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(54) Identifying spurious signals in audio signals

(57) A method and system for identifying a spurious signal in an audio signal are provided, which include: receiving at least one audio signal having a frequency spectrum, the at least one audio signal being derived from at least one digital signal; spectrally analyzing the at least one audio signal; determining the presence of a spurious signal, if a rate of increase of the audio level in a predetermined frequency region of the frequency spectrum exceeds a predetermined value and if a threshold value of the audio level is exceeded; and providing a trigger signal for attenuating the predetermined frequency portion of the at least one audio signal, if the presence of a spurious signal is determined.

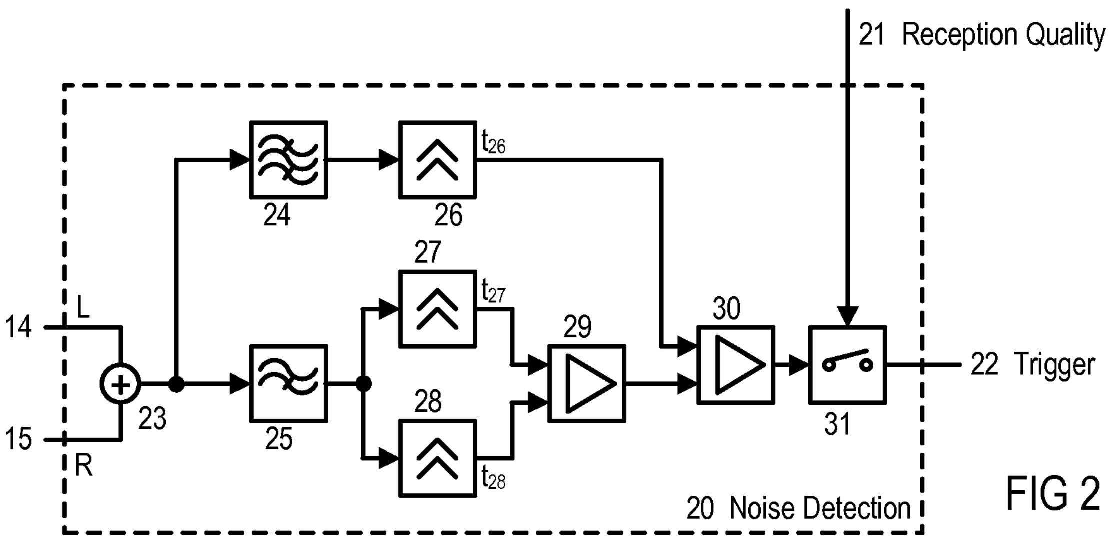

FIG 2

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Description

BACKGROUND

1. Technical Field

[0001] The disclosure relates to a system and method (generally referred to as a "system") for processing signals, in particular for identifying spurious signals in audio signals.

2. Related Art

[0002] An audio signal may be a composite signal containing features that are attributable to noise and features that are attributable to the desired signal. To boost the desired signal while attenuating the noise, the features of the composite signal that are noise may be distinguished from the features of the composite signal that are attributable to the desired signal. Features that have been identified as noise can then be removed or reduced from the composite signal.

[0003] Features that are noise may be relatively constant background noise and spurious signals, for example in a high frequency portion of the audio frequency spectrum. These spurious signals may be generated internally by an audio reception system that may employ demodulation of a high-frequency carrier and decoding of the demodulated signals. These spurious internal signals are commonly referred to as birdies.

[0004] Common approaches for detecting and overriding birdies in digital audio signal transmission includes attenuating demodulated and decoded audio signals in a frequency selective manner and superimposing substitute signals on the audio signals in frequency selective manner as a function of the data error statistics of the digital signal in order to improve the subjective auditory perception of the audio signal.

[0005] Further improvements to methods for identifying spurious signal and reducing noise in an audio signal are, however, desirable.

SUMMARY

[0006] A method for identifying a spurious signal in an audio signal is provided. The method includes: receiving at least one audio signal having a frequency spectrum, the at least one audio signal being derived from at least one digital signal; spectrally analyzing the at least one audio signal; determining the presence of a spurious signal, if a rate of increase of the audio level in a predetermined frequency region of the frequency spectrum exceeds a predetermined value and if a threshold value of the audio level is exceeded; and providing a trigger signal for attenuating the predetermined frequency portion of the at least one audio signal if the presence of a spurious signal is determined.

