Nonlinear Distortion Reduction by Complementary Distortion*

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Summary—**Nonlinear distortion produced in a given circuit can be reduced by pre- or postdistorting the signal applied to or from the circuit. Such complementary distortion cannot reduce the original distortion to zero in practice because of distortion of distortion, but it can result in greatly reduced output distortion over a limited amplitude range. General results for the design of pre- or postdistortion circuits are given, and the mathematical results are illustrated by comparing the total harmonic distortions obtained with pre- and postdistortion corrections of increasing complexity applied to a simple nonlinear circuit.**

Introduction

THE correction of an undesired frequency distortion, such as a droop in loudspeaker output at low frequencies, by means of a complementary response in the applied signal is well known and often used. Somewhat less well known and understood is the corresponding technique for reducing nonlinear distortion. It is usually stated or implied[1,2] that nonlinear distortion such as that arising from the response characteristic of Fig. 1(a) can be cancelled by passing the distorted signal through a circuit having the complementary response characteristic of Fig. 1(b). For example, it is often expected that if the distortion arises only from a square-law term, it may be completely cancelled by subsequent transmission through a network yielding square-law distortion of equal magnitude but opposite sign. The present work shows that complete cancellation is impossible because of distortion of the original distortion and that over-all distortion reduction is only possible over a limited range of input signal amplitude.

Negative feedback is commonly regarded as the great panacea for distortion. Nevertheless, there are instances where its application for nonlinear distortion reduction is inconvenient or impossible. Such instances often occur at the beginning or end of a signal transmission system. In the audio field, it is difficult to generate an error signal to correct any nonlinear distortion arising in a record pickup. Loudspeaker nonlinear distortion, at the opposite end of the system, is usually more important because of its greater magnitude. Because of reverberation and phase shifts, it is not generally practical to apply negative feedback between the sound output of a loudspeaker and its driver. On the other hand, feedback derived from a separate winding on the voice coil will be imperfectly related to the actual sound output. In this instance, where negative feedback is impractical or inefficient, complementary nonlinear distortion can greatly reduce the distortion present in the speaker output.

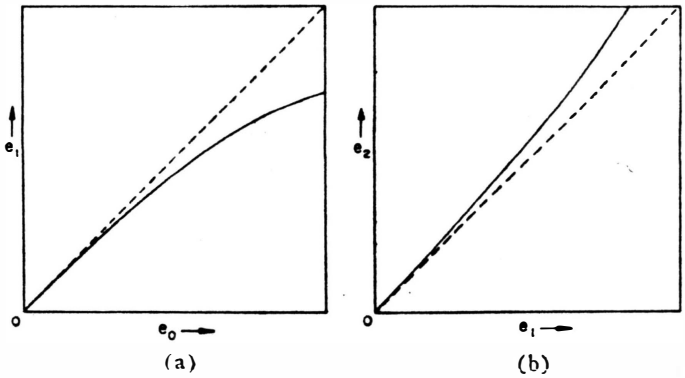

Fig. 1—(a) Typical input-output characteristic for a nonlinear circuit. (b) Input-output characteristic complementary to that of (a).

There are two ways by which complementary distortion correction may be applied. The usual way, which will be designated postdistortion, is that illustrated in Fig. 1. Here the complementary distortion acts on the originally distorted signal. Comparable but not identical results can be obtained, however, if the signal is first in-

* Manuscript received by the PGA, July 6, 1959.
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[1] P. A. Reiling, U. S. Patent No. 2,293,628, issued August 18, 1942.
[2] G. Guanella, U. S. Patent No. 2,776,410, issued January 1, 1957. A means alternative to complementary distortion correction is described in this patent.