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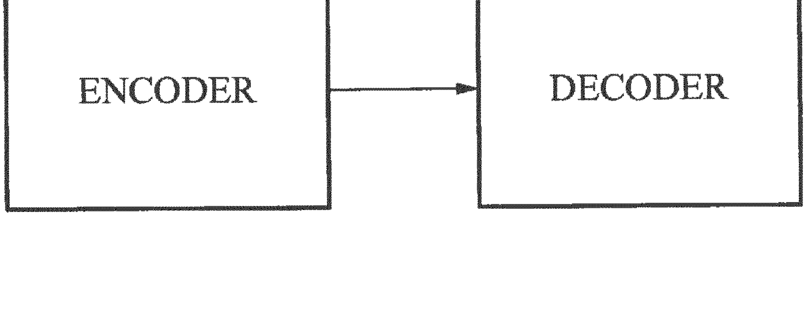
(54) **ENCODER AND ENCODING METHOD FOR MULTICHANNEL SIGNAL, AND DECODER AND DECODING METHOD FOR MULTICHANNEL SIGNAL**

(57) Disclosed are an encoder and encoding method for a multi-channel signal, and a decoder and decoding method for a multi-channel signal. The present invention may code a normal channel signal and a low-frequency effects (LFE) channel signal included in a multi-channel signal through a two-stage coding process or a one-stage coding process employing a time delay, thereby efficiently coding a multi-channel signal.

FIG. 1



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Description

Technical Field

[0001] Exemplary embodiments relate to an encoder and encoding method for a multi-channel signal, and a decoder and decoding method for a multi-channel signal, and more particularly to a codec for efficiently processing a multi-channel signal including a plurality of channel signals.

Background Art

[0002] With demands for ultrahigh quality of audiovisual (AV) media require, novel technology for compression/transmission of AV media is needed. For superhigh audio content, audio quality and accurate representation of a sound field of multi-channels are important rather than backward comparability. For instance, a 22.2 channel audio signal, which is for reproducing a sound field of an ultrahigh-quality audio, requires a high-quality multi-channel audio coding technique which enables representation of unique sound quality and effects of a sound field of content as it is, rather than compression/transmission techniques for backward compatibility.

[0003] Thus, new codec structures are needed for encoding/decoding known 5.1 or 7.1 channel or greater multi-channel signals.

Disclosure of Invention

Technical problems

[0004] An aspect of the present invention is to provide an apparatus and method of encoding or decoding a multi-channel signal including a low-frequency effects (LFE) channel signal.

[0005] Another aspect of the present invention is to provide an apparatus and method of performing two-stage encoding/decoding or one-stage encoding/decoding employing a time delay.

Technical solutions

[0006] According to a first embodiment of the present invention, there is provided a method of encoding a multi-channel signal, the method including outputting a first downmixed signal and a first spatial cue by encoding a first normal channel signal and a first low-frequency effects (LFE) channel signal which are included in a multi-channel signal; outputting a second downmixed signal and a second spatial cue by encoding a second normal channel signal and a second LFE channel signal which are included in the multi-channel signal; encoding the first downmixed signal the second downmixed signal together; and generating a bitstream including the encoded first downmixed signal, the encoded second downmixed signal, the first spatial cue and the second spatial cue.

[0007] The outputting of the first cue may output the first downmixed signal and the first spatial cue by applying parametric coding to the first normal channel signal and the first LFE channel signal in an LFE mode, the outputting of the second cue may output the second downmixed signal and the second spatial cue by applying parametric coding to the second normal channel signal and the second LFE channel signal in the LFE mode, and the first spatial cue and the second spatial cue may include a channel level difference (CLD) output from an LFE band of the first LFE channel signal or the second LFE channel signal.

[0008] According to a second embodiment of the present invention, there is provided a method of encoding a multi-channel signal, the method including outputting a first downmixed signal and a first spatial cue by encoding a first normal channel signal and a first LFE channel signal which are included in a multi-channel signal; outputting a second downmixed signal and a second spatial cue by encoding a second normal channel signal and a second LFE channel signal which are included in the multi-channel signal; encoding the first downmixed signal; encoding the second downmixed signal separately from the first downmixed signal; and generating a bitstream including the encoded first downmixed signal, the encoded second downmixed signal, the first spatial cue and the second spatial cue.

[0009] The outputting of the first cue may output the first downmixed signal and the first spatial cue by applying parametric coding to the first normal channel signal and the first LFE channel signal in an LFE mode, the outputting of the second cue may output the second downmixed signal and the second spatial cue by applying parametric coding to the second normal channel signal and the second LFE channel signal in the LFE mode, and the first spatial cue and the second spatial cue may include a CLD output from an LFE band of the first LFE channel signal or the second LFE channel signal.

[0010] According to a third embodiment of the present invention, there is provided a method of encoding a multi-channel signal, the method including outputting a downmixed signal and a spatial cue by encoding a first LFE channel signal and a second LFE channel signal which are included in a multi-channel signal; encoding the downmixed signal; and generating a bitstream including the encoded downmixed signal and the spatial cue.

[0011] The outputting may output the downmixed signal and the spatial cue by applying parametric coding to the first LFE channel signal and the second LFE channel signal in an LFE mode, and the spatial cue may include a CLD output from an LFE band of the first LFE channel signal or the second LFE channel signal.

[0012] According to a fourth embodiment of the present invention, there is provided a method of encoding a multi-channel signal, the method including applying a time delay to a first LFE channel signal included in a multi-channel signal; applying the time delay to a second LFE channel signal included in the multi-channel signal; encoding the first LEF channel signal to which the time delay is applied; encoding the second LEF channel signal to which the time delay is applied; and generating a bitstream including the encoded first LEF channel signal and the encoded second LEF channel signal.

[0013] The time delay may include a time delay which occurs in encoding a normal channel signal included in the multi-channel signal.

[0014] According to a fifth embodiment of the present invention, there is provided a method of encoding a multi-channel signal, the method including applying a time delay a normal channel signal included in a multi-channel signal; encoding the normal channel signal to which the time delay is applied; outputting a downmixed signal and a spatial cue by encoding an LFE channel signal included in the multi-channel signal; and encoding the encoded LFE channel signal, wherein the time delay includes a time delay which occurs in encoding the LFE channel signal.

[0015] The outputting may output the downmixed signal and the spatial cue by conducting parametric coding on the LFE channel signal in an LFE mode.

[0016] According to a first embodiment of the present invention, there is provided a method of decoding a multi-channel signal, the method including generating a first downmixed signal and a second downmixed signal by decoding an encoded result extracted from a bitstream; outputting a first normal channel signal and a first LFE channel signal by decoding the first downmixed signal; and outputting a second normal channel signal and a second LFE channel signal by decoding the second downmixed signal.

[0017] The outputting of the first normal channel signal and the first LFE channel signal may output the first normal channel signal and the first LEF channel signal from the first downmixed signal by applying a first spatial cue to parametric coding, the outputting of the second normal channel signal and the second LFE channel signal may output the second normal channel signal and the second LEF channel signal from the second downmixed signal by applying a second spatial cue to parametric coding, and the first spatial cue and the second spatial cue may include a CLD output from an LFE band of the first LFE channel signal or the second LFE channel signal.

[0018] According to a second embodiment of the present invention, there is provided a method of decoding a multi-channel signal, the method including generating a first downmixed signal by decoding an encoded result extracted from a bitstream; generating a second downmixed signal by decoding another encoded result extracted from the bitstream; outputting a first normal channel signal and a first LFE channel signal by decoding the first downmixed signal; and outputting a second normal channel signal and a second LFE channel signal by decoding the second downmixed signal.

[0019] The outputting of the first normal channel signal and the first LFE channel signal may output the first normal channel signal and the first LEF channel signal using parametric coding based on a first spatial cue for the first downmixed signal, the outputting of the second normal channel signal and the second LFE channel signal may output the second normal channel signal and the second LEF channel signal using parametric coding based on a second spatial cue for the second downmixed signal, and the first spatial cue and the second spatial cue may include a CLD output from an LFE band of the first LFE channel signal or the second LFE channel signal.

