$$Z(t) = \begin{pmatrix} Z_1(t) \\ Z_2(t) \\ \vdots \\ Z_N(t) \end{pmatrix} \quad [2]$$

$$= \boldsymbol{R}(t) \text{ x } X(t). \quad [3]$$

[0041] The coefficients of encoder pre-mixer matrix $\boldsymbol{R}$ may vary over time, and $\boldsymbol{R}$ may thus be considered to be a function of time. The values of the elements of $\boldsymbol{R}$ may be computed at regular intervals (e.g., where the interval may be 20 ms, or a value between 1 ms and 100 ms) or at irregular intervals. When the values of the elements of $\boldsymbol{R}$ are changed, the change may be smoothly interpolated. In the following discussion, references to $\boldsymbol{R}$ should be treated as references to a time-varying encoder pre-mixer $\boldsymbol{R}(t)$ and references to $\boldsymbol{R'}$ should be treated as references to a time-varying decoder pre-mixer $\boldsymbol{R'}(t)$.

[0042] In an embodiment, encoder pre-mixer 102 may make use of mixing coefficients, $\boldsymbol{R_b}(t)$ for processing the components of the audio signals in a band b, where $1 \leq b \leq B$. FIG. 4 illustrates an arrangement of processing elements 150 whereby multi-channel audio signal 151 (X) is split by filterbank 152 into B sub-band signals, $X^{[1]}(t), X^{[2]}(t), \ldots X^{[B]}(t)$, with each sub-band signal (for example 153 ($X^{[1]}(t)$)) is processed by a mixing matrix (for example 154 ($\boldsymbol{R}_1$) to produce a remixed subband signal (for example 155 ($Z^{[1]}(t)$)). Remixed sub-band signals, $Z^{[1]}(t)$, $Z^{[2]}(t), \ldots Z^{[B]}(t)$, are recombined by combiner 156 to form multi-channel audio signal 157 (Z).

[0043] For the purpose of the following discussion, references to the matrix $\boldsymbol{R}(t)$ may be interpreted as references to $\boldsymbol{R_b}(t)$, where b refers to a subband. It will be appreciated that the discussion that follows may be applied to signals that are processed in subbands, or to signals that are processed without subband treatment. It will be appreciated by those skilled in the art that many methods may be used to process audio signals according to sub-bands, and the discussion of the matrix $\boldsymbol{R}$ will apply to those methods.

[0044] Referring to FIG. 2, $\boldsymbol{R}$ mixes the channels of multi-channel audio signal 101 to produce multi-channel audio signal 103 that possesses the attributes, DD1 and DD2, as described above, thus enabling encoder 106 to achieve improved data efficiency. Decoder pre-mixer 108 ($\boldsymbol{R'}$) provides a mixing operation that is the inverse of mixer $\boldsymbol{R}$, such that:

$$X'(t) = \boldsymbol{R'}(t) \times Z'(t) \quad . \quad [4]$$

[0045] FIG. 3 is a block diagram of an arrangement 200 of two mixing operations intended to implement the function of encoder pre-mixer 102 (***R***) of FIG. 2 or encoder pre-mixer $\boldsymbol{R_b}$ of FIG. 4. N-channel multi-channel input signal 201 (X) is mixed by mixing matrix 202 (***M***) to produce the N-channel intermediate signal 203 (Y), which is then processed by mixer 204 (***P***) to produce the N-channel signal 205 (Z). The signals 201 (X) and 205 (Z) in FIG. 3 are intended to correspond respectively with input signal 101(X) and 103 (Z) in FIG. 2, or to sub-band signals 153 ($X_b(t)$) and 155 ($Z_b(t)$) in FIG. 4.

[0046] Analysis block 210 (A) takes input from signal 201, and computes the coefficients 212 to be used to adapt the operation of the mixer 204. Analysis block 210 also produces the metadata 211 (Q), corresponding to the metadata 112 of FIG. 2, which will be provided to the decoder, as 113 (Q), to be used by decoder post-mixer 108.

[0047] It will be appreciated from the arrangement of the mixers 202 and 204 in FIG. 4, that the matrix ***R*** will be:

$$R(t) = \boldsymbol{P}(t) \times \boldsymbol{M} \qquad [5]$$

wherein the matrix $\boldsymbol{P}(t)$ may vary with time.

[0048] Hence:

$$\begin{aligned} Y(t) &= \boldsymbol{M} \times X(t) \\ Z(t) &= \boldsymbol{P}(t) \times Y(t) \\ &= \boldsymbol{P}(t) \times \boldsymbol{M} \times X(t) \\ &= \boldsymbol{R}(t) \times X(t) \end{aligned} \qquad [6]\text{-}[9]$$

[0049] The matrix ***M*** is adapted to ensure that the intermediate signal 203 (Y) possesses attribute DD1. That is the N-channel signal 203 (Y) contains one channel that may be considered to be a dominant channel. Without loss of generality, the matrix ***M*** is adapted to ensure that the first channel, $Y_1(t)$ is a dominant channel. Hereinafter, when the first channel of a multi-channel signal is a dominant channel, this first channel will be referred to as a primary channel. The primary channel may also be referred to as an "eigen channel" in some contexts.

[0050] The $[N \times N]$ matrix ***M*** may be determined from the [N x N] expected covariance matrix ***Cov*** of the N-channel input signal, $X(t)$: