

The invention relates to a method of transmitting an audio signal wherein components of this signal lying below predetermined thresholds are not taken into consideration in the coding.

Such a method has already been disclosed in EP-A-0 193 143.

With the aid of this method it is possible to keep small the band width required for the transmission in order to manage with a narrow-band channel, to be able to simultaneously transmit as many audio signals as possible on an existing channel or to enable an existing mass memory to be utilized as efficiently as possible. Here use is made of the recognition that on the basis of psycho-acoustic characteristics of hearing not all components of an audio presentation are perceived by the listener, and thus are irrelevant from the standpoint of information technology. These components, which would occupy a substantial part of the normally required transmission capacity, are omitted.

In EP-A-0 251 028 (published on 7.1.88) and in D. Krahé, Rundfunktech. Mitteilungen, 30 (1986), Vol. 3, p. 117-123, in the short-term spectrum of an audio signal, components of this signal lying below predetermined thresholds are not taken into consideration in the coding.

It has proved that in order to decide which components can be omitted, various criteria must be considered individually or in combination with other criteria. If this consideration is not made, in the event of specific, unusual sound phenomena the omission of specific components can lead to unsatisfactory audio effects.

Therefore the aim of the invention is to provide a method of transmitting an audio signal wherein a data reduction is effected in such manner that even in the case of unusual sound phenomena no impairment of the audio impression occurs.

This aim is fulfilled in a method according to the preamble of Claim 1 by the features described in the characterising part of the Claim.

In the conversion of the signal into a signal representing the short-term spectrum, which takes place by block-by-block transformation, spectral components can arise which are not present in the long-term spectrum. The taking into consideration of these spectrum components in the reconversion is important in order to regain a true image of the original signal. If the spectral components were suppressed in the course of the data reduction, this would lead to a perceptible adulteration of the audio presentation.

However, one of the measures for data reduction consists precisely in suppressing or not taking into consideration spectral components with an amount value below a predetermined threshold. The basic permissibility of this measure in the face of the contradictory requirement of high playback quality is based on the psycho-acoustic masking effect.

However, it has now proved that this masking effect cannot always be utilized when the suppression relates to spectral components which have additionally arisen as a result of the block-by-block transformation in the short-term spectrum. This applies even when the spectral components lie below the threshold at which the suppression of other spectral components would not lead to audible reductions in quality.

It would be desirable to be able to distinguish the additional spectral components produced as a result of the block-by-block transformation from the other spectral components, thereby facilitating an identifiable classification into "essential" and "unessential" spectral components. This is not the case however.

Therefore suppression of the spectral components must be limited in those frequency ranges in which a masking effect is not definitely assured. In order nevertheless to be able to retain the data reduction by suppression of spectral components of a small amount values, below a first defined threshold this measure is carried out only in frequency ranges lying outside of psycho-acoustically differentiatable frequency ranges.

A further development of the invention provides concrete frequency ranges in which the masking effect is not assured and therefore suppression of spectral components can be disadvantageous. These consist on the one hand of the low frequency range below approximately 1 kHz and on the other

hand of the direct vicinity of the largest spectral component of the audio signal. The specification of the latter frequency range is based on the recognition that here the "essential" spectral components occur with a particularly high degree of probability and their suppression is still of a quality-reducing influence even when their amount values are well below the predetermined threshold.

Additional further developments and advantageous embodiments of the invention are described in the claims, the description and the drawing which illustrates an exemplary embodiment.

In the drawing:

Fig. 1 illustrates a block of an audio signal transformed into the frequency domain in an amount value diagram;

Fig. 2 is a flow diagram illustrating the method according to the invention.

The signal illustrated in Fig. 1 occurs in that a low-pass-filtered audio signal is converted by an analogue-digital converter into a digital signal, a specific portion of the digital audio signal is cut out of the long-term signal through a time window, and the block thus obtained is transformed from the time domain into the frequency domain.

In the exemplary embodiment the frequency axis is divided into 513 locations with the indices 0 ... 512 which can be assigned spectral components. Several of these locations

are combined to form frequency groups of which there are a total of 26. The number of locations for spectral components in the individual frequency groups g differs and increases from low frequency groups in the direction of higher frequency groups.

Because of the large number of locations, a scale representation over the frequency axis has been omitted. Only those ranges which are of significance in terms of the explanation of the solution according to the invention have been shown in expanded form. This is the frequency range below somewhat above 1 kHz, represented here by the groups 0 to 12, and the other frequency range from which as an example the groups 16, 17 and 18 have been selected.

On the ordinate the amounts of the spectral components have been logarithmized and related to the value of the absolute maximum. The spectrum illustrated in the drawing is a short-term spectrum, the spectral lines of which on the one hand have been produced by the original signal, but on the other hand have also been produced as a result of the block-by-block transformation, thus by convolution of the signal function with the transform of the time window function.

The spectral lines additionally produced as a result of the block-by-block transformation are also of significance in order to regain a true image of the original signal after the transmission and reconversion of the signal from the frequency domain into the time domain.

In order to save transmission- and storage capacity during transmission or storage, previously spectral components below a threshold 1, which latter in each group g relates specifically to the maximum amount value of the spectral components of this group g and is defined by the logarithmized ratio of the effective value of the maximum amount value to the root of the mean energy of all the spectral components of this group multiplied by a factor 3, have not been taken into consideration or have been suppressed, e.g. set at a very small amount value or zero. However, this can lead to unsatisfactory results if those spectral components which are not taken into consideration have additionally arisen as a result of the block-by-block transformation. As these spectral components cannot however be distinguished from the other spectral components, as a deviation from the general practice of not taking into consideration or suppressing spectral components which lie below the threshold 1, the method is modified in the following manner.