[0020] According to a third embodiment of the present invention, there is provided a method of decoding a multi-channel signal, the method including generating a downmixed signal by decoding an encoded result extracted from a bitstream; and outputting a first LFE channel signal and a second LFE channel signal by decoding the downmixed signal.

[0021] The outputting may output the first LEF channel signal and the second LFE channel signal by applying parametric coding based on a spatial cue to the downmixed signal, and the spatial cue may include a CLD output from an LFE band of the first LFE channel signal or the second LFE channel signal.

[0022] According to a fourth embodiment of the present invention, there is provided a method of decoding a multi-channel signal, the method including outputting a first LFE channel signal by decoding an encoded result extracted from a bitstream; outputting a second LFE channel signal by decoding another encoded result extracted from the bitstream; applying a time delay to the first LEF channel signal; and applying the time delay to the second LFE channel signal.

[0023] The time delay may include a time delay which occurs in decoding a normal channel signal.

[0024] According to a fifth embodiment of the present invention, there is provided a method of decoding a multi-channel signal, the method including decoding a normal channel signal from a bitstream; applying a time delay to the decoded normal channel signal; decoding an LFE channel signal from the bitstream; and decoding the decoded LFE channel signal.

[0025] The time delay may include a time delay which occurs in decoding the LFE channel signal.

[0026] The decoding of the LFE channel signal may output a downmixed signal and a spatial cue by conducting parametric coding on the LFE channel signal in an LFE mode.

[0027] According to a first embodiment of the present invention, there is provided an encoder for a multi-channel signal, the encoder including a first encoding unit to output a first downmixed signal and a first spatial cue by encoding a first normal channel signal and a first low-frequency effects (LFE) channel signal which are included in a multi-channel signal and to output a second downmixed signal and a second spatial cue by encoding a second normal channel signal and a second LFE channel signal which are included in the multi-channel signal; a second encoding unit to encode the first downmixed signal and the second downmixed signal together; and a bitstream formatter to generate a bitstream including the encoded first downmixed signal, the encoded second downmixed signal, the first spatial cue and the second spatial cue.

[0028] The first encoding unit may output the first downmixed signal and the first spatial cue by applying parametric coding to the first normal channel signal and the first LFE channel signal in an LFE mode and may output the second downmixed signal and the second spatial cue by applying parametric coding to the second normal channel signal and the second LFE channel signal in the LFE mode, and the first spatial cue and the second spatial cue may include a channel level difference (CLD) output from an LFE band of the first LFE channel signal or the second LFE channel signal.

[0029] According to a second embodiment of the present invention, there is provided an encoder for a multi-channel signal, the encoder including a first encoding unit to output a first downmixed signal and a first spatial cue by encoding a first normal channel signal and a first LFE channel signal which are included in a multi-channel signal and to output a second downmixed signal and a second spatial cue by encoding a second normal channel signal and a second LFE channel signal which are included in the multi-channel signal; a second encoding unit to encode the first downmixed signal; encoding the second downmixed signal separately from the first downmixed signal; and a bitstream formatter to generate a bitstream including the encoded first downmixed signal, the encoded second downmixed signal, the first spatial cue and the second spatial cue.

[0030] The first encoding unit may output the first downmixed signal and the first spatial cue by applying parametric coding to the first normal channel signal and the first LFE channel signal in an LFE mode and may output the second downmixed signal and the second spatial cue by applying parametric coding to the second normal channel signal and the second LFE channel signal in the LFE mode, and the first spatial cue and the second spatial cue may include a CLD output from an LFE band of the first LFE channel signal or the second LFE channel signal.

[0031] According to a third embodiment of the present invention, there is provided an encoder for a multi-channel signal, the encoder including a first encoding unit to output a downmixed signal and a spatial cue by encoding a first LFE channel signal and a second LFE channel signal which are included in a multi-channel signal; a second encoding unit to encode the downmixed signal; and a bitstream formatter to generate a bitstream including the encoded downmixed signal and the spatial cue.

[0032] The first encoding unit may output the downmixed signal and the spatial cue by applying parametric coding to the first LFE channel signal and the second LFE channel signal in an LFE mode, and the spatial cue may include a CLD output from an LFE band of the first LFE channel signal or the second LFE channel signal.

[0033] According to a fourth embodiment of the present invention, there is provided an encoder for a multi-channel signal, the encoder including a delay unit to apply a time delay to a first LFE channel signal included in a multi-channel signal and to applying the time delay to a second LFE channel signal included in the multi-channel signal; a second encoding unit to encode the first LEF channel signal to which the time delay is applied and to encode the second LEF channel signal to which the time delay is applied; and a bitstream formatter to generate a bitstream including the encoded first LEF channel signal and the encoded second LEF channel signal.

[0034] The time delay may include a time delay which occurs in encoding a normal channel signal included in the multi-channel signal.

[0035] According to a fifth embodiment of the present invention, there is provided an encoder for a multi-channel signal, the encoder including a delay unit to apply a time delay a normal channel signal included in a multi-channel signal; a first encoding unit to encode the normal channel signal to which the time delay is applied; a second encoding unit to output a downmixed signal and a spatial cue by encoding an LFE channel signal included in the multi-channel signal; and a third encoding unit to encode the encoded LFE channel signal, wherein the time delay includes a time delay which occurs in encoding the LFE channel signal.

[0036] The second encoding unit may output the downmixed signal and the spatial cue by conducting parametric coding on the LFE channel signal in an LFE mode.

[0037] According to a first embodiment of the present invention, there is provided a decoder for a multi-channel signal, the decoder including a first decoding unit to generate a first downmixed signal and a second downmixed signal by decoding an encoded result extracted from a bitstream; and a second decoding unit to output a first normal channel signal and a first LFE channel signal by decoding the first downmixed signal and to output a second normal channel signal and a second LFE channel signal by decoding the second downmixed signal.

[0038] The second decoding unit may output the first normal channel signal and the first LEF channel signal from the first downmixed signal by applying a first spatial cue to parametric coding and may output the second normal channel signal and the second LEF channel signal from the second downmixed signal by applying a second spatial cue to parametric coding, and the first spatial cue and the second spatial cue may include a CLD output from an LFE band of the first LFE channel signal or the second LFE channel signal.

[0039] According to a second embodiment of the present invention, there is provided a decoder for a multi-channel signal, the decoder including a first decoding unit to generate a first downmixed signal by decoding an encoded result extracted from a bitstream and to generate a second downmixed signal by decoding another encoded result extracted from the bitstream; and a second decoding unit to output a first normal channel signal and a first LFE channel signal by decoding the first downmixed signal; and to output a second normal channel signal and a second LFE channel signal by decoding the second downmixed signal.

[0040] The second decoding unit may output the first normal channel signal and the first LEF channel signal using parametric coding based on a first spatial cue for the first downmixed signal and may output the second normal channel signal and the second LEF channel signal using parametric coding based on a second spatial cue for the second downmixed signal, and the first spatial cue and the second spatial cue may include a CLD output from an LFE band of the first LFE channel signal or the second LFE channel signal.

[0041] According to a third embodiment of the present invention, there is provided a decoder for a multi-channel signal, the decoder including a first decoding unit to generate a downmixed signal by decoding an encoded result extracted from a bitstream; and a second decoding unit to output a first LFE channel signal and a second LFE channel signal by decoding the downmixed signal.

[0042] The second decoding unit may output the first LEF channel signal and the second LFE channel signal by applying parametric coding based on a spatial cue to the downmixed signal, and the spatial cue may include a CLD output from an LFE band of the first LFE channel signal or the second LFE channel signal.

[0043] According to a fourth embodiment of the present invention, there is provided a decoder for a multi-channel signal, the decoder including a first decoding unit to output a first LFE channel signal by decoding an encoded result extracted from a bitstream and to output a second LFE channel signal by decoding another encoded result extracted from the bitstream; and a delay unit to apply a time delay to the first LEF channel signal and to apply the time delay to the second LFE channel signal.

