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(54) CIRCUIT FOR AUTOMATIC DYNAMIC COMPRESSION OR EXPANSION

(71) We, LICENTIA PATENT-VERWALTUNGS-GESELLSCHAFT MIT BESCHRANKTER HAFTUNG, a company organised under the laws of Germany, of Theodor-Stern-Kai 1, 6 Frankfurt/Main 70, Germany do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to circuits for dynamic compression or expansion of signals such as audio-frequency signals. In relation to the reproduction of audio-frequency signals over a noise-introducing signal path, such as a magnetic tape, it is known to improve the signal to noise ratio by compressing the signals prior to transmission and expanding them after reception. This is the so-called Compander System. One example of such a system is described in our co-pending Patent Application No. 1881/75 (Serial No 1 500 192). This includes, in a useful signal path an amplifier in the form of a differential amplifier having an inverted input connected to the output via an electronically controllable impedance. The electronically controllable impedance is controlled, to vary the feedback, by a signal derived either from the input or the output of the differential amplifier.

It is an object of this invention to provide another form of that system.

According to the invention there is provided a circuit, for automatic compression or expansion of the dynamic range of a signal, comprising a first signal path between an input and an output of the circuit, the first signal path including a differential amplifier having a non-inverting input connected to the input of said path, a feedback path, including an electronically controllable impedance, between the output and an inverting input of the amplifier, a further path, branched from the first path at the input or the output thereof, including a control voltage generator for deriving a control voltage, for the electronically controllable impedance, to achieve compression or expansion of signals in the first path and means for limiting, to a predetermined value, the feedback voltage between the output and the inverting input of the amplifier.

In order that the invention may be clearly understood and readily carried into effect an example thereof will now be described with reference to the single figure of the accompanying drawing which shows a circuit incorporating the invention.

Compander systems include a compression circuit for dynamic narrowing prior to the transmission or storage of a useful signal and an expansion circuit for dynamic widening after transmission or prior to the reproduction of a previously stored signal.

Such systems operate inter alia with control members for reducing the signal amplitude or for influencing the frequency of the signal, the control signal necessary for the control of the control member being derived from the input or output signal of the compander circuit.

The drawing shows a simplified circuit for a compression circuit of a compander arrangement. The useful alternating voltage signal applied to an input terminal 1 and to be compressed is applied to the non-inverting input 2 of a differential amplifier 4. The inverting input 3 of this differential amplifier 4 is connected on the one hand, via an electronically controllable impedance 8, to the output 5 of the differential amplifier 4, and on the other hand, via an impedance 9, to ground. The impedances 8 and 9 therefore form a controllable feedback branch. By this control of the differential amplifier 4 the amplification thereof is controllable.

The output 5 of the differential amplifier 4 is connected on the one hand to an output terminal 6 and on the other hand to the

input of a control voltage generator 7. The control voltage generator 7 consists in principle of a rectifier circuit which generates at its output a direct control voltage dependent on its input alternating voltage. The control voltage generator can in some cases be connected to the input of the circuit instead of to its output. The direct control voltage generated is applied to the control input of the controllable impedance 8, so that a regulating circuit is formed. The circuit arrangement described is, in this example, so arranged in terms of component values that in the differential amplifier 4 the useful signals of low level are amplified relatively more than the useful signals of higher level. In this manner the output signal that can be taken off at the output terminal 6 has a smaller dynamic range than the signal at the input terminal 1.

The circuit so far described is conventional. It may happen, however, that for a relatively rapid change, of the useful signals to be compressed, at the input terminal 1 an overswing occurs at the output terminal 6 owing to the unavoidable time constants in the regulating circuit. In order to prevent this effect there are provided the two diodes 10 and 11, which are connected in anti-parallel between the output 5 and the inverting input 3 of the differential amplifier 4. The two diodes 10 and 11 limit to a predetermined value the feedback voltage occurring between the output 5 and the input 3. As a result of this limitation of the voltage, which also exists across the controllable impedance 8, the output voltage of the differential amplifier 4 can only exceed the input voltage at the non-inverting input 2 by, at most, a predetermined value, namely the limiting voltage of the diodes 10 and 11. The above-described overswing is thereby reduced to an appreciably lower value.

