have ranged from about 10 kHz to about 3500 Hz. U.S. Patents 5,583,962; 5,633,981, 5,727,119, 5,909,664, and 6,021,386 include teachings that relate to the combining of multiple audio channels into a composite channel and auxiliary or sidechain information and the recovery therefrom of an approximation to the original multiple channels. Each of said patents is hereby incorporated by reference in its entirety.

Methods according to the pre-characterizing portion of claims 1 ~~and 12~~ are known from the document WO 03/090208 A1 that describes encoding of N input audio channels to a monophonic audio signal and a set of spatial parameters including a parameter representing a measure of similarity of waveforms of the N input audio channels, namely interchannel level difference and a selected one of interchannel time difference and interchannel phase difference. The monophonic audio signal is derived from the N input audio channels by summing the N input audio channels after a phase correction in accordance with interchannel time difference. The corresponding decoding method disclosed in this document synthesizes replica of the N input audio channels from the monophonic audio signal and the spatial parameters.

Disclosure of the Invention

Aspects of the present invention may be viewed as improvements upon the "coupling" techniques of the AC-3 encoding and decoding system and also upon other techniques in which multiple channels of audio are combined either to a monophonic composite signal or to multiple channels of audio along with related auxiliary information and from which multiple channels of audio are reconstructed. Aspects of the present invention also may be viewed as improvements upon techniques for downmixing multiple audio channels to a monophonic audio signal or to multiple audio channels and for decorrelating multiple audio channels derived from a monophonic audio channel or from multiple audio channels.

Aspects of the invention may be employed in an N:1:N spatial audio coding technique (where "N" is the number of audio channels) or an M:1:N spatial audio coding technique (where "M" is the number of encoded audio channels and "N" is the number of decoded audio channels) that improve on channel coupling, by providing, among other things, improved phase compensation, decorrelation mechanisms, and signal-dependent variable time-constants. Aspects of the present invention may also be employed in N:x:N and M:x:N spatial audio coding techniques wherein "x" may be 1 or greater than 1. Goals include the

reduction of coupling cancellation artifacts in the encode process by adjusting relative interchannel phase before downmixing, and improving the spatial dimensionality of the reproduced signal by restoring the phase angles and degrees of decorrelation in the decoder. Aspects of the invention when embodied in practical embodiments mayshould allow for continuous rather than on-demand channel coupling and lower coupling frequencies than, for example in the AC-3 system, thereby reducing the required data rate.

According to a first aspect of the present invention, there is provided a method for decoding M encoded audio channels representing N audio channels, where N is two or more, and a set of one or more spatial parameters having a first time resolution, the method comprising: a) receiving said M encoded audio channels and said set of spatial parameters having the first time resolution, b) employing interpolation over time to produce a set of one or more spatial parameters having a second time resolution from said set of one or more spatial parameters having the first time resolution, c) deriving N audio signals from said M encoded channels, wherein each audio signal is divided into a plurality of frequency bands, wherein each band comprises one or more spectral components, and d) generating a multichannel output signal from the N audio signals and the one or more spatial parameters having the second time resolution, wherein M is two or more, at least one of said N audio signals is a correlated signal derived from a weighted combination of at least two of said M encoded audio channels, said set of spatial parameters having the second resolution includes a first parameter indicative of the amount of an uncorrelated signal to mix with a correlated signal and step d) includes deriving at least one uncorrelated signal from said at least one correlated signal, and controlling the proportion of said at least one correlated signal to said at least one uncorrelated signal in at least one channel of said multichannel output signal in response to one or ones of said spatial parameters having the second resolution, wherein said controlling is at least partly in accordance with said first parameter.

According to a second aspect of the present invention, there is provided an apparatus comprising means adapted to carry out each of the steps of the method as defined in the first aspect.

According to a third aspect of the present invention, there is provided a medium that conveys a program of instructions and is readable by a device for executing the program of instructions to perform all of the steps in the method as defined in the first aspect.

Description of the Drawings

FIG. 1 is an idealized block diagram showing the principal functions or devices of an N:1 encoding arrangement embodying aspects of the present invention.

FIG. 2 is an idealized block diagram showing the principal functions or devices of a 1:N decoding arrangement embodying aspects of the present invention.

FIG. 3 shows an example of a simplified conceptual organization of bins and subbands along a (vertical) frequency axis and blocks and a frame along a (horizontal) time axis. The figure is not to scale.

FIG. 4 is in the nature of a hybrid flowchart and functional block diagram showing encoding steps or devices performing functions of an encoding arrangement embodying aspects of the present invention.

FIG. 5 is in the nature of a hybrid flowchart and functional block diagram showing decoding steps or devices performing functions of a decoding arrangement embodying aspects of the present invention.

FIG. 6 is an idealized block diagram showing the principal functions or devices of a first N:x encoding arrangement embodying aspects of the present invention.

FIG. 7 is an idealized block diagram showing the principal functions or devices of an x:M decoding arrangement embodying aspects of the present invention.

FIG. 8 is an idealized block diagram showing the principal functions or devices of a first alternative x:M decoding arrangement embodying aspects of the present invention.

FIG. 9 is an idealized block diagram showing the principal functions or devices of a second alternative x:M decoding arrangement embodying aspects of the present invention.

Best Mode for Carrying Out the Invention

Basic N:1 Encoder

Referring to FIG. 1, an N:1 encoder function or device embodying aspects of the