Distortion in BJT Amplifiers

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Overview

This paper explores the linearity of the transfer function of a bipolar junction transistor. The bipolar junction transistor has an exponential transfer function and is thus very non-linear and the desired signal may be subjected to considerable distortion. However, if the signals are small enough then the exponential can be approximated as very linear.

The fundamental problem with the exponential transfer function is that as the signal at the base of the transistor goes positive the collector current increases at an increasing rate and as the signal at the base goes negative the collector current decreases at a decreasing rate. This causes distortion as shown in Figure 1.

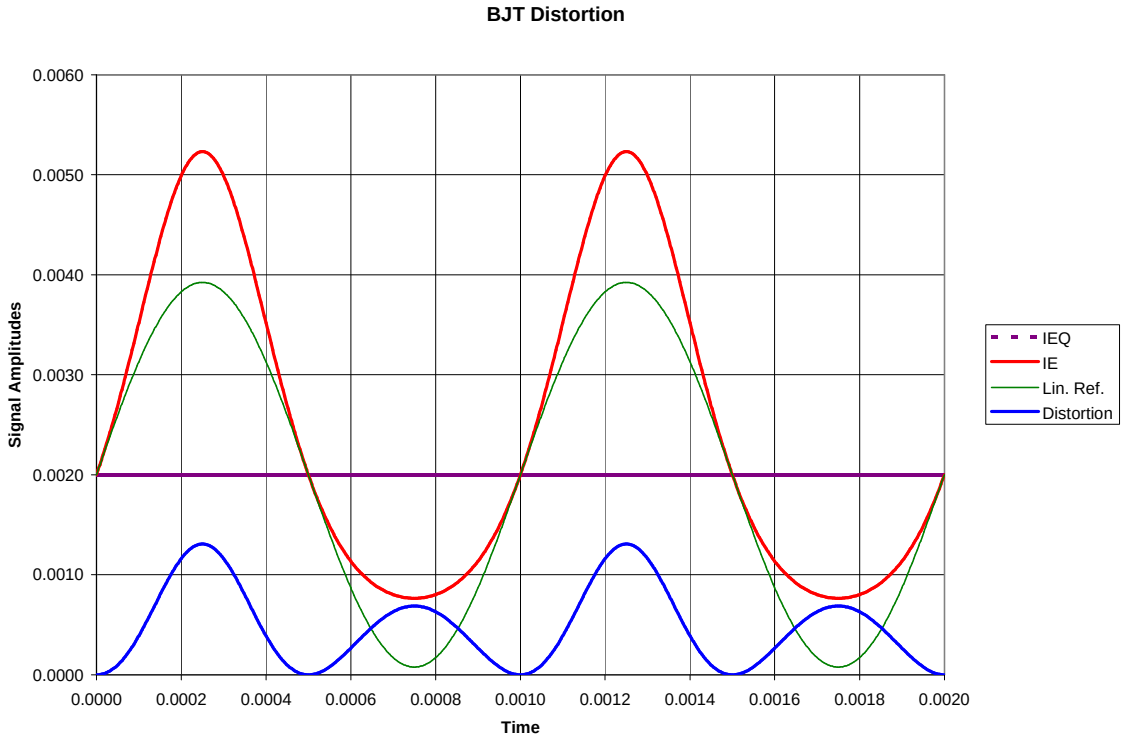

Figure 1: BJT Distortion for 50 mVpp across base-emitter junction

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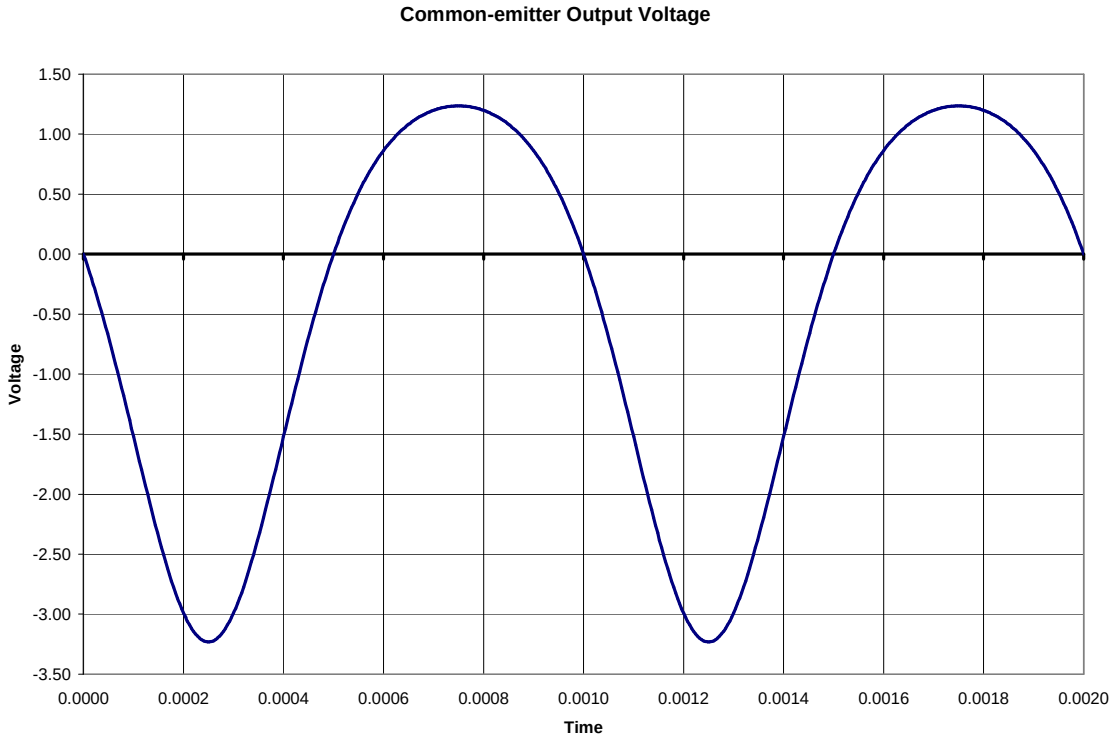

Figure 2: BJT collector output signal for 50 mVpp across base-emitter junction

A 1 mV change across the base emitter junction leads to a 3.8 percent change in the collector current.

When the source impedance of the signal source is negligibly small, the following two equations give predict the total harmonic distortion that will occur in the collector current due to variation in re with signal. The equations are very accurate for distortion (for sine waves) up to about 10 percent. Accuracy beyond 10 percent is moot as that level of distortion is too high for any good use as we generally strive to have distortion well below 10 percent. The term, vjpp, is the peak-peak signal in volts across the base-emitter junction. V_T is the thermal voltage which is around 0.026 volts at room temperature.

Percent distortion = vjpp * 481

Percent distortion = (vjpp / V_T) * 12.5

Distortion	**(vjpp/VT)**	**vjpp**	**vjrms**
0.1 %	0.008	0.000208	0.0000735
0.3 %	0.024	0.000624	0.000221
1.0 %	0.08	0.00208	0.000735
3.0 %	0.24	0.00624	0.00221
10.0 %	0.80	0.0208	0.00735

This does not automatically mean that the input signal to the amplifier has to be limited to these levels. It is the portion of the input signal that appears across the base-emitter junction that needs to be limited. In a common-emitter amplifier there is usually some un-bypassed external resistance in the emitter circuit. In a common-collector amplifier there is significant resistance in the emitter circuit. In each case a significant portion of the input signal may be across the external resistance.