In the range below approximately 1 kHz, i.e. here the groups 1 to 10, an additional threshold 2 is defined which is arranged below the threshold 1, preferably 10 dB below this threshold. If spectral components, e.g. the spectral components designated 3, lie above the threshold 1, they are coded and transmitted. If they lie below the threshold 1 but still above the threshold 2, as is the case with the spectral component 4, they are likewise transmitted. Only in the case of the spectral components designated 5, which also lie below the threshold 2, does suppression take place.

A further modification occurs in the close vicinity of the absolute maximum of the amount values of the spectrum. In the case of the spectrum serving as an example, the spectral component with the highest amount value 6 is present in group 17. Irrespectively of whether the adjacent spectral components 7 and 8 lie above the threshold 1 as in the case of the spectral components 7, or below the threshold 1 as in the case of the spectral components 8, no suppression takes place. This applies independently of which group g the spectral component 6 with the absolute maximum of the amplitude value occurs in. Even when this is the case in the frequency range of groups 0 to 10, no suppression of the spectral components takes place.

In the adjoining lower and upper groups 16 and 18 on the other hand, the spectral components lying above the threshold 1, here designated 9, are transmitted and those spectral components 10 lying below the threshold 1 are suppressed.

The implementation of the method is expediently carried out using the same computer with which the transformation and coding are carried out. In explanation of the process flow reference is made to Fig. 2 which represents a flow diagram.

After the start at 11, the group with the group number $g=1$ is addressed at 12. The group $g=0$ assumes a special position as it represents a direct component and is of no further significance to the process flow. Then at 13 a

decision is made whether the investigated group 9 contains the absolute maximum of the amount value.

If this is so, no suppression of the spectral components present in this group is carried out, but a branch is made to 14, the group number to be investigated is changed to the following number and at 15 a decision is made as to whether all the groups have been investigated. If this is so, this completes the investigation for the respective block and the routine 16 is ended. Then in the acquisition of the next block a jump-back is made to the start 11 and the routine recommences.

If this is not so, a jump-back is made to 13 and it is checked whether the group g now being investigated contains the absolute maximum. If the group g contains the absolute maximum, at 17 it is checked whether the group being investigated is in the range of the ordinal numbers 1 to 10.

If so, at 18 the threshold 2 determines the non-consideration or suppression of the spectral components, which threshold 2 is 10 dB lower than the threshold 1. If the group lies outside of the range of the groups 1 to 10, the threshold 1 is determinative at 19.

At 20, in the case of group g currently being investigated the group maximum, i.e. the spectral component of the maximum amount value in the same group, is defined. Then the other spectral components of this group are checked. For this purpose at 21 firstly the spectral component with the smallest index within the group g currently being

investigated is examined. At 22 it is checked whether the spectral component lies below the threshold 1 or 2. This checking procedure takes place taking into consideration the group maximum. For this purpose the difference is formed between the group maximum and the amount of the respective spectral component. If the difference is greater than the threshold, i.e. if the spectral component is below the threshold 1 or 2, the spectral component is marked at 24 for suppression. Otherwise no marking takes place.

At 25 the index of the spectral component currently being investigated is advanced by 1 and at 26 it is checked whether the index i is greater than the maximum index of the group. If this is not so, the next group 9 is addressed. If this is so, the spectral component with the next index is checked in the same way.

Following the checking of the spectral component with the index 512 in group number 26, as already mentioned the checking procedure is completed and in the coding of the transformed signal blocks which now follows a corresponding suppression of the marked spectral components takes place. On the occurrence of the next transformed signal block, the process then recommences from the start 11.

Claims

1. A method of transmitting an audio signal wherein the analogue signal is converted into a digital signal, is transmitted in digital form and is reconverted into an analogue signal, where prior to the transmission the signal is converted into a signal representing the short-term spectrum and on the basis of psycho-acoustic laws components of this signal are not taken into consideration in the coding of the digital signal to be transmitted below predetermined thresholds, where the entire frequency range of the short-term spectrum is divided into frequency groups (g) which in each case contain at least one spectral component and in each group (g) at least one first threshold (1) is defined which relates in particular to the maximum amount value of the spectral components of the respective group (g), characterised in that for the frequency groups lying outside of psycho-acoustically differentiable frequency ranges the amount values of the short-term spectrum which lie below this first threshold (1) are not taken into consideration and that for the frequency groups lying inside a selected sub-range of the psycho-acoustically differentiable frequency range a second threshold (2) is defined which lies below the first threshold (1) and below which the amount values of the short-term spectrum likewise are not taken into consideration.

2. A method as claimed in Claim 1, characterised in that a psycho-acoustically differentiable frequency range is formed by the frequency range preferably below 1 kHz and/or by the



neighbourhood of the absolute maximum (6) of the amount values of the short-term spectrum.

3. A method as claimed in Claim 1, characterised in that the selected sub-range within the psycho-acoustically differentiable frequency range is formed by the frequency range below 1 kHz.

4. A method as claimed in one of Claims 1 to 3, characterised in that the second threshold (2) lies preferably 10 dB below the first threshold (1).

5. A method as claimed in Claim 1, characterised in that the first threshold (1) is defined by the logarithmized ratio of the effective value of the maximum amount value of the spectrum components of each group (g) to the root of the mean energy of all the spectral components of this group (g), multiplied by a constant factor of preferably 3.

6. A method as claimed in Claim 5, characterised in that the first threshold (1) is limited to a variation range of the logarithmized ratio between 30 dB and 70 dB.

7. A method as claimed in Claim 3, characterised in that the frequency range formed by the neighbourhood of the absolute maximum (6) of the amount values of the short-term spectrum is identical to the frequency range assumed by the group (g) containing the absolute maximum of the amount values.

