellent performance up to 100,000 Hz and beyond.

CIRCUIT DESIGN

Figure 1 is a schematic diagram of the Locanthi three-stage cascaded complementary symmetry emitter-follower output circuit, hereafter referred to as the T-circuit. (Because of its NPN-PNP symmetry, the configuration has the general appearance of a bridged-T circuit.) Before describing the special advantages of this particular design, perhaps it should be explained why the complementary symmetry emitter-follower was chosen as the starting point for the development of an amplifier.

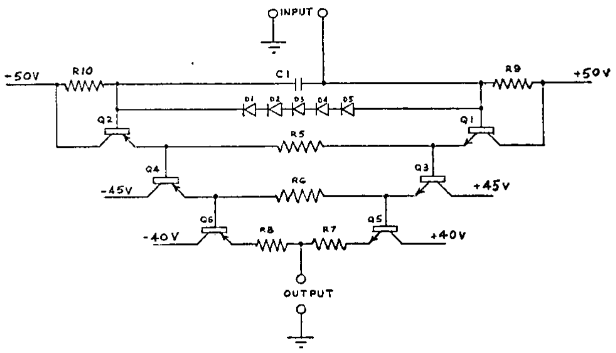

Fig. 1. Three-stage output circuit (note the **T** configuration).

First, a look at the negative side of the picture. Of all three possible configurations for a transistor output circuit, the emitter-follower places the most difficult demands upon the preceding driver stage. In the first place, since β is a function of output current, the impedance presented by the output stage to the driver varies directly with the output current. Obviously, a high-impedance driver stage cannot be used successfully because distortion will result as the β of the output stage varies.

Moreover, the base-to-emitter capacitance of most transistors is quite large, and varies with the output current of the transistor. At high frequencies, this nonlinear input capacitance presented by the emitter-follower to its driver stage results in another limitation on performance. The high-frequency distortion produced by this effect can be severe, particularly with germanium output transistors. Even though the input capacitance of silicon power transistors is an order of magnitude lower than that of comparable germanium devices, the problem is still there and cannot be ignored.

Third, the power gain of an emitter-follower is relatively low, approximately a factor of ten lower than that of either of the other two possible output circuit configurations. Fourth, since the voltage gain of the output stage is only about 0.92, the driver must supply 8% more voltage than appears across the load impedance.

These disadvantages were overbalanced by the desire for a low-distortion voltage-following amplifier of very wide bandwidth. Since the voltage gain for the output transistors is approximately equal to $\beta/(1+\beta)$, and since beta at the highest output current for the transistors selected is about 25, the instantaneous output voltage at the point of maximum output current is down only 4%;