[0007] A system for identifying a spurious signal in an audio signal which is derived from a digital signal is provided. The includes: a receiver block configured to receive at least one audio signal having a frequency spectrum, the at least one audio signal being derived from at least one digital signal; a analyzing block configured to spectrally analyze the reproduced audio signal; a detector block configured to determine the presence of a spurious signal, if a rate of increase of the audio level in a predetermined frequency region of the frequency spectrum exceeds a predetermined value and if a threshold value of the audio level is exceeded, and to provide a trigger signal for attenuating the predetermined frequency portion of the at least one audio signal if the presence of a spurious signal is determined.

[0008] Other systems, methods, features and advantages will be, or will become, apparent to one with skill in the art upon examination of the following figures and detailed description. It is intended that all such additional systems, methods, features and advantages be included within this description, be within the scope of the invention, and be protected by the following claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The system may be better understood with reference to the following drawings and description. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention. Moreover, in the figures, like referenced numerals designate corresponding parts throughout the different views.

FIG. 1 is a block diagram illustrating a digital audio broadcast receiver that includes a block for identifying a spurious signal in a demodulated and decoded audio signal.

FIG. 2 is a block diagram illustrating the signal flow in an exemplary noise detector as used in the receiver of FIG. 1.

FIG. 3 is a block diagram illustrating the signal flow in an exemplary level detector as used in the noise detector of FIG. 2.

DETAILED DESCRIPTION

[0010] FIG. 1 illustrates a digital audio broadcast receiver system 10 that allows for reducing noise in demodulated and decoded digital audio signals. System 10 comprises an antenna 11 for receiving a frequency carrier that is modulated with a coded digital audio signal. Antenna 11 is coupled to a front end receiver block 12, which is configured to derive by way of demodulation an intermediate signal from the received modulated high-frequency signal, which is modulated and coded according to a digital audio broadcast (DAB) standard in this particular exemplary system 10. Front end receiver block

12 is coupled to a DAB decoder block 13 which is configured to decode the reproduced audio signal and provide the left (L) and right (R) signals of a stereo audio signal on lines 14 and 15.

[0011] System 10 further comprises a noise (birdie) detection block 20 which is coupled to lines 14 and 15 so as to receive one or both of the demodulated signals of the stereo signals on lines 14, 15. Noise detection block 20 further receives a signal from the front-end receiver block 12 on line 21 indicative of the reception quality of the high-frequency signal. Noise detection block 20 controls via line 22 an attenuation block 16, which is coupled to line 14 of audio signal decoder block 13 and a loudspeaker 18 for the left stereo audio signal L. Noise reduction block 20 controls, via line 22, an attenuation block 17, which is coupled to line 15 of audio block 13 and a loudspeaker 19 for the right stereo audio signal R. Attenuation blocks 16 and 17 may provide frequency-dependent attenuation, which may be achieved, e.g., with a controllable cut-off frequency. For example, the lowpass filter's cut-off frequency may be switched between 18kHz (less attenuation in the range 16-18kHz) and 16kHz (more attenuation in the range 16-18kHz).

[0012] Noise detection block 20 is illustrated in more detail in FIG. 2. Lines 14 and 15 are coupled to an adder 23, which adds left audio signal L on line 14 and right audio signal R on line 15 to generate an input signal to a high pass filter 25 and a band-pass filter 24. The inputs of two level detectors 27 and 28, which have different averaging time constants t_{27} and t_{28}, respectively, are connected to the output of high pass filter 25; their outputs provide an input into comparator 29, which provides an input into comparator 30 indicative of which output level of level detectors 27 and 28 is higher. Comparator 30 further receives input from level detector 26 having an averaging time constant t_{26}, whose value may be (approximately) the same as that of time constant t_{27} ($t_{26} \approx t_{27}$). A controllable gate 31 is connected downstream of comparator 30 and receives from front-end block 12 signal 21, which is indicative of the reception quality and which controls gate 31. Gate 31 lets the output signal of comparator 30, also called trigger signal 22, pass if the reception quality is below a certain level or otherwise blocks trigger signal 22. The averaging time constant of level detector 27 may be small, e.g., < 10ms, so that short impulses are detected by comparing the output signal of detector 27 with the output signal of level detector 28, whose averaging time constant is large, e.g., > 100 ms.

