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(21) International reference number: PCT/EP88/00866 (22) International application date: September 27, 1988 (09/27/1988) (31) Priority file number: P 37 33 016.0 (32) Priority date: September 30, 1987 (09/30/1987) (33) Priority country: DE (71) Applicant (for all designated countries except the US): DEUTSCHE THOMSON-BRANDT GMBH [DE/DE]; D-7730 Villingen-Schwenningen (DE). (72) inventor; and (75) Inventor/applicant (only for the US): VÖSSING, Walter [DE/DE]; Am Weingarter 14, D-3015 Wennigsen 1 (DE). HEIN, Ronald [DE/DE]; Bauernwinkel 2, D-3160 Lehrte (DE). (74) Attorney: KÖRNER, Peter; Deutsche Thomson-Brandt GmbH, Göttinger Chaussee 76, D-3000 Hannover 91 (DE).		(81) Designated countries: AT (European patent), BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), JP, KR, LU (European patent), NL (European patent), SE (European patent), US. Published <i>With international research report.</i>
(54) Title: METHOD FOR TRANSMITTING AUDIO SIGNALS (57) Abstract During transformative coding of audio signals, the bits are allocated to the spectrum components for purposes of quantification. After a preliminary approximative quantification, there remains the problem of distributing the still available bits of a data block among the spectrum components, in order to obtain the highest possible precision. The following steps are followed during a process of precise quantification: a) determination of values as absolute values, b) standard conversion of the values obtained by means of a control value, c) summing of all values greater than 0, d) determination of a control value from the saved bits and from the previous sum, e) allocation of the remaining bits to values on the basis of the characteristic values. The invention finds application in audio systems with which a high-quality transmission at a low data speed is sought.		

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- [hw:] / -

Method for transmitting an audio signal

The invention relates to a method for transmitting an audio signal according to the general term of claim 1.

When transmitting an audio signal, e.g., in broadcasting, cable transmission, satellite transmission, and recording devices, it is known to convert the analog audio signal into a digital audio signal with a certain resolution, transmit it in this form, and convert it back into an analog signal during playback. Digital transmission achieves a greater signal-to-noise ratio, particularly during playback.

The bandwidth required for the transmission of such a signal is essentially determined by the number of samples to be transmitted per time unit and by the resolution.

In practice, there is a requirement to keep the bandwidth required for transmission as small as possible in order to make do with a narrowband channel or to be able to transmit as many audio signals as possible simultaneously via an existing channel. The required bandwidth can be reduced by reducing the number of samples or the number of bits per sample.

However, this measure usually results in a deterioration in playback. In a method known from DE-OS 35 06 912, the digital audio signal is transformed into a short-term spectrum in successive time sections to improve the playback quality, which represents the spectrum components of the signal for each of the time sections, e.g., 20 ms. Due to psycho-acoustic [sic: psycho-acoustic] laws, components that are not perceived by the listener, i.e., that are irrelevant in the communication sense, can generally be found more easily in the short-time spectrum than in the time domain. These components are weighted less in the transmission or omitted completely. This measure allows a

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considerable part of the data otherwise required for transmission to be omitted, so that the average bit rate can be considerably reduced. Therefore, only a limited number of bits is made available for coding the spectrum components present in the time segments, namely the magnitudes and phases, which is specified by the desired data reduction.

For the transmission of the transformed values, which are magnitudes and phases that characterize the spectrum lines of the blocks of the audio signal, some of these spectrum lines are assigned from the maximum number of bits available for each block. It is important to quantize these values as precisely as possible. The allocation of bits using a recursive method requires a considerable amount of computing power, which makes real-time processing almost impossible.

The invention is based on the task of assigning the bits available for coding to the spectrum components to be transmitted in the method described at the beginning in such a way that quantization corresponding to the weighting of the spectrum components can be realized within a short time while utilizing the available bits as completely as possible.

This task is solved by the features specified in the characterizing part of claim 1.

The first step in bit allocation is to assign a specified number of bits to the absolute magnitude maximum, the magnitude maximum in frequency groups of the short-time spectrum, the addresses of the magnitude maximum and the dynamics of the frequency groups. Quantization ratios are obtained from the dynamics of the groups and bits are assigned to the remaining magnitudes according to the quantization ratios. The phases are quantized with the same number of bits.

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The assignment of the bits based on the quantization key figures represents an approximative quantification. It is dimensioned so that the number of bits available for coding is sufficient for an initial assignment, even for short-time spectra with many magnitudes and phases to be transmitted.

For short-time spectra with few magnitudes and phases to be transmitted, this results in a more or less large number of remaining bits. These are now assigned to those magnitudes and phases that were initially only roughly quantized using the quantization key figures. For the following steps, the absolute values of the approximatively quantized magnitudes are identified, i.e., the exact values that are not falsified by the approximative quantification.

A control value is then defined which controls the distribution of the remaining bits to selected spectrum components. It is placed as a threshold in the magnitude spectrum, wherein the height of the threshold depends on the number of bits not distributed in the approximative quantification.

After comparing the control value with the approximatively quantized magnitudes, only those values above the control value are selected for bit allocation. By forming the difference between the approximatively quantized magnitudes and the control value, a modified spectrum is formed as the basis for further bit allocation. The magnitudes of this modified spectrum are added together. The non-distributed bits, divided by the previously identified sum of the magnitudes, result in a characteristic value as bits per dB. Multiplying the magnitudes of the spectrum that are still selected for the allocation of bits by the characteristic value results in the number of bits that are distributed to the selected magnitudes of the spectrum.

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These values are generally not integers. However, as bits can only be distributed as integers, there is a residual number of bits available for distribution. These bits can either remain unconsidered or be distributed by rounding up and down and according to the absolute magnitudes of the magnitudes of the spectrum.

Further embodiments and advantageous embodiments of the invention are shown in the claims, the description and the drawing, which explains the invention in more detail.

The following is shown in the drawing:

- Fig. 1 a block of an audio signal transformed into the
 frequency domain in magnitude representation,
Fig. 2 a modified spectrum.

The signal shown in Fig. 1 is obtained by converting a low-pass filtered audio signal into a digital signal by means of an analog/digital converter, cutting out a certain section of the digital audio signal from the long-term signal by means of a time window and transforming the resulting block from the time domain into the frequency domain. In the illustration, a number I of spectrum lines occurring within a transformed block are plotted in relation to an 0-dB line. These are the magnitudes B. A control value St , which results from the number of non-distributed bits, is shown as a horizontal line. It is determined using the empirical formula:

$$St = k1 + f * (\text{number of saved bits} - k2),$$

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wherein the following parameters have been set:

$$\begin{aligned} k1 &= 30 \text{ dB} \\ f &= 0.06 \text{ dB} \\ k2 &= 447 \end{aligned}$$

As can be seen, the spectrum lines end partly above and partly below the control value S_t . The magnitudes B below the control value are not assigned any bits. The difference between the magnitudes B above the control value S_t and the control value S_t itself results in a modified spectrum, which is shown in Fig. 2. To identify the measure for the allocation of the bits for the following precise quantification, the control value S_t is compared with the magnitudes B . Only those magnitudes B that are above the control value B are taken into account. The result is shown in Fig. 2. The magnitudes B of this modified spectrum are added together. The values B are added up according to the formula:

$$S = \sum B(I) \text{ with } I = 1 \text{ to } N.$$

The non-distributed bits, divided by the previously identified sum S of the magnitudes, result in a characteristic value X as bits per dB. By multiplying the magnitudes B of the spectrum that are still selected for the allocation of bits by the characteristic value X , the numbers of bits that are distributed to the selected magnitudes of the spectrum are obtained according to the following formula:

$$\text{Bit per spectr.}(I) = X * B(I) \text{ wherein } 1 \leq I \leq N.$$

These values are generally not integers. However, as bits can only be distributed as integers, there is a residual number that is still available for distribution. These bits are distributed

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by rounding and transmitting the remainder according to the absolute magnitudes of the magnitudes of the spectrum.