[0044] The time delay may include a time delay which occurs in decoding a normal channel signal.

[0045] According to a fifth embodiment of the present invention, there is provided a decoder for a multi-channel signal, the decoder including a first decoding unit to decode a normal channel signal from a bitstream; a delay unit to apply a time delay to the decoded normal channel signal; a second decoding unit to decode an LFE channel signal from the bitstream; and a third decoding unit to decode the decoded LFE channel signal.

[0046] The time delay may include a time delay which occurs in decoding the LFE channel signal.

[0047] The second decoding unit may output a downmixed signal and a spatial cue by conducting parametric coding on the LFE channel signal in an LFE mode.

Effects of Invention

[0048] According to an aspect of the present invention, a multi-channel signal including a low-frequency effects (LFE) channel signal in addition to a normal channel signal may be effectively encoded or decoded.

[0049] According to another aspect of the present invention, synchronized multi-channel signals may be output by employing two-stage encoding/decoding or one-stage encoding/decoding employing a time delay.

Brief Description of Drawings

[0050]

FIG. 1 illustrates an encoder and a decoder according to an embodiment.

FIG. 2 illustrates an encoder which encodes a multi-channel signal including a low-frequency effects (LFE) channel signal according to a first embodiment.

FIG. 3 illustrates an encoder which encodes a multi-channel signal including an LFE channel signal according to a second embodiment.

FIG. 4 illustrates an encoder which encodes a multi-channel signal including an LFE channel signal according to a third embodiment.

FIG. 5 illustrates an encoder which encodes a multi-channel signal including an LFE channel signal according to a fourth embodiment.

FIG. 6 illustrates a decoder which decodes an encoded result of FIG. 2.

FIG. 7 illustrates a decoder which decodes an encoded result of FIG. 3.

FIG. 8 illustrates a decoder which decodes an encoded result of FIG. 4.

FIG. 9 illustrates a decoder which decodes an encoded result of FIG. 5.

FIG. 10 illustrates a process of encoding a multi-channel signal using the encoder of FIG. 2.

FIG. 11 illustrates a decoder which decodes an encoded result of FIG. 10.

FIG. 12 illustrates a process of encoding a multi-channel signal when encoding bits are sufficient in FIG. 10.

FIG. 13 illustrates a decoder which decodes an encoded result of FIG. 12.

FIG. 14 illustrates an example of encoding a multi-channel signal using the encoder of FIG. 4.

FIG. 15 illustrates another example of encoding a multi-channel signal using the encoder of FIG. 4.

FIG. 16 illustrates an example of encoding a multi-channel signal using the encoder of FIG. 5.

FIG. 17 illustrates an example of decoding a multi-channel signal using the decoder of FIG. 9.

FIG. 18 illustrates an encoder which encodes a multi-channel signal when the multi-channel signal includes an odd number of LFE channel signals according to an embodiment.

FIG. 19 illustrates an encoder which encodes a normal audio signal, not an LFE channel signal, according to an embodiment.

FIG. 20 illustrates a decoder which decodes an encoded result of FIG. 19.

FIG. 21 illustrates an encoding process and a decoding process according to an embodiment.

FIG. 22 illustrates a USAC encoder and a USAC decoder according to a first embodiment.

FIG. 23 illustrates a USAC encoder and a USAC decoder according to a first embodiment.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0051] Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[0052] FIG. 1 illustrates an encoder and a decoder according to an embodiment.

[0053] Referring to FIG. 1, the encoder 101 and the decoder 102 are shown. The encoder 101 may encode a multi-channel signal including a plurality of channel signals to generate a bitstream. The decoder 101 may decode the multi-channel signal from the bitstream received from the encoder 101 or stored in a medium of the encoder 101.

[0054] Here, according to one embodiment, the multi-channel signal may include a low-frequency effects (LFE) channel signal. Here, an LFE channel signal refers to a channel signal for low-frequency effects (LFE) of a selective and limited sound range. Here, a low sound range may refer to a low-frequency range from 20 to 120 Hz. An LFE channel signal may be used to supplement low-frequency information on a main channel signal by transmitting additional low-frequency information.

[0055] Hereinafter, processes of encoding or decoding a multi-channel signal including an LFE channel signal will be described in detail.

[0056] FIG. 2 illustrates an encoder which encodes a multi-channel signal including an LFE channel signal according to a first embodiment.

[0057] FIGS. 2 to 5 illustrate processes of encoding a multi-channel signal including two LFE channel signals, and FIGS. 6 to 9 illustrate processes of decoding encoded results of FIGS. 2 to 5.

[0058] Referring to FIG. 2, the encoder may include a first encoding unit 201, a first encoding unit 202, a second encoding unit 203 and a bitstream formatter 204. Here, the first encoding units 201 and 202 may perform the same operations.

[0059] In detail, the first encoding unit 201 may generate a downmixed signal dmx_1 using an LFE channel signal Lfe_1 and a normal channel signal x_i. Here, a normal channel signal may refer to a channel signal which does not exhibit low-frequency effects. The first encoding unit 202 may generate a downmixed signal dmx_2 using an LFE channel signal Lfe_2 and a normal channel signal x_{i+1}. i represents an index of a normal channel signal. That is, the encoder of FIG. 2 may encode a multi-channel signal including a normal channel signal coupled to an LFE channel signal.

[0060] Here, the first encoding units 201 and 202 may perform parametric coding to output spatial cues and the downmixed signals. Here, the first encoding units 201 and 202 perform parametric coding using the LFE channel signals.

[0061] When parametric coding is performed using an LFE channel signal, a channel level difference (CLD) as a spatial cue may be extracted from an LFE band. Accordingly, a spatial cue output through parametric coding using an LFE channel signal may output a relatively smaller amount of data than a spatial cue output through generally used parametric coding. Here, the spatial cues output from the first encoding units 201 and 202 are bit1 and bit2, respectively.

[0062] The second encoding unit 203 may encode the downmixed signal dmx_1 output from the first encoding unit 201 and the downmixed signal dmx_2 output from the first encoding unit 202. The downmixed signals dmx_1 and dmx_2 may be input as a stereo signal to the second encoding unit 203. For instance, the second encoding unit 203 may be an Advanced Audio Codec (AAC), MP3, or the like. The second encoding unit 203 outputs bit3 as an encoded result, which is input to the bitstream formatter 204. The bitstream formatter 204 may convert bit3 into a bitstream.

[0063] FIG. 3 illustrates an encoder which encodes a multi-channel signal including an LFE channel signal according to a second embodiment.

[0064] The encoder of FIG. 3 may include a first encoding unit 301, a second encoding unit 302, a first encoding unit 303, a second encoding unit 304 and a bitstream formatter 305.

[0065] The first encoding units 301 and 303 of FIG. 3 may operate in the same manner as the first encoding units 201 and 202 of FIG. 2. That is, the first encoding units 301 and 303 may perform parametric coding using an LFE channel signal to extract a CLD as a spatial cue from an LFE band. In detail, the first encoding unit 301 may generate a downmixed signal dmx_1 using an LFE channel signal Lfe_1 and a normal channel signal x_i. The first encoding unit 303 may generate a downmixed signal dmx_2 using an LFE channel signal Lfe_2 and a normal channel signal x_{i+1}.

[0066] The downmixed signal dmxi resulting from encoding by the first encoding unit 301 is input as a mono signal to the second encoding unit 302. The second encoding unit 302 may output bit3 using the downmixed signal dmx_1. The downmixed signal dmx_2 resulting from encoding by the first encoding unit 303 is input as a mono signal to the second encoding unit 304. The second encoding unit 304 may output bit4 using the downmixed signal dmx_2.

[0067] FIG. 4 illustrates an encoder which encodes a multi-channel signal including an LFE channel signal according to a third embodiment.

