Diode compensates distortion in amplifier stage

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THE VOLTAGE AMPLIFIER in **Figure 1** exhibits smaller nonlinear distortion than does the conventional amplifier in **Figure 2**. Diode D_1 compensates for the distortion inherent in the npn transistor. The voltage gain of a common-emitter amplifier depends on the transconductance of the transistor. The transconductance of the bipolar transistor is as follows:

$$S=\frac{eI}{k(273+T°C)}=nI,$$

where e is the charge of an electron, k is Boltzmann's constant (approximately 1.38×10^{-23}J/°K), T°C is temperature in degrees Celsius, I is the emitter current, and n=e/[k(273+T°C)]. So, the transconductance is proportional to the emitter current. Consequently, the instantaneous voltage-gain coefficient of the conventional common-emitter amplifier is proportional to the instantaneous emitter current. As a result, the negative half-cycle of the output signal gets more amplification than does the positive half-cycle (**Figure 3**).

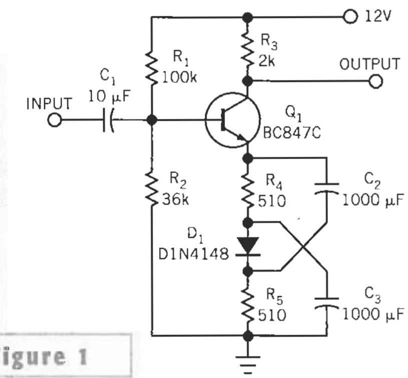

Figure 1 The addition of a simple diode in the emitter circuit yields the symmetric waveform of Figure 4.

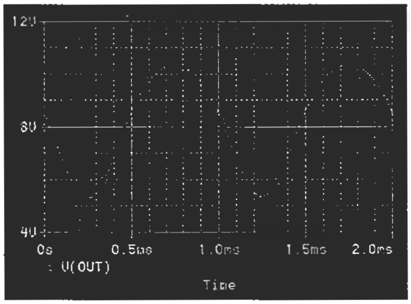

Figure 3 Nonlinearity of the transconductance of Q_1 results in this distorted waveform.

The dynamic resistance of diode D_1 in **Figure 1** is inversely proportional to the instantaneous current. That dynamic resistance forms part of the negative-feedback circuit of the amplifier. The average current of diode D_1 is equal to the average emitter current of transistor Q_1. However, the instantaneous current of D_1 becomes smaller, and the instantaneous dynamic resistance of D_1 becomes larger when the instantaneous emitter current of Q_1 becomes larger, and vice versa. Therefore, the negative feedback becomes stronger during the negative half-cycle of the output signal. As a result, the output signal of the amplifier becomes more symmetric (**Figure 4**). The circuits in **figures 1** and **2** have the same average collector current and the same load resistance. **Figures 3** and **4** show the results of their PSpice simulation. The amplitude of the output signal is 5V p-p in both cases with a 1-kHz sinusoidal signal applied to the input. You can see that the linearized amplifier yields a more symmetrical output signal. **Figure 5** gives the quantitative results of the simulations. The improvement in harmonic distortion accrues because of the suppression of the even harmonics in the output of the linearized amplifier.□

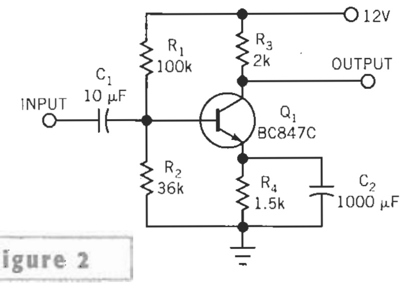

Figure 2 This amplifier circuit produces the distorted waveform of Figure 3.

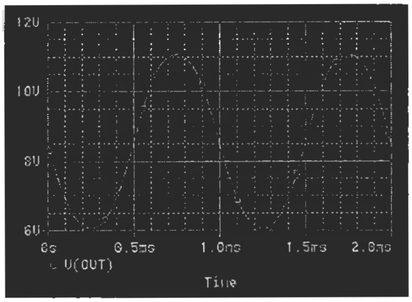

Figure 4 The diode in the circuit of Figure 1 produces varying, beneficial, negative feedback.

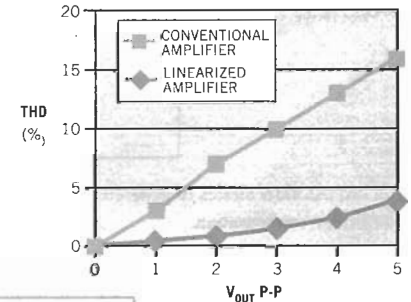

Figure 5 The linearized amplifier produces less than one-third the harmonic distortion of the conventional amplifier.