The procedure is as follows: The first number of bits to be distributed is first rounded down and the remainder is temporarily stored between the non-integer and the integer number of bits. The temporarily stored remainder is then added to the next number of bits to be distributed. The resulting sum is rounded down again, and the remainder is stored again temporarily. The remainder is added to the next number of bits to be distributed. These cycles are repeated for each magnitude to be quantized until the last number of bits to be distributed has been distributed. Since the value "one" is very likely to be reached after adding several remainders, a further bit can be distributed repeatedly after several cycles, so that finally only one or no bit remains.

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Claims

1. Method for transmitting an audio signal, in which the analog signal is converted into a digital signal, transmitted digitally and converted back into an analog signal, wherein the signal is converted before transmission into a short-time spectrum which is represented by magnitudes and phases, for the transmission of which a predetermined number of bits is available and components of the spectrum are weighted differently in their representation accuracy on the basis of psychoacoustic laws during coding, characterized by the following method steps:
 - a. approximative quantification of the magnitudes and phases by allocating a portion of the bits to be distributed,
 - b. determination of the absolute magnitudes of the approximatively quantized magnitudes,
 - c. determination of a control value depending on the remaining part of the bits to be distributed,
 - d. comparison of the control value with the approximatively quantized magnitudes,
 - e. formation of the difference between the approximatively quantized magnitudes and the control value to obtain a modified spectrum as the basis for further bit allocation,

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- f. formation of the sum of the magnitudes of the modified spectrum,
 - g. identification of a characteristic value from the saved bits and the previous sum
 - h. assignment of the remaining bits to the magnitudes and phases based on the characteristic value.
2. Method according to claim 1, **characterized in** that the numbers of bits calculated for the assignment to the already approximatively quantized magnitudes and phases are converted into positive integer numbers of bits.
3. Method according to claim 2, **characterized in** that the non-integer numbers of bits are always rounded down.
4. Method according to claim 2, **characterized in** that the non-integer numbers of bits are rounded up and down depending on the bits available for allocation.
5. Method according to claim 2, **characterized in** that the first number of bits to be distributed is first rounded down and the remainder between the non-integer and the integer number of bits is temporarily stored, in that the temporarily stored remainder is added to the next number of bits to be distributed, in that the sum obtained is rounded down and the remainder is again temporarily stored and then added to the next number of bits to be distributed until the last number of bits to be distributed has been distributed.