This effect depends on the fact that the output voltage of the differential amplifier 4 is composed of the voltage across the impedance 9 and the voltage across the controllable impedance 8. The voltage across the impedance 9 is substantially equal to the input voltage at the input 2 in conventional differential amplifiers.

At low levels of the useful signal to be compressed the voltage across the impedance 8 is relatively high compared with the input voltage, whilst at high levels it is relatively low compared with the input voltage. In the latter case the amplification of the differential amplifier 4 goes towards unity. The limiting diodes 10 and 11 now have the effect that a rapid increase of the signal level occurring at an initially low level causes the feedback voltage to increase not arbitrarily but only to the value determined by the limiting diodes 10 and 11. In this way the output voltage of the differential amplifier 4 is also limited.

It is advantageous to select the limiting voltage of the diodes 10 and 11 such that it corresponds to the maximum feedback voltage which may occur for nominal operation of the circuit described.

Instead of the diodes 10 and 11 other means may be employed which are suitable for limiting or keeping constant an alternating voltage to a predetermined threshold value.

If the compander associated with the compression circuit described is so constructed that the controllable impedance 8 is also used in expansion, then the advantageous reduction of the overswing upon rapid variations of the input signal is also obtained during expansion.

It is also possible, in accordance with our co-pending, Patent Application No. 1881/75 (Serial No. 1 500 192) to insert between the junction of the output 5 of the differential amplifier 4 and the output terminal 6 on the one hand and the input terminal of the control voltage generator 7 on the other hand a further controllable amplifier which is likewise controlled by the output of the control voltage generator 7.

With such an improved compander arrangement it is advantageous to construct the further controllable amplifier like the differential amplifier, to control it similarly by a respective electronically controlled impedance and correspondingly to limit the feedback voltage by two diodes such as 10 and 11.

WHAT WE CLAIM IS:—

1. A circuit, for automatic compression or expansion of the dynamic range of a signal, comprising a first signal path between an input and an output of the circuit, the first signal path including a differential amplifier having a non-inverting input connected to the input of said path, a feedback path, including an electrically controllable impedance, between the output and an inverting input of the amplifier, a further path, branched from the first path at the input or the output thereof, including a control voltage generator for deriving a control voltage, for the electronically controllable impedance, to achieve compression or expansion of signals in the first path and means for limiting, to a predetermined value, the feedback voltage between the output and the inverting input of the amplifier.

2. A circuit according to claim 1 wherein the feedback path is arranged so that the limitation of the feedback commences only after a threshold value such that the

input of a control voltage generator 7. The control voltage generator 7 consists in principle of a rectifier circuit which generates at its output a direct control voltage dependent on its input alternating voltage. The control voltage generator can in some cases be connected to the input of the circuit instead of to its output. The direct control voltage generated is applied to the control input of the controllable impedance 8, so that a regulating circuit is formed. The circuit arrangement described is, in this example, so arranged in terms of component values that in the differential amplifier 4 the useful signals of low level are amplified relatively more than the useful signals of higher level. In this manner the output signal that can be taken off at the output terminal 6 has a smaller dynamic range than the signal at the input terminal 1.

The circuit so far described is conventional. It may happen, however, that for a relatively rapid change, of the useful signals to be compressed, at the input terminal 1 an overswing occurs at the output terminal 6 owing to the unavoidable time constants in the regulating circuit. In order to prevent this effect there are provided the two diodes 10 and 11, which are connected in anti-parallel between the output 5 and the inverting input 3 of the differential amplifier 4. The two diodes 10 and 11 limit to a predetermined value the feedback voltage occurring between the output 5 and the input 3. As a result of this limitation of the voltage, which also exists across the controllable impedance 8, the output voltage of the differential amplifier 4 can only exceed the input voltage at the non-inverting input 2 by, at most, a predetermined value, namely the limiting voltage of the diodes 10 and 11. The above-described overswing is thereby reduced to an appreciably lower value.

