

United States Patent

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[54] REDUCTION OF HARMONIC DISTORTION

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[51] Int. Cl.H03b 1/04

[58] Field of Search.....328/165, 167, 171, 162; 332/18; 307/229, 237

[56]

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[57]

ABSTRACT

Harmonic distortion generated in signal processors is reduced by pre-emphasizing the processor input signal and de-emphasizing the processor output signal.

4 Claims, 3 Drawing Figures

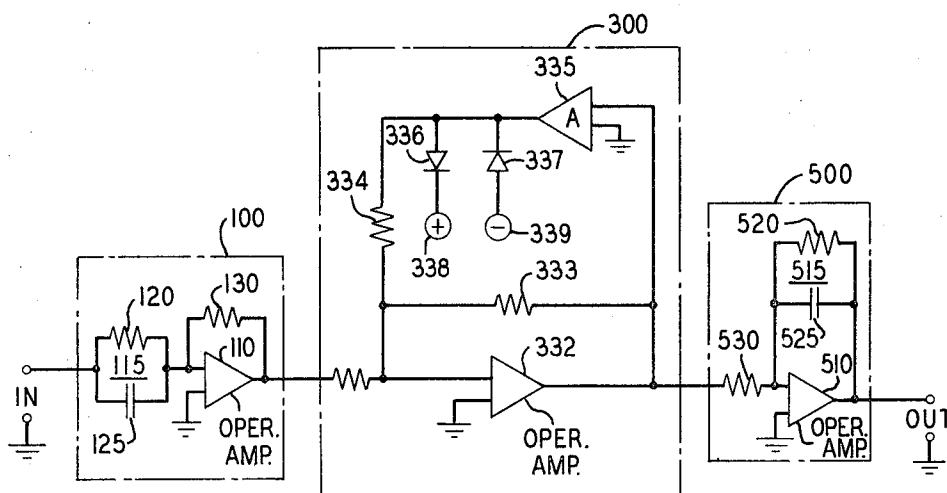


FIG. 1

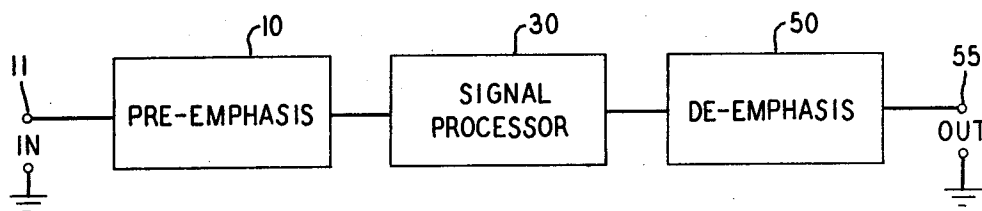


FIG. 2

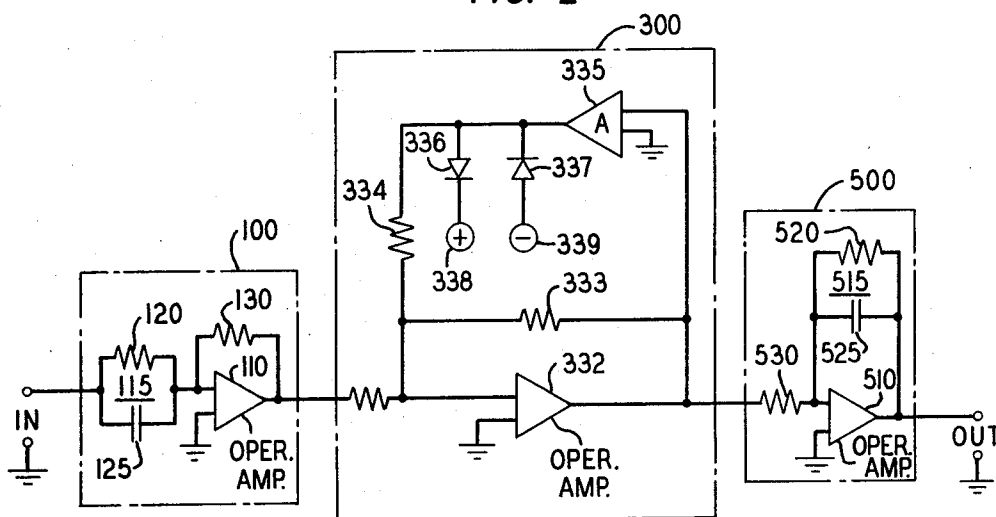
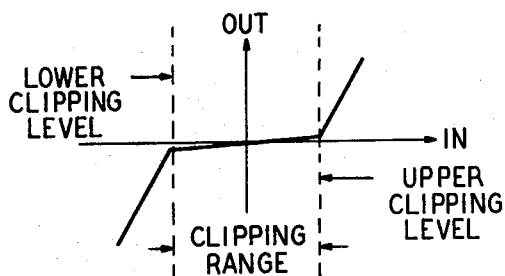