[0013] FIG. 3 illustrates an exemplary signal flow structure of level detectors 26, 27 and 28. The respective input signal is rectified or its absolute value is determined in a absolute value calculating block 32. The absolute value is then averaged in an appropriate way, e.g., by way of an RC element. The RC element may include a resistor 33 in a series arm and a resistor 34 and a capacitor 35 in a shunt arm of the RC element. The averaging time constants can be adjusted by adequately dimensioning resistors 33 and 34 and capacitor 35, whereby resistor 33 may include zero Ohms and resistor 34 infinite Ohms.

[0014] The system described above in connection with FIGS. 1-3 may employ a method for identifying a spurious signal in the demodulated and decoded audio signal derived from the modulated and coded digital signal received by antenna 11. The reproduced audio signals provided by DAB decoder block 13 are spectrally analyzed by noise (birdie) detector block 20. If a rate of increase of the audio level in a predetermined frequency region of the frequency spectrum exceeds a predetermined value and if a threshold value of the audio signal is exceeded, then the presence of a spurious signal is determined at comparator 30. The reception quality can also be taken into account when determining if a signal is spurious. If the reception quality exceeds a threshold value, i.e. if the reception quality is good, then the signal is not triggered to attenuate the audio signal even if comparator 30 determines the presence of a spurious signal. This method can assist in improving the perceived quality of the audio signal, as it is less probable that the signal determined to be spurious is in fact a spurious signal if the reception quality is high. The predetermined region may be a high-frequency region of the audio frequency spectrum, e.g., 16-18kHz, and is selected by high-pass filter 25. The rate of increase in this particular frequency range is detected by level detectors 27 and 28 in combination with comparator 29. Threshold value detection of the audio signal is performed by comparator 30 in connection with band-pass filter 24 and level detector 26.

[0015] The predetermined portion of the frequency spectrum in which the presence of a spurious signal is determined may be attenuated by muting the audio signal during the time period of the spurious signal (frequency independent attenuation) or by reducing the frequencies of low pass filters 16 and 17 (frequency-dependent attenuation). The system described above in connection with FIGS. 1-3 may be realized in analog, digital or mixed analog-digital circuitry. The digital circuitry may be controlled by adequate software.

[0016] While various embodiments of the invention have been described, it will be apparent to those of ordinary skill in the art that many more embodiments and implementations are possible within the scope of the invention. Accordingly, the invention is not to be restricted except in light of the attached claims and their equivalents.

Claims

1. A method for identifying a spurious signal in an audio signal which is derived from a digital signal, the method comprising:

   receiving at least one audio signal having a frequency spectrum, the at least one audio signal being derived from at least one digital signal;
   spectrally analyzing the at least one audio sig-

nal;
determining the presence of a spurious signal, if a rate of increase of the audio level in a predetermined frequency region of the frequency spectrum exceeds a predetermined value and if a threshold value of the audio level is exceeded; and
providing a trigger signal for attenuating the predetermined frequency portion of the at least one audio signal, if the presence of a spurious signal is determined.

2. The method of claim 1, where the digital signal is derived from a received modulated high-frequency signal; the method further comprising determining a reception quality and if the reception quality exceeds a threshold value, blocking the trigger signal to attenuate the predetermined frequency portion of the at least one audio signal, or if the reception quality is less than the threshold value, transferring the trigger signal to attenuate the predetermined frequency portion of the at least one audio signal.

3. The method of claim 1 or 2, where attenuating the predetermined frequency portion is frequency dependent or frequency independent.

4. The method of any of claims 1-3, where spectrally analyzing the at least one audio signal comprises high-pass filtering of the at least one audio signal.

5. The method of claim 4, where the at least one high-pass filtered audio signal is level detected with first and second time constants that differ from each other, and where the level detected signals are compared with each other to provide a signal representative of the rate of increase of the audio level in the predetermined frequency region.

6. The method of claim 5, where the at least one audio signal is level detected with a third averaging time constant and where the signal representative of the rate of increase of the audio level in the predetermined frequency region is compared with this at least one level detected audio signal.