[0068] Referring to FIG. 4, the encoder may include a first encoding unit 401, a second encoding unit 402 and a bitstream formatter 403. LFE channel signals Lfe_1 and Lfe_2 may be coupled to each other and input to the first encoding unit 401. The first encoding unit 401 may output a downmixed signal dmx_3 as a mono signal using the LFE channel signals Lfe_1 and Lfe_2. Here, bit1 means a spatial cue derived by the first encoding unit 401 through parametric coding.

[0069] The downmixed signal dmx_3 may be input to the second encoding unit 402. Here, the second encoding unit 402 may code an LFE band in the downmixed signal dmx_3. A Unified Speech and Audio Codec (USAC) and an Advanced Audio Codec (AAC) may have a separate coding mode for coding an LFE band. The second encoding unit 402 may use a coding mode provided by the USAC or AAC. Bit2 output from the second encoding unit 402 and bit1 output from the first encoding unit 401 may be output as a bitstream through the bitstream formatter 403.

[0070] FIG. 5 illustrates an encoder which encodes a multi-channel signal including an LFE channel signal according to a fourth embodiment.

[0071] Referring to FIG. 5, the encoder may include a delay unit 501, a second encoding unit 502, a delay unit 503, a second encoding unit 504 and a bitstream formatter 505. FIG. 5 illustrates a process of encoding an LFE channel signal using the second encoding units 502 and 504, not via the aforementioned first encoding units.

[0072] In FIG. 5, the second encoding units 502 and 504 may perform parametric coding on an LFE band. Input signals for the second encoding units 502 and 504 may need to be delayed corresponding to the presence of a first encoding unit. When normal channel signals are subjected to encoding two times and LFE channel signals are subjected to encoding once, one more encoding process of the normal channel signals may cause a time delay. Accordingly, a bitstream of the LFE channel signals synchronized with the normal channel signals may be generated only when the time delay is considered.

[0073] Thus, the delay units 501 and 503 may apply a time delay τ_{enc}, which may occur in real encoding, to the LFE channel signals Lfe_1 and Lfe_2. Subsequently, time-delayed LFE channel signals $Lfe_1(n-\tau_{enc})$ and $Lfe_2(n-\tau_{enc})$ may be input to the second encoding units 502 and 504, respectively. Bit1 and bit2, encoded results by the second encoding units 502 and 504 may be output as a bitstream via the bitstream formatter 505.

[0074] FIG. 6 illustrates a decoder which decodes an encoded result of FIG. 2.

[0075] Referring to FIG. 6, the decoder may include a bitstream deformatter 601, a first decoding unit 602, a second decoding unit 603 and a second decoding unit 604. FIG. 6 may operate in an inverse manner to FIG. 2.

[0076] A bitstream input to the bitstream deformatter 601 may be the bitstream generated in FIG. 2. The bitstream deformatter 601 may output bit1, bit2 and bit3 from the bitstream. Bit1, bit2 and bit3 are the same as those mentioned in FIG. 2.

[0077] Bit3 may be input to the first decoding unit 602. The first decoding unit 602 may generate downmixed signals dmx_1 and dmx_2 using bit3. The second decoding unit 603 may perform parametric coding on bit1 as a spatial cue and the downmixed signal dmx_1 to output a normal channel signal x_i and an LFE channel signal Lfe_1. Likewise, the second decoding unit 604 may perform parametric coding on bit2 as a spatial cue and the downmixed signal dmx_2 to output a normal channel signal x_{i+1} and an LFE channel signal Lfe_2.

[0078] FIG. 7 illustrates a decoder which decodes an encoded result of FIG. 3.

[0079] Referring to FIG. 7, the decoder may include a bitstream deformatter 701, a first decoding unit 702, a second decoding unit 703, a first decoding unit 704 and a second decoding unit 705. FIG. 7 may operate in an inverse manner to FIG. 3.

[0080] A bitstream input to the bitstream deformatter 701 may be the bitstream generated in FIG. 3. The bitstream deformatter 701 may output bit1, bit2, bit3 and bit4 from the bitstream. Bit1, bit2, bit3 and bit4 are the same as those mentioned in FIG. 3.

[0081] Bit3 may be input to the first decoding unit 702, and bit4 may be input to the first decoding unit 704. The first decoding unit 702 may generate a downmixed signal dmx_1 using bit3. The first decoding unit 704 may generate a downmixed signal dmx_2 using bit4.

[0082] Subsequently, the second decoding unit 703 may perform parametric coding on bit1 as a spatial cue and the downmixed signal dmx_1 to output a normal channel signal x_i and an LFE channel signal Lfe_1. Likewise, the second decoding unit 703 may perform parametric coding on bit2 as a spatial cue and the downmixed signal dmx_2 to output a normal channel signal x_{i+1} and an LFE channel signal Lfe_2.

[0083] FIG. 8 illustrates a decoder which decodes an encoded result of FIG. 4.

[0084] Referring to FIG. 8, the decoder may include a bitstream deformatter 801, a first decoding unit 802 and a second decoding unit 803. FIG. 8 may operate in an inverse manner to FIG. 4.

[0085] A bitstream input to the bitstream deformatter 801 may be the bitstream generated in FIG. 4. The bitstream deformatter 801 may output bit1 and bit2 from the bitstream. Bit1 and bit2 are the same as those mentioned in FIG. 4.

[0086] Bit1 may be input to the first decoding unit 802, and bit2 may be input to the second decoding unit 803. The first decoding unit 802 may generate a downmixed signal dmx_3 using bit3. The second decoding unit 803 may perform parametric coding on bit2 as a spatial cue and the downmixed signal dmx_3 to output LFE channel signals Lfe_1 and Lfe_2. In FIG. 8, the first decoding unit 802 and the second decoding unit 803 may perform parametric coding on an LFE band of the input downmixed signal dmx_3.

[0087] FIG. 9 illustrates a decoder which decodes an encoded result of FIG. 5.

[0088] Referring to FIG. 9, the decoder may include a bitstream deformatter 901, a first decoding unit 902, a delay unit 903, a first decoding unit 904 and a delay unit 905. FIG. 9 may operate in an inverse manner to FIG. 5.

[0089] A bitstream input to the bitstream deformatter 901 may be the bitstream generated in FIG. 5. The bitstream deformatter 901 may output bit1 and bit2 from the bitstream. Bit1 and bit2 are the same as those mentioned in FIG. 5.

[0090] Bit1 may be input to the first decoding unit 902, and bit2 may be input to the first decoding unit 904. The first decoding unit 902 may generate an LFE channel signal $Lfe_1(n-\tau_{enc})$ using bit1, and the second decoding unit 904 may generate an LFE channel signal $Lfe_2(n-\tau_{enc})$ using bit2.

[0091] The delay unit 903 may apply a time delay to the LFE channel signal $Lfe_1(n-\tau_{enc})$ to output $Lfe_1(n-\tau_{enc}-\tau_{dec})$. Likewise, the delay unit 905 may apply a time delay to the LFE channel signal $Lfe_2(n-\tau_{enc})$ to output $Lfe_2(n-\tau_{enc}-\tau_{dec})$.

[0092] That is, unlike in FIGS. 6 to 8, since a decoding process is carried out once in FIG. 9, the delay units 903 and 905 may apply a time delay τ_{dec} occurring in one-time decoding so that signals subjected to one-time decoding synchronize with those subjected to two-time decoding.

[0093] FIG. 10 illustrates a process of encoding a multi-channel signal using the encoder of FIG. 2.

[0094] FIG. 10 illustrates an encoder for a multi-channel signal which adopts the encoder Type1 illustrated in FIG. 2. In FIG. 10, Two To Ones (TTOs) 1001, 1002, 1004 and 1005 may encode an input signal according to a parametric coding mode for an MPEG Surround stereo signal. That is, the TTOs may correspond to the first encoding units of FIG. 2, and USAC encoders may correspond to the second encoding unit of FIG. 2.

[0095] In FIG. 10, TTOs 1001 and 1002 may perform parametric coding according to a normal mode, and TTOs 1004 and 1005 may perform parametric coding according to an LFE mode. When parametric coding is performed according to the normal mode, a CLD, Inter-Channel Coherence (ICC) and Interchannel Phase Difference (IPD) as spatial cues may be extracted by analyzing a normal channel signal x_i. When parametric coding is performed according to the LFE mode, only a CLD may be extracted from an LFE band of an input LFE channel signal.

[0096] FIG. 10 illustrates an encoding process when N multi-channel signals are input. In detail, in a first operation, the N multi-channel signals may be subjected to parametric coding via the TTOs into M downmixed signals dmx_1 to dmx_M. In a second operation, the M downmixed signals may be input in a stereo form and encoded through USAC core coding. In FIG. 10, LFE channel signals Lfe_1 and Lfe_2 may be coupled to normal channel signals to be input to the TTO 1004 and TTO1005.

[0097] That is, referring to FIG. 10, normal channel signals of the multi-channel signals may be coupled and downmixed by two channels, and a downmixed result may be subjected to stereo coding by the USAC encoders. Among the normal channel signals of the multi-channel signals, two normal channel signals x_{2M-1} and x_{2M} may be respectively coupled to the LFE channel signals Lfe_1 and Lfe_2 and input to the TTOs(Lfe).

[0098] Although FIG. 10 shows that the encoder Type 1 of FIG. 2 is adopted, the encoder Type 2 illustrated in FIG. 3 may be applied, instead of the encoder Type 1.

[0099] FIG. 11 illustrates a decoder which decodes an encoded result of FIG. 10.

[0100] FIG. 11 illustrates a decoder for a multi-channel signal which adopts the decoder Type 1 illustrated in FIG. 6. In FIG. 11, One To Twos (OTTs) 1103, 1104, 1106 and 1107 may decode an input signal according to a parametric coding mode for an MPEG Surround stereo signal. That is, the OTTs may correspond to the second decoding units of FIG. 6, and USAC decoders may correspond to the first decoding unit.

[0101] In FIG. 11, OTTs 1103 and 1104 may perform parametric coding according to a normal mode, and the OTTs 1106 and 1107 may perform parametric coding according to an LFE mode. In FIG. 11, the encoded result may be decoded to output N multi-channel audio signals.

[0102] In detail, in a first operation, M downmixed signals may be output from a bitstream via the USAC decoders. In a second operation, the M downmixed signals may be input to the respective OTTs to output stereo signals. The OTTs 1103 and 1104 may output two normal channel signals, and the OTTs 1106 and 1107 may output normal channel signals coupled to LEF channel signals.

[0103] FIG. 12 illustrates a process of encoding a multi-channel signal when encoding bits are sufficient in FIG. 10.

[0104] When encoding bits for normal channel signals included in a multi-channel signal are sufficient, the encoding process of FIG. 12 may be performed. That is, normal channel signals x_1 to x_{2M-2} may be encoded by USAC encoders 1203 and 1206. Here, a delay time τ_{enc}, occurring in encoding via delay units 1201, 1201, 1204 and 1205, may be applied to the normal channel signals x_1 to x_{2M-2}. Accordingly, time-delayed results may be encoded by the USAC encoders 1203 and 1206.

[0105] Here, the time delay τ_{enc} occurs in OTTs 1207 and 1208 and may include time delays due to quadrature mirror filter (QMF) analysis, hybrid analysis and QMF synthesis. When a signal input to a USAC Encoder 1209 is a QMF signal, a time delay occurring by QMF synthesis may be excluded when calculating τ_{enc}.

[0106] FIG. 13 illustrates a decoder which decodes an encoded result of FIG. 12.

[0107] FIG. 13 may perform an inverse process to FIG. 12. Referring to FIG. 13, a normal channel signal is decoded by USAC decoders 1302 and 1305 and output via delay units 1303, 1304, 1306 and 1307. A result derived by a bitstream deformatter 1301 maybe decoded by a USAC decoder 1308 to generate downmixed signals, and the downmixed signals may be respectively input to OTTs 1309 and 1310 to output normal channel signals x_{2M-1} and x_{2M} respectively coupled to LFE channel signals Lfe_1 and Lfe_2.

[0108] Here, since the LFE channel signals are subjected to decoding two times, the delay units 1303, 1304, 1306 and 1307 may apply a time delay τ_{dec} occurring in one-time decoding to one-time to output results from the USAC decoders 1302 and 1305. Here, τ_{dec} includes QMF analysis, hybrid analysis, QMF synthesis and filtering delays and is different from τ_{ene}. When output signals from the USAC decoders 1302 and 1305 are QMF signals, a time delay occurring by QMF analysis may be excluded when determining τ_{dec}. A filtering delay refers to a time delay which occurs due to a filtering operation by the OTTs 1309 and 1310, irrespective of QMF conversion. For example, a filtering delay may be a time delay occurring in a decorrelator operation by the OTTs 1309 and 1310.

[0109] FIG. 14 illustrates an example of encoding a multi-channel signal using the encoder of FIG. 4.

[0110] In FIG. 14, the encoder Type 3 illustrated in FIG. 4 may be used. Normal channel signals x_1 to x_{2M} of a multi-channel signal may be coupled by two and input to TTOs 1401 and 1402. The TTOs 1401 and 1402 may perform parametric coding on the normal channel signals coupled by two to output downmixed signals dmx_1 and dmx_2 along with spatial cues. The output downmixed signals dmx_1 and dmx_2 may be input in a stereo form to a USAC encoder 1403.

[0111] Meanwhile, LFE channel signals Lfe_1 and Lfe_2 included in the multi-channel signal may be coupled by two and input to a TTO 140. The TTO 1404 may perform parametric coding using the two LFE channel signals Lfe_1 and Lfe_2 to output a downmixed signal dmx_3 in a mono form. Subsequently, a USAC encoder 1405 may encode the downmixed signal dmx_3 in the LFE mode.

[0112] FIG. 15 illustrates another example of encoding a multi-channel signal using the encoder of FIG. 4.

[0113] In FIG. 15, the encoder Type 3 illustrated in FIG. 4 may be used. Here, in Fig. 15, a normal channel signal may be encoded by USAC encoders 1503 and 1506, instead of being subjected to parametric coding by TTOs 1401 and 1402 in FIG. 14. As illustrated below, since an LFE channel signal is subjected to encoding two times through a TTO 1507 and a USAC encoder 1508, delay units 1501, 1502, 1504 and 1505 may apply a time delay occurring by the TTO 1507 to the normal channel signal.

[0114] Meanwhile, LFE channel signals Lfe_1 and Lfe_2 may be encoded by the TTO 1507 in the LFE mode to output a downmixed signal dmx_3, and the downmixed signal dmx_3 may be encoded by the USAC encoder.

[0115] While FIGS. 14 and 15 illustrate the encoders, corresponding decoders may operate according to inverse processes. In detail, a normal channel signal may be output from a bitstream obtained in FIG. 14 via a USAC decoder and an OTT. Also, LFE channel signals Lfe_1 and Lfe_2 may be output from the bitstream obtained in FIG. 14 via a USAC decoder and an OTT.

[0116] In addition, a normal channel signal may be output from a bitstream obtained in FIG. 15 via a USAC decoder and a delay unit. Also, LFE channel signals Lfe_1 and Lfe_2 may be output from the bitstream obtained in FIG. 15 via a USAC decoder and an OTT.

[0117] FIG. 16 illustrates an example of encoding a multi-channel signal using the encoder of FIG. 5.

[0118] FIG. 16 illustrates an encoder for a multi-channel signal which adopts the encoder Type 4 illustrated in FIG. 5.

[0119] Normal channel signals may be converted into downmixed signals through TTOs 1601 and 1602, and the converted downmixed signals may be output as a bitstream through a USAC encoder 1603.

[0120] Meanwhile, delay units 1604 and 1606 may apply a time delay τ_{enc} occurring in the TTOs 1601 and 1602 to LFE channel signals, and time-delayed results may be encoded respectively by USAC encoders 1605 and 1607 according to the LFE mode. That is, since the LFE channel signals are subjected to encoding once, unlike the normal channel signals subjected to encoding two times, the time delay τ_{enc} occurring in encoding by the TTOs may need to be applied to the LFE channel signals.