FIG. 3



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REDUCTION OF HARMONIC DISTORTION

BACKGROUND OF THE INVENTION

The present invention relates generally to improving the operation of harmonically distortive signal processors and particularly a method and arrangement for reducing the harmonics generated by the operation of such processors.

An harmonically distortive signal processor is an electrical circuit or system which, ideally, provides an output signal comprising only frequencies present in the input signal thereto but which, as a result, for example, of nonlinearities in the processor, generates harmonics of the input signal in addition to the desired (ideal) output signal. Illustrative of such a processor is a center clipper used, for example, to substantially remove low level noise accompanying a speech signal, but which use generates harmonics of the speech waveform in the process, thereby distorting the speech.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide a method and arrangement for reducing the harmonic distortion of signals processed in harmonically distortive signal processors generally, and in center clippers in particular.

The preceding and other objects are achieved by pre-emphasizing the processor input signal and de-emphasizing the processor output signal. More specifically, pre-emphasis of the input signal is provided in a network having a positive-slope frequency response curve. De-emphasis of the output signal is provided in a network having a negative-slope frequency response curve.

BRIEF DESCRIPTION OF THE DRAWINGS

A clear understanding of the invention and of the preceding and other objects thereof may be gained from a consideration of the following detailed description and drawings, in which:

FIG. 1 is a block diagram illustrating the invention;

FIG. 2 is a center clipping arrangement which embodies the principles of the invention; and

FIG. 3 is the transfer characteristic of the center clipper shown in FIG. 2.

DETAILED DESCRIPTION

FIG. 1 shows an arrangement for reducing harmonic distortion created by center clippers, nonlinear amplifiers and certain other electrical circuits and systems in which are generated unwanted harmonics of an input signal. In FIG. 1, signal processor 30 comprises such an harmonically distortive system. Ideally, only frequencies present in the input signal to processor 30 should appear in the output signal thereof. However, as a result, for example, of nonlinearities in processor 30, harmonics having as their respective fundamentals the above-mentioned input signal frequencies, are generated by processor 30 along with the desired (ideal) output signal. In the present invention the harmonic distortion thus generated is significantly reduced by extending input signals to processor 30 through pre-emphasis network 10 and by thereafter extending the processed signals through de-emphasis network 50. The input signals to be processed are applied to ter-

minal 11 of pre-emphasis network 10 and the processed output signals appear at output terminal 55 of de-emphasis network 50.

De-emphasis network 50 is characterized by a negative-slope frequency response curve; the attenuation provided thereby is an increasing function of frequency. Thus, the harmonics generated in processor 30 are attenuated relative to their respective fundamentals by de-emphasis network 50. Since those fundamentals collectively comprise the desired processor output signal, de-emphasis network 50 thus reduces the harmonic distortion thereof.