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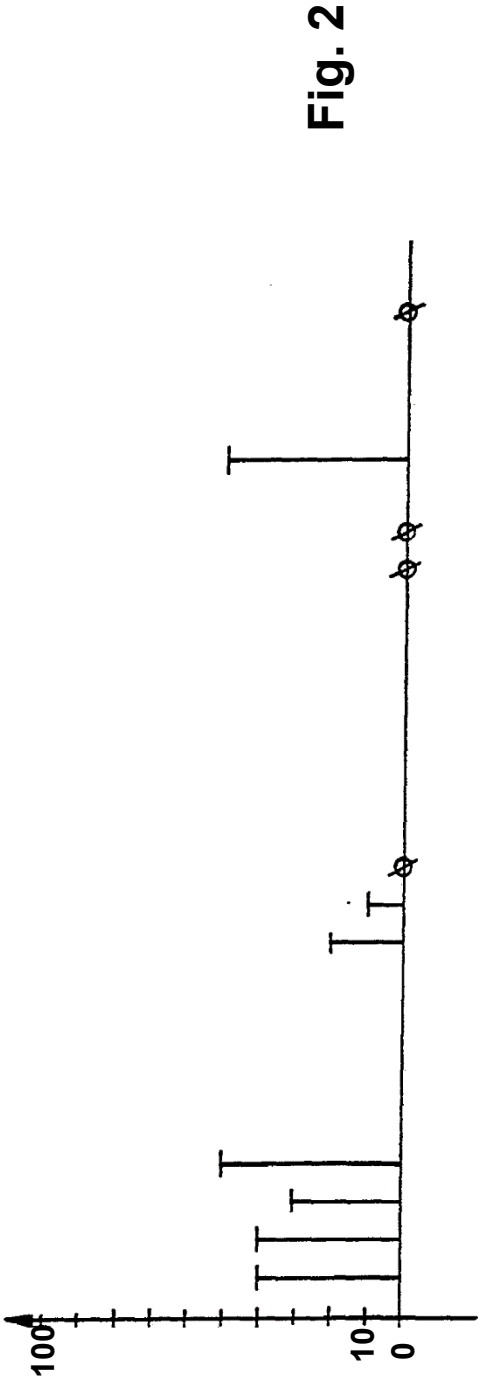
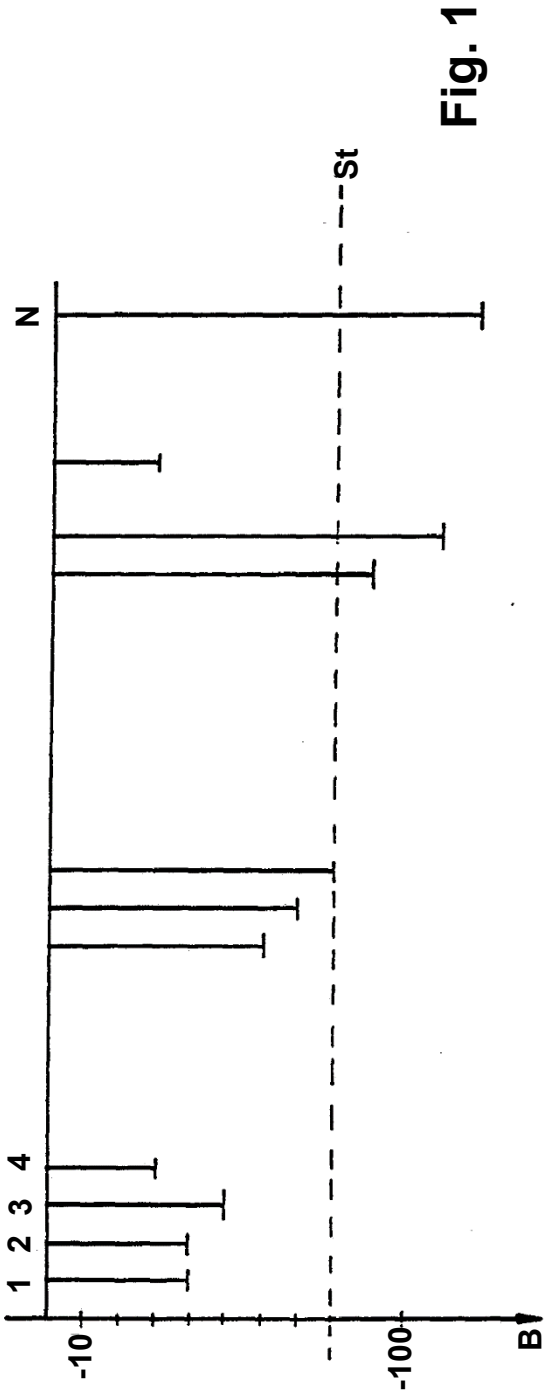
6. Method according to one or more of claims 1 through 4, characterized in that the control value is determined according to the following empirical formula:
- $$St = k1 + f * (\text{number of saved bits} - k2),$$
- wherein the following parameters were set in a preferred version:

$$k1 = 30 \text{ dB}$$

$$f = 0.06 \text{ dB}$$

$$k2 = 447$$

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INTERNATIONAL SEARCH REPORT

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I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
⁴ Int.Cl.: H 04 B 1/66		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
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⁴ Int.Cl.:	H 04 B 1/66	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	WO, A1, 83/03935 (TORSTENSSON-FJÄLLBRANT) 10 November 1983 see page 1, lines 4-13; page 3, lines 2-15 -----	1
* Special categories of cited documents: ¹⁰ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
IV. CERTIFICATION		
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24 November 1988 (24.11.88)	28 December 1988 (28.12.88)	
International Searching Authority	Signature of Authorized Officer	
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