[0121] FIG. 17 illustrates an example of decoding a multi-channel signal using the decoder of FIG. 9.

[0122] In FIG. 17, the decoder Type 4 illustrated in FIG. 9 is used. Referring to FIG. 17, normal channel signals may be output through a USAC decoder 1702 and a TTO 1703 and 1704. LFE channel signals may be output through USAC decoders 1705 and 1707 and delay units 1706 and 1708.

[0123] Since the LFE channel signals are subjected to decoding once, the delay units 1706 and 1708 may need to apply a time delay τ_{dec} occurring in decoding by the TTOs 1703 and 1704 to the LFE channel signals. Accordingly, the normal channel signals and the LFE channel signals output from the decoder may be synchronized with each other.

[0124] FIG. 18 illustrates an encoder which encodes a multi-channel signal when the multi-channel signal includes an odd number of LFE channel signals according to an embodiment.

[0125] While FIGS. 2 to 17 illustrate an even number of LFE channel signals, FIG. 18 illustrates an odd number of LFE channel signals.

[0126] Referring to FIG. 18, one LEF channel signal Lfe 2n+1 may be input to a delay unit 1801, and a time delay τ may be applied to the LEF channel signal. The time-delayed LFE channel signal may be encoded by a second encoding unit 1802 in an LFE mode to output bit1. That is, an odd number of LFE channel signals may be processed by the encoder Type 4 of FIG. 5 or the decoder Type 4 of FIG. 9.

[0127] Although not shown in FIG. 18, unlike the LFE channel signal, a normal channel signal is encoded by a first encoding unit and the second encoding unit, and thus a delay unit 1801 may need to apply a time delay occurring due to the first encoding unit to the LFE channel signal for synchronization with the normal channel signal.

[0128] FIG. 19 illustrates an encoder which encodes a normal audio signal, not an LFE channel signal, according to an embodiment.

[0129] Referring to FIG. 19, normal channel signals x_1 and x_2 may be subjected to parametric coding by a first encoding unit 1901 to be converted into a downmixed signal dmx_1 along with a spatial cue bit1. Likewise, normal channel signals x_3 and x_4 may be subjected to parametric coding by a first encoding unit 1902 to be converted into a downmixed signal dmx_2 along with a spatial cue bit2.

[0130] As described above, parametric coding applied to the normal channel signals may extract not only a CLD but also an ICC and IPD as spatial cues. The downmixed signal dmx_1 and dmx_2 may be input in a stereo form to a second encoding unit 1903 and encoded to output bit3. Bit3 may be converted into a bistream by a bitstream formatter 1904.

[0131] FIG. 20 illustrates a decoder which decodes an encoded result of FIG. 19.

[0132] Referring to FIG. 20, spatial cues bit1 and bit2 and encoded bit3 may be output by a bitstream deformatter 2001 from the bitstream generated in FIG. 19.

[0133] A first decoding unit 2002 may decode bit3 to output downmixed signals dmx_1 and dmx_2. A second decoding unit 2003 may decode a downmixed signal dmx_1 to output normal channel signals x_1 and x_2. Likewise, a second decoding unit 2004 may decode a downmixed signal dmx_2 to output normal channel signals x_1 and x_2.

[0134] FIG. 21 illustrates an encoding process and a decoding process according to an embodiment.

[0135] The foregoing first encoding units may correspond to TTOs 2101 and 2102 of FIG. 21, and the foregoing second encoding units may correspond to a USAC encoder 2103. Also, the foregoing first decoding units may correspond to a USAC decoder 2104, and the foregoing second encoding units may correspond to OTTs 2105 and 2106.

> (i) Four normal channel signals or (ii) results of coupling one normal channel signal and one LFE channel signal may be input to the TTOs 2101 and 2102. The TTOs 2101 and 2102 may generate a downmixed signal along with a spatial cue through parametric coding. The USAC encoder 2103 may encode the downmixed signal.

[0136] On the contrary, the USAC decoder 2104 may output two downmixed signals from a bitstream. The OTTs 2105 and 2106 may output (i) four normal channel signals or (ii) results of coupling one normal channel signal and one LFE channel signal from the downmixed signals.

[0137] FIG. 22 illustrates a USAC encoder and a USAC decoder according to a first embodiment.

[0138] The foregoing embodiments illustrate configurations in which a USAC encoder is separate from a TTO or a USAC decoder is separate from an OTT. Alternatively, as in FIG. 22, a USAC encoder may include TTOs 2203 and 2204 to configure an extended USAC encoder 2201. Likewise, a USAC decoder may include OTTs 2211 and 2212 to configure an extended USAC decoder 2202.

> (i) Four normal channel signals or (ii) one normal channel signal and one LFE channel signal may be subjected to parametric coding by the TTOs 2203 and 2204 and output as downmixed signals. The downmixed signals output from the TTOs 2203 and 2204 may be input in a stereo form to a TTO 2205 and be subjected to parametric coding one more time. A result of parametric coding is subjected to in frequency extension by a spectral band replication (SBR) 2206, and a non-frequency-extended core band may be encoded by a core encoder 2207.

[0139] In a bitstream generated by the extended USAC encoder 2201, the non-frequency-extended core band is decoded by a core decoder 2208, and a decoded result may be input to and subjected to frequency extension by an SBR 2209, thereby reconstructing an original signal. Subsequently, a result of frequency extension by the SBR 2209 may be subjected to parametric coding by an OTT 2210 to generate two downmixed signals, and the downmixed signals may be subjected to parametric coding by the OTTs 2211 and 2212 to output (i) four normal channel signals or (ii) one normal channel signal and one LFE channel signal.

[0140] FIG. 23 illustrates a USAC encoder and a USAC decoder according to a second embodiment.

[0141] In FIG. 23, positions of an SBR 2305 and a TTO 2306 in an extended USAC encoder 2301 and positions of an OTT 2309 and an SBR 2310 in an extended USAC decoder 2302 are changed from those in FIG. 22. Other components may be equivalent to those in FIG. 22.

[0142] The apparatuses described herein may be implemented using hardware components, software components, and/or combinations of hardware components and software components. For instance, the units and components illustrated in the embodiments may be implemented using one or more general-purpose or special purpose computers, such as, for example, a processor, a controller, an arithmetic logic unit (ALU), a digital signal processor, a microcomputer, a field programmable array (FPA), a programmable logic unit (PLU), a microprocessor or any other device capable of responding to and executing instructions. A processing device may run an operating system (OS) and one or more software applications that run on the OS. The processing device also may access, store, manipulate, process, and create data in response to execution of the software. For purpose of simplicity, the description of a processing device is used as singular; however, one skilled in the art will appreciated that a processing device may include multiple processing elements and multiple types of processing elements. For example, a processing device may include multiple processors or a processor and a controller. In addition, different processing configurations are possible, such as parallel processors.

[0143] The software may include a computer program, a piece of code, an instruction, or one or more combinations thereof, to independently or collectively instruct or configure the processing device to operate as desired. Software and/or data may be embodied permanently or temporarily in any type of machine, component, physical or virtual equipment, computer storage medium or device, or in a propagated signal wave in order to provide instructions or data to the processing device or to be interpreted by the processing device. The software may also be distributed over network coupled computer systems so that the software is stored and executed in a distributed fashion. The software and data may be stored by one or more non-transitory computer readable recording mediums.

[0144] The methods according to the embodiments may be realized as program instructions implemented by various computers and be recorded in non-transitory computer-readable media. The media may also include, alone or in combination with the program instructions, data files, data structures, and the like. The program instructions recorded in the media may be designed and configured specially for the embodiments or be known and available to those skilled in computer software. Examples of the non-transitory computer readable recording medium may include magnetic media such as hard disks, floppy disks, and magnetic tape; optical media such as CD ROM disks and DVDs; magneto-optical media such as floptical disks; and hardware devices that are specially configured to store and perform program instructions, such as read-only memory (ROM), random access memory (RAM), flash memory, and the like. Examples of program instructions include both machine codes, such as produced by a compiler, and higher level language codes that may be executed by the computer using an interpreter. The described hardware devices may be configured to act as one or more software modules in order to perform the operations of the above-described exemplary embodiments, or vice versa.