7. The method of claim 6, where the at least one audio signal that is level detected with the third averaging time constant is bandpass filtered before level detection.

8. The method of any of claims 1-7, further comprising receiving a first signal and a second signal of a stereo audio signal and adding the first signal and the second signal to form the audio signal to be analyzed.

9. A system for identifying a spurious signal in an audio signal that is derived from a digital signal, the system comprising:

a receiver block configured to receive at least one audio signal having a frequency spectrum, the at least one audio signal being derived from at least one digital signal;
an analyzing block configured to spectrally analyze the reproduced audio signal;
and
a detector block configured to determine the presence of a spurious signal, if a rate of increase of the audio level in a predetermined frequency region of the frequency spectrum exceeds a predetermined value and if a threshold value of the audio level is exceeded, to provide a trigger signal for attenuating the predetermined frequency portion of the at least one audio signal if the presence of a spurious signal is determined.

10. The system of claim 9, where the detector block is further configured to determine reception quality and if the reception quality exceeds a threshold value, to not trigger the signal to attenuate the predetermined frequency portion of the audio signal, or if the reception quality is less than the threshold value, to trigger the signal to attenuate the predetermined frequency portion of the at least one audio signal.

11. The system of claim 9 or 10, where attenuating the predetermined frequency portion is frequency-dependent or frequency-independent.

12. The system of any of claims 9-11, where the analyzing block comprises a high-pass filter for filtering of the at least one audio signal.

13. The system of claim 12, where the detector block comprises a first level detector and second level detector that are configured to detect the level of the at least one high-pass filtered audio signal with first and second time constants that differ from each other; and a comparator configured to compare the level detected-signals with each other to provide a signal representative of the rate of increase of the audio level in the predetermined frequency region.

14. The system of claim 13, where the detector block further comprises a third level detector configured to level detect the at least one audio signal with a third averaging time constant and a further comparator configured to compare the signal representative of the rate of increase of the level of the at least one audio signal in the predetermined frequency region with the at least one audio signal level detected by the third level detector.

15. The system of claim 14, where the analyzing block comprises a bandpass filter configured to bandpass filter the at least one audio signal that is level detected with the third averaging time constant before level detection.

