Helping a 709-type op amp to outperform itself

by Jiří Dostál
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A complementary-transistor output stage turns the 709-type operational amplifier into a far better performer than it is by itself. Such a stage can extend the device's unity-gain bandwidth to 15 megahertz, its slew rate to 300 volts/microsecond, its full-power frequency to 5 MHz, and its dc gain to 300,000. Moreover, the resulting over-all amplifier settles in only 3 μs to within 0.01% of the full-scale output voltage.

The circuit's high-frequency and pulse characteristics are derived from the output stage. Its input offset characteristics are principally those of the op amp.

At dc or low frequencies, the gain of the op amp is multiplied by the gain of the output stage. The equivalent differential resistance between the collectors of transistors Q_1 and Q_2 is designed to be about 100 kilohms, making the gain of the output stage approximately equal to 7. Resistor R_1 is included to keep the stage's gain at this value, in case the differential resistance changes. Resistor R_2, on the other hand, reduces output distortion by assuring that the op amp's output emitter-follower is effectively biased off.

At the circuit's upper frequency limit, the op amp rolls off rapidly and the gain of the parallel feed-forward path dominates. The transfer function of the op amp becomes that of an integrator, which is formed by series resistor R_3 and the feedback collector capacitances, C_{C1} and C_{C2}, of transistors Q_1 and Q_2. The circuit's small-signal bandwidth can be written as:

$$f_t = 1/[2\pi R_3(C_{C1}+C_{C2})$$

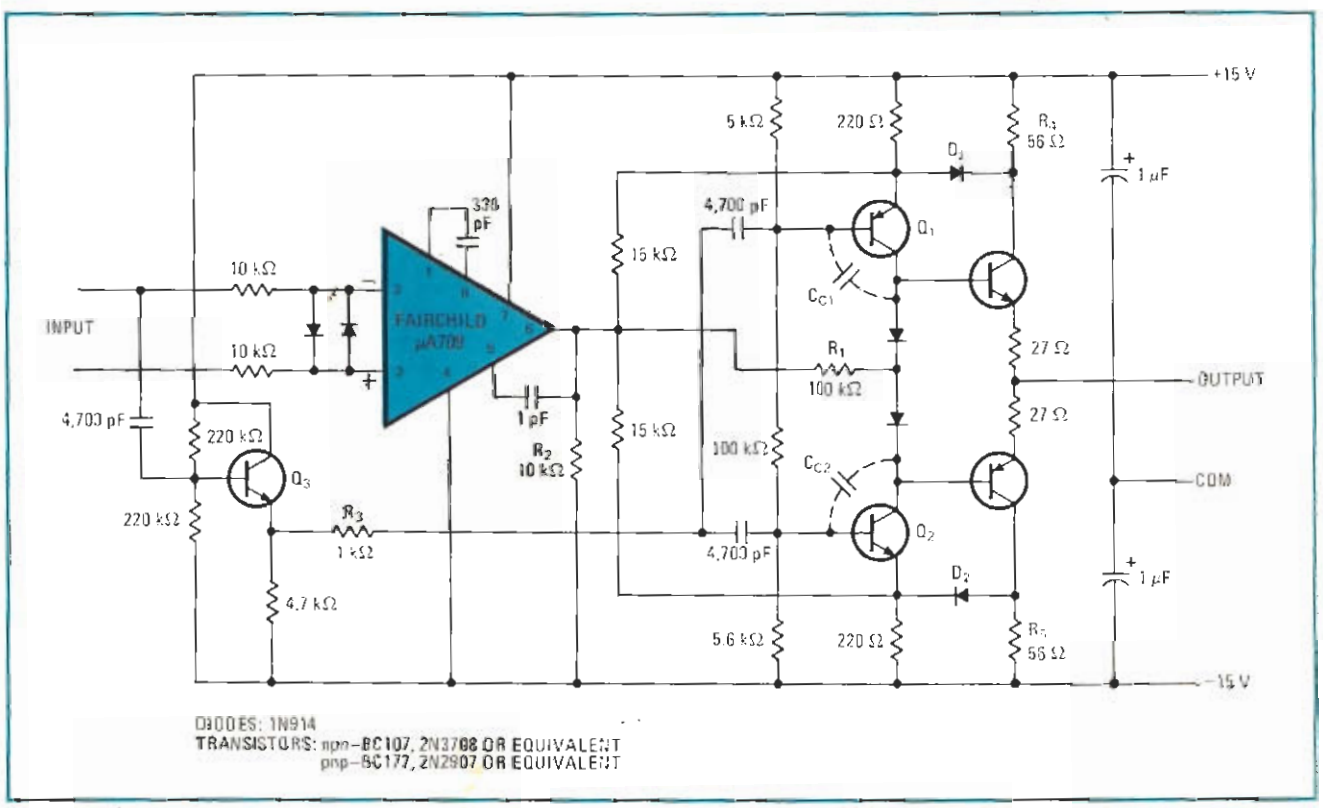
which is approximately 15 MHz when C_{C1} and C_{C2} are each 5 picofarads. The emitter current of transistor Q_3 sets the circuit's slew rate:

$$S.R. = I_{E3}/(C_{C1}+C_{C2})$$

which is around 300 V/μs for an emitter current of 3 milliamperes.

The constant base potentials of transistors Q_1 and Q_2 are used to limit any output short-circuit currents, which are sensed by resistors R_4 and R_5 and diodes D_1 and D_2. If desired, the signal line to the op-amp's noninverting input can be biased within the common-mode range of the 709-type op amp. □

Super amplifier. Output stage made up of complementary transistors increases the speed and extends the frequency response of the 709-type op amp. The over-all amplifier, which can be powered by one ±15-volt supply, has a unity-gain bandwidth of 15 megahertz and slews at the rate of 300 volts/microsecond. At high frequencies, the op amp is like an integrator, and capacitances C_{C1} and C_{C2} dominate.



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