[0145] While a few exemplary embodiments have been shown and described with reference to the accompanying drawings, it will be apparent to those skilled in the art that various modifications and variations can be made from the foregoing descriptions. For example, adequate effects may be achieved even if the foregoing processes and methods are carried out in different order than described above, and/or the aforementioned elements, such as systems, structures, devices, or circuits, are combined or coupled in different forms and modes than as described above or be substituted or switched with other components or equivalents. Thus, other implementations, alternative embodiments and equivalents to the claimed subject matter are construed as being within the appended claims.

Claims

1. A method of encoding a multi-channel signal, the method comprising:

outputting a first downmixed signal and a first spatial cue by encoding a first normal channel signal and a first low-frequency effects (LFE) channel signal which are comprised in a multi-channel signal;
outputting a second downmixed signal and a second spatial cue by encoding a second normal channel signal and a second LFE channel signal which are comprised in the multi-channel signal;
encoding the first downmixed signal the second downmixed signal together; and
generating a bitstream comprising the encoded first downmixed signal, the encoded second downmixed signal, the first spatial cue and the second spatial cue.

2. The method of claim 1, wherein the outputting of the first cue outputs the first downmixed signal and the first spatial cue by applying parametric coding to the first normal channel signal and the first LFE channel signal in an LFE mode, the outputting of the second cue outputs the second downmixed signal and the second spatial cue by applying parametric coding to the second normal channel signal and the second LFE channel signal in the LFE mode, and the first spatial cue and the second spatial cue comprise a channel level difference (CLD) output from an LFE band of the first LFE channel signal or the second LFE channel signal.

3. A method of encoding a multi-channel signal, the method comprising:

outputting a first downmixed signal and a first spatial cue by encoding a first normal channel signal and a first low-frequency effects (LFE) channel signal which are comprised in a multi-channel signal;
outputting a second downmixed signal and a second spatial cue by encoding a second normal channel signal and a second LFE channel signal which are comprised in the multi-channel signal;
encoding the first downmixed signal;
encoding the second downmixed signal separately from the first downmixed signal; and
generating a bitstream comprising the encoded first downmixed signal, the encoded second downmixed signal, the first spatial cue and the second spatial cue.

4. The method of claim 3, wherein the outputting of the first cue outputs the first downmixed signal and the first spatial cue by applying parametric coding to the first normal channel signal and the first LFE channel signal in an LFE mode, the outputting of the second cue outputs the second downmixed signal and the second spatial cue by applying parametric coding to the second normal channel signal and the second LFE channel signal in the LFE mode, and the first spatial cue and the second spatial cue comprise a channel level difference (CLD) output from an LFE band of the first LFE channel signal or the second LFE channel signal.

5. A method of encoding a multi-channel signal, the method comprising:

outputting a downmixed signal and a spatial cue by encoding a first low-frequency effects (LFE) channel signal and a second LFE channel signal which are comprised in a multi-channel signal;
encoding the downmixed signal; and
generating a bitstream comprising the encoded downmixed signal and the spatial cue.

6. The method of claim 5, wherein the outputting outputs the downmixed signal and the spatial cue by applying parametric coding to the first LFE channel signal and the second LFE channel signal in an LFE mode, and the spatial cue comprises a channel level difference (CLD) output from an LFE band of the first LFE channel signal or the second LFE channel signal.

7. A method of encoding a multi-channel signal, the method comprising:

applying a time delay to a first low-frequency effects (LFE) channel signal comprised in a multi-channel signal;
applying the time delay to a second LFE channel signal comprised in the multi-channel signal;
encoding the first LEF channel signal to which the time delay is applied;
encoding the second LEF channel signal to which the time delay is applied; and
generating a bitstream comprising the encoded first LEF channel signal and the encoded second LEF channel signal.

8. The method of claim 7, wherein the time delay comprises a time delay which occurs in encoding a normal channel signal comprised in the multi-channel signal.

9. A method of encoding a multi-channel signal, the method comprising:

applying a time delay a normal channel signal comprised in a multi-channel signal;
encoding the normal channel signal to which the time delay is applied;
outputting a downmixed signal and a spatial cue by encoding a low-frequency effects (LFE) channel signal comprised in the multi-channel signal; and
encoding the encoded LFE channel signal,

wherein the time delay comprises a time delay which occurs in encoding the LFE channel signal.

10. The method of claim 9, wherein the outputting outputs the downmixed signal and the spatial cue by conducting parametric coding on the LFE channel signal in an LFE mode.

11. A method of decoding a multi-channel signal, the method comprising:

generating a first downmixed signal and a second downmixed signal by decoding an encoded result extracted from a bitstream;
outputting a first normal channel signal and a first low-frequency effects (LFE) channel signal by decoding the first downmixed signal; and
outputting a second normal channel signal and a second LFE channel signal by decoding the second downmixed signal.

12. The method of claim 11, wherein the outputting of the first normal channel signal and the first LFE channel signal outputs the first normal channel signal and the first LEF channel signal from the first downmixed signal by applying a first spatial cue to parametric coding, the outputting of the second normal channel signal and the second LFE channel signal outputs the second normal channel signal and the second LEF channel signal from the second downmixed signal by applying a second spatial cue to parametric coding, and the first spatial cue and the second spatial cue comprise a channel level difference (CLD) output from an LFE band of the first LFE channel signal or the second LFE channel signal.

13. A method of decoding a multi-channel signal, the method comprising:

generating a first downmixed signal by decoding an encoded result extracted from a bitstream;
generating a second downmixed signal by decoding another encoded result extracted from the bitstream;
outputting a first normal channel signal and a first low-frequency effects (LFE) channel signal by decoding the first downmixed signal; and
outputting a second normal channel signal and a second LFE channel signal by decoding the second downmixed signal.

14. The method of claim 13, wherein the outputting of the first normal channel signal and the first LFE channel signal outputs the first normal channel signal and the first LEF channel signal using parametric coding based on a first spatial cue for the first downmixed signal, the outputting of the second normal channel signal and the second LFE channel signal outputs the second normal channel signal and the second LEF channel signal using parametric coding based on a second spatial cue for the second downmixed signal, and the first spatial cue and the second spatial cue comprise a channel level difference (CLD) output from an LFE band of the first LFE channel signal or the second LFE channel signal.

15. A method of decoding a multi-channel signal, the method comprising:

generating a downmixed signal by decoding an encoded result extracted from a bitstream; and
outputting a first low-frequency effects (LFE) channel signal and a second LFE channel signal by decoding the downmixed signal.

16. The method of claim 15, wherein the outputting outputs the first LEF channel signal and the second LFE channel signal by applying parametric coding based on a spatial cue to the downmixed signal, and the spatial cue comprises a channel level difference (CLD) output from an LFE band of the first LFE channel signal or the second LFE channel signal.

17. A method of decoding a multi-channel signal, the method comprising:

outputting a first low-frequency effects (LFE) channel signal by decoding an encoded result extracted from a bitstream;
outputting a second LFE channel signal by decoding another encoded result extracted from the bitstream;
applying a time delay to the first LEF channel signal; and
applying the time delay to the second LFE channel signal.

18. The method of claim 17, wherein the time delay comprises a time delay which occurs in decoding a normal channel signal.

19. A method of decoding a multi-channel signal, the method comprising:

decoding a normal channel signal from a bitstream;
applying a time delay to the decoded normal channel signal;
decoding a low-frequency effects (LFE) channel signal from the bitstream; and
decoding the decoded LFE channel signal,

wherein the time delay comprises a time delay which occurs in decoding the LFE channel signal.