This effect depends on the fact that the output voltage of the differential amplifier 4 is composed of the voltage across the impedance 9 and the voltage across the controllable impedance 8. The voltage across the impedance 9 is substantially equal to the input voltage at the input 2 in conventional differential amplifiers.

At low levels of the useful signal to be compressed the voltage across the impedance 8 is relatively high compared with the input voltage, whilst at high levels it is relatively low compared with the input voltage. In the latter case the amplification of the differential amplifier 4 goes towards unity. The limiting diodes 10 and 11 now have the effect that a rapid increase of the signal level occurring at an initially low level causes the feedback voltage to increase not arbitrarily but only to the value determined by the limiting diodes 10 and 11. In this way the output voltage of the differential amplifier 4 is also limited.

It is advantageous to select the limiting voltage of the diodes 10 and 11 such that it corresponds to the maximum feedback voltage which may occur for nominal operation of the circuit described.

Instead of the diodes 10 and 11 other means may be employed which are suitable for limiting or keeping constant an alternating voltage to a predetermined threshold value.

If the compander associated with the compression circuit described is so constructed that the controllable impedance 8 is also used in expansion, then the advantageous reduction of the overswing upon rapid variations of the input signal is also obtained during expansion.

It is also possible, in accordance with our co-pending, Patent Application No. 1881/75 (Serial No. 1 500 192) to insert between the junction of the output 5 of the differential amplifier 4 and the output terminal 6 on the one hand and the input terminal of the control voltage generator 7 on the other hand a further controllable amplifier which is likewise controlled by the output of the control voltage generator 7.

With such an improved compander arrangement it is advantageous to construct the further controllable amplifier like the differential amplifier, to control it similarly by a respective electronically controlled impedance and correspondingly to limit the feedback voltage by two diodes such as 10 and 11.

WHAT WE CLAIM IS:—

1. A circuit, for automatic compression or expansion of the dynamic range of a signal, comprising a first signal path between an input and an output of the circuit, the first signal path including a differential amplifier having a non-inverting input connected to the input of said path, a feedback path, including an electrically controllable impedance, between the output and an inverting input of the amplifier, a further path, branched from the first path at the input or the output thereof, including a control voltage generator for deriving a control voltage, for the electronically controllable impedance, to achieve compression or expansion of signals in the first path and means for limiting, to a predetermined value, the feedback voltage between the output and the inverting input of the amplifier.

2. A circuit according to claim 1 wherein the feedback path is arranged so that the limitation of the feedback commences only after a threshold value such that the

feedback voltage at the tuned-in condition is not limited or is substantially not limited.

3. A circuit according to either of claims 1 or 2 wherein the means for limiting comprises two diode paths connected in anti-parallel between the output of the amplifier and its inverting input.

4. A circuit according to claim 3 in which the diode paths comprise semiconducting diodes.

5. A circuit according to any preceding claim including, in said branched path, prior to the control voltage generator, a second differential amplifier having its output connected to the input of the control voltage generator and its non inverting input connected to the output of the first amplifier, a second electronically controlled impedance, responsive to said control voltage, connected in a feedback path between the inverting input of the second amplifier and its output and means for limiting to a predetermined value the feedback voltage between the output and inverting input of the second amplifier.

6. A circuit according to claim 5 wherein the second feedback path is arranged so that limitation of the feedback commences only after a threshold value such that the feedback voltage at the tuned condition of the circuit is not limited or is substantially not limited.

7. A circuit according to either of claims 5 or 6 wherein the second means for limiting comprises two diode paths connected in anti-parallel between the output and the inverting input of the second amplifier.

8. A circuit according to claim 7 in which the diode paths are semiconducting diodes.

9. A circuit for automatic compression or expansion of the dynamic range of a signal substantially as herein described with reference to the accompanying drawing.

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