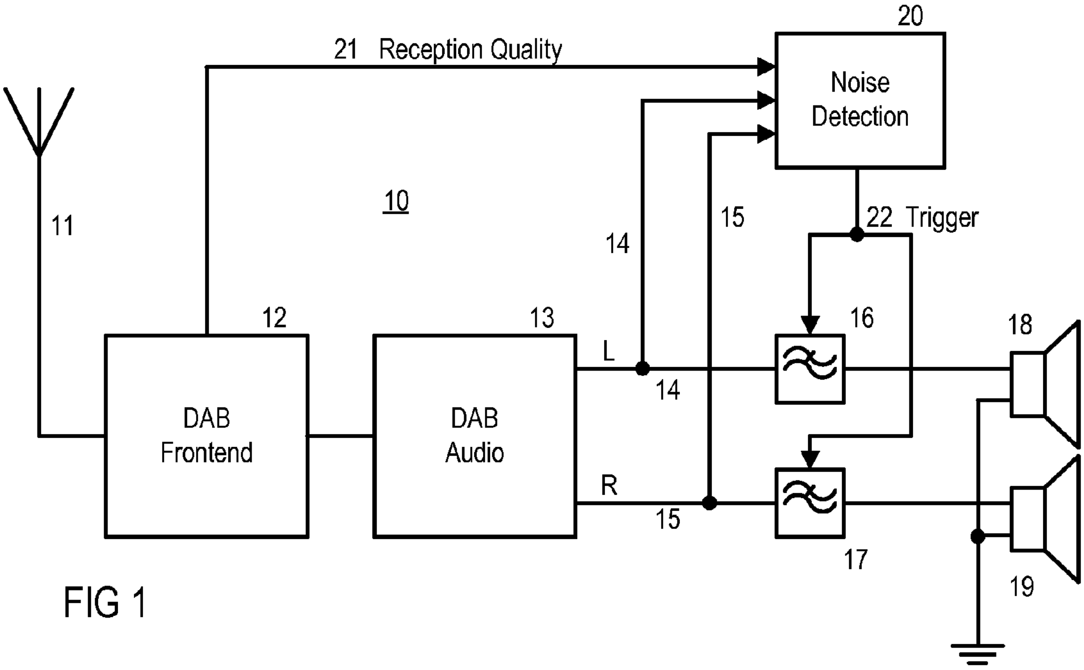

FIG 1

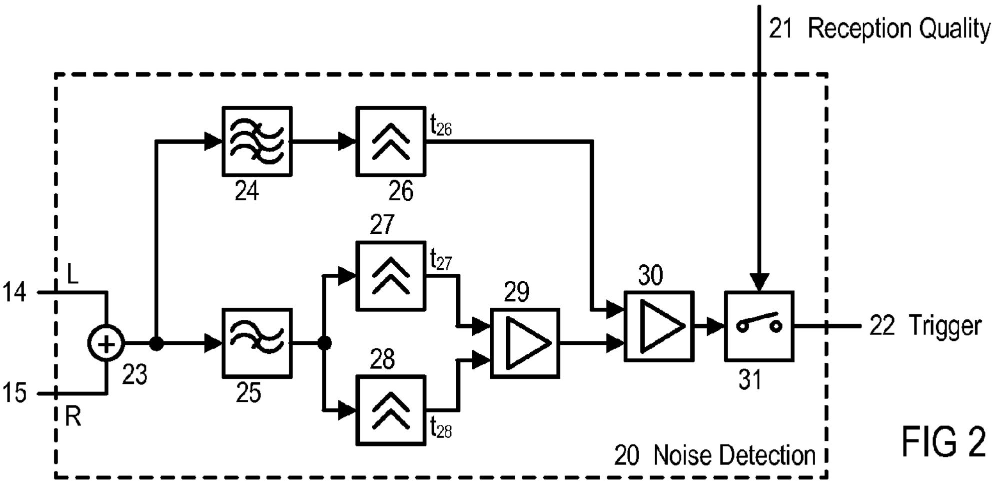

FIG 2

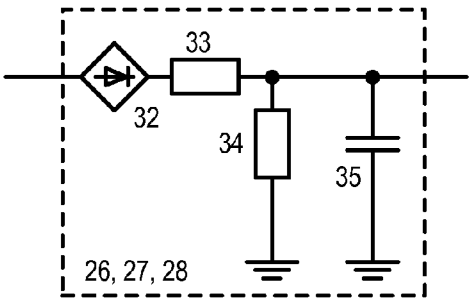

FIG 3

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EUROPEAN SEARCH REPORT

Application Number
EP 13 17 3079

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 2 180 465 A2 (YAMAHA CORP [JP]) 28 April 2010 (2010-04-28) * abstract * * * page 11, paragraph [0054] - page 12, paragraph [0062] * * figure 9 * -----	1,9	INV. G10L21/0208
A	SHIGEKI INOUE ET AL: "High Quality FM Stereo Decoding IC with Birdie Noise Cancelling Circuit", IEEE TRANSACTIONS ON CONSUMER ELECTRONICS, IEEE SERVICE CENTER, NEW YORK, NY, US, vol. 52, no. 3, 1 August 1981 (1981-08-01), pages 243-253, XP011153264, ISSN: 0098-3063 * abstract * * * page 245, paragraph [3. Basic concept] * * figures 5,6 * -----	1,9	
A	CHI-MIN LIU ET AL: "Compression Artifacts in Perceptual Audio Coding", IEEE TRANSACTIONS ON AUDIO, SPEECH AND LANGUAGE PROCESSING, IEEE SERVICE CENTER, NEW YORK, NY, USA, vol. 16, no. 4, 1 May 2008 (2008-05-01), pages 681-695, XP011207621, ISSN: 1558-7916 * abstract * * * page 681, left-hand column, paragraph 1 - right-hand column, paragraph 2 * * page 693, right-hand column, paragraph 2 - page 694, left-hand column, paragraph 2 * * figure 1b * -----	1,9	TECHNICAL FIELDS SEARCHED (IPC): G10L

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	12 August 2013	Greiser, Norbert

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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E : earlier patent document, but published on, or after the filing date
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 17 3079

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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