Of course, de-emphasis network 50 also attenuates the various components of the desired output signal of processor 30 relative to each other. The higher the frequency of a given component the greater its attenuation in network 50 relative to the other components of the desired output signal. Accordingly, pre-emphasis network 10, having a positive frequency response curve slope of magnitude advantageously equal to that of de-emphasis network 50, is provided to anticipate that attenuation. The various frequency components of the input signal at terminal 11 are thus increased in amplitude relative to each other in pre-emphasis network 10 in substantially inverse relationship to the relative attenuation thereof in de-emphasis network 50. Consequently, while the unwanted harmonics generated in processor 30 are attenuated in de-emphasis network 50, the frequency characteristic of the input signal at terminal 11 is substantially preserved in the output signal at terminal 55.

FIG. 2 shows an illustrative center clipping arrangement, including center clipper 300, which embodies the principles of the present invention. As can be seen from FIG. 3, which shows the transfer characteristic of center clipper 300, the gain of the center clipper is substantially zero when the instantaneous magnitude of the input signal thereto lies within a clipping range defined by upper and lower clipping levels. The center clipper gain outside the clipping range is substantially greater than zero. Thus, such center clippers are advantageously employed, for example, to attenuate crosstalk or other low level noise which might accompany a transmitted signal. The clipping levels are adjusted to correspond to anticipated noise levels so that center clipping a noisy speech signal, for example, substantially removes the noise components therefrom while substantially passing the speech components, the latter having greater amplitudes than the noise components. Of course, the "center" of the speech signal, that portion lying within the clipping range, is removed along with the noise and this harmonically distorts the speech.

Therefore, in accordance with the present invention, input signals to center clipper 300 in the arrangement of FIG. 2 are first pre-emphasized in pre-emphasis network 100 and the center clipper output signals are then de-emphasized in de-emphasis network 500. The harmonic distortion generated by center clipper 300 is thereby significantly reduced.

Pre-emphasis network 100 illustratively includes operational amplifier 110, feedback resistor 130, and input network 115, the latter comprising resistor 120 and capacitor 125, connected in parallel. De-emphasis network 500 illustratively includes operational ampli-

er 510, input resistor 530 and feedback network 515, the latter comprising resistor 520 and capacitor 525, connected in parallel. Pre-emphasis is provided by network 100 at a rate of 6db/octave, for example, and, advantageously, de-emphasis is provided by network 500 at this same rate. Thus the first harmonic of each desired center clipper output component is attenuated 6db relative thereto, and each higher-order harmonic is attenuated 6db relative to the next lower-order harmonic. In general, of course, the rate of pre-emphasis and corresponding de-emphasis employed in networks 100 and 500 will depend on the particular application.

Center clipper 300 illustratively includes operational amplifier 332, a first feedback path, comprising resistor 333, and a second feedback path comprising noninverting amplifier 335 and resistor 334, connected in series. In addition, oppositely poled diodes 336 and 337 connect the output terminal of amplifier 335 to positive source 338 and negative source 339, respectively.

The magnitudes of sources 338 and 339 are chosen so that both diodes 336 and 337 are nonconductive when the center clipper input signal is within the clipping range. Thus negative feedback is provided via both of the above-mentioned feedback paths and the gain of center clipper 300 is small (essentially zero). Once the center clipper input signal exceeds the clipping range, however, the output of amplifier 335 is clamped to a constant voltage via one of the two diodes

336 and 337, and negative feedback is thereafter provided via resistor 333 only. Thus, in accordance with the transfer characteristic of FIG. 3, the gain of center clipper 300 is substantially greater for input signals which exceed the clipping range than for input signals which lie within the clipping range.

It is to be understood that the preceding detailed description and embodiments are merely illustrative of the invention and that modifications obvious to those skilled in the art can be made without departing from the scope of the invention.

I claim:

1. A method of reducing harmonics generated in a center clipper including the steps of, pre-emphasizing the center clipper input signal and de-emphasizing the center clipper output signal.

2. A method in accordance with claim 1 wherein the rates of pre-emphasizing and de-emphasizing are substantially equal.

3. A low distortion signal processing arrangement including, a center clipper, means for pre-emphasizing input signals for said center clipper and means for de-emphasizing the output signals of said center clipper.

4. An arrangement in accordance with claim 3 wherein said pre-emphasis means and said de-emphasis means have frequency response curve slopes of substantially equal magnitude.

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