20. The method of claim 19, wherein the decoding of the LFE channel signal outputs a downmixed signal and a spatial cue by conducting parametric coding on the LFE channel signal in an LFE mode.

FIG. 1

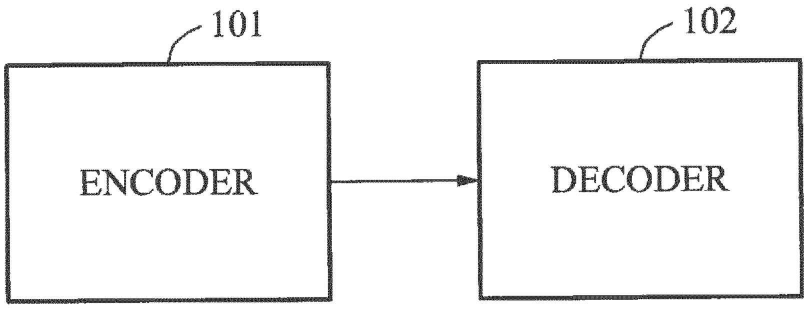


FIG. 2

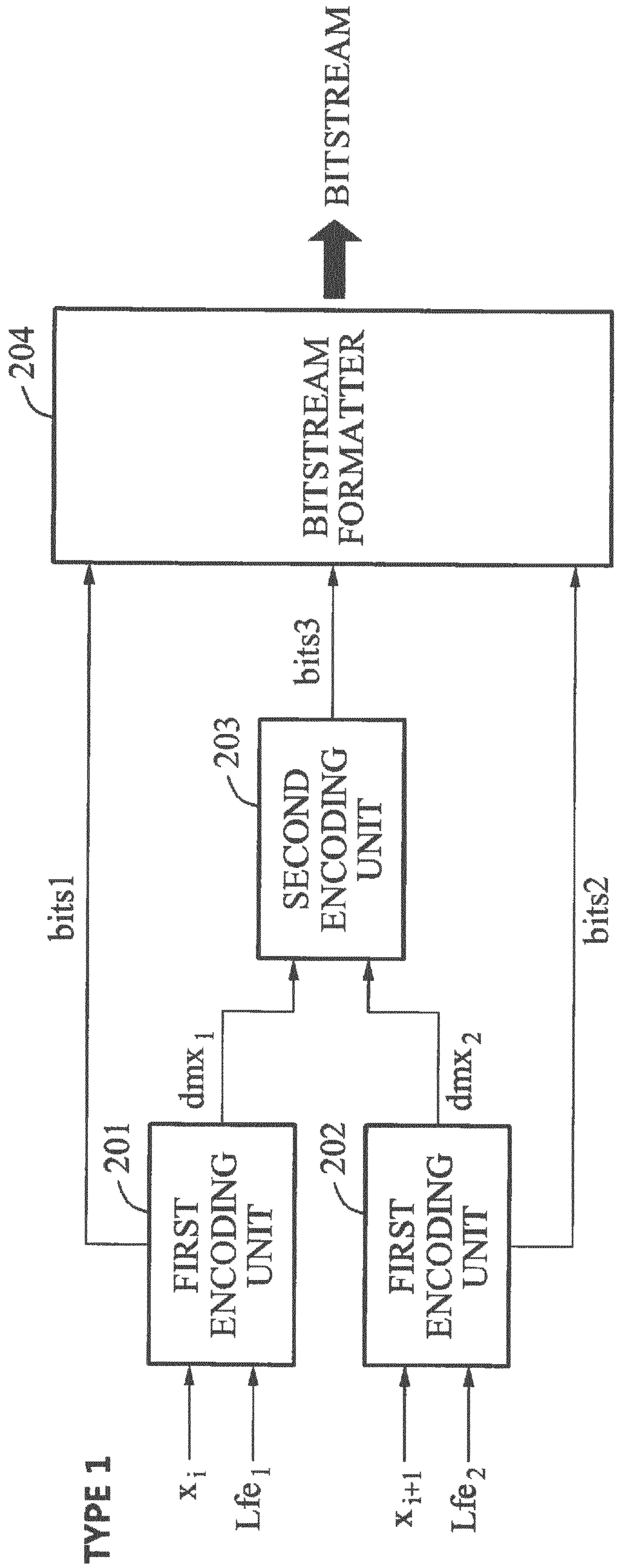
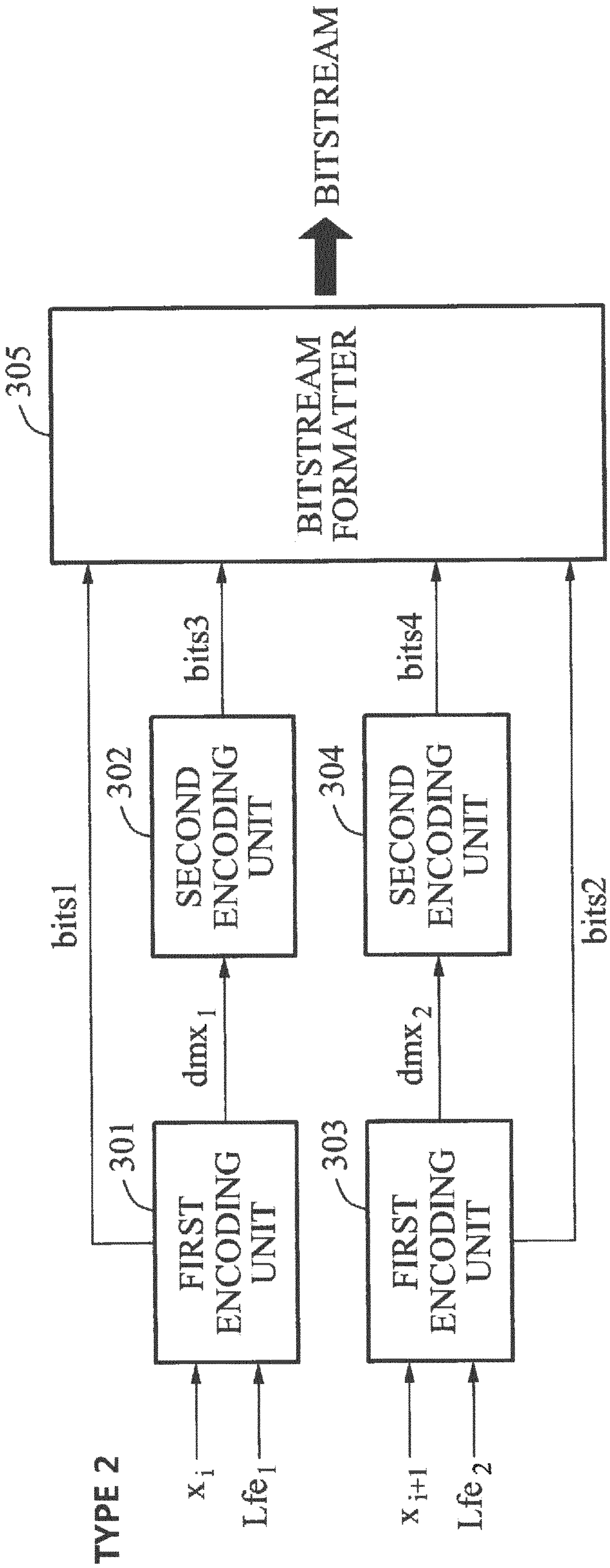

TYPE 1
x i
Lfe 1
x i+1
Lfe 2
201
FIRST ENCODING UNIT
202
FIRST ENCODING UNIT
dmx 1
dmx 2
203
SECOND ENCODING UNIT
bits1
bits2
bits3
204
BITSTREAM FORMATTER
BITSTREAM

FIG. 3


TYPE 2
x_i
Lfe_1
x_{i+1}
Lfe_2
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FIRST ENCODING UNIT
303
FIRST ENCODING UNIT
dmx_1
dmx_2
302
SECOND ENCODING UNIT
304
SECOND ENCODING UNIT
bits1
bits2
bits3
bits4
305
BITSTREAM FORMATTER
BITSTREAM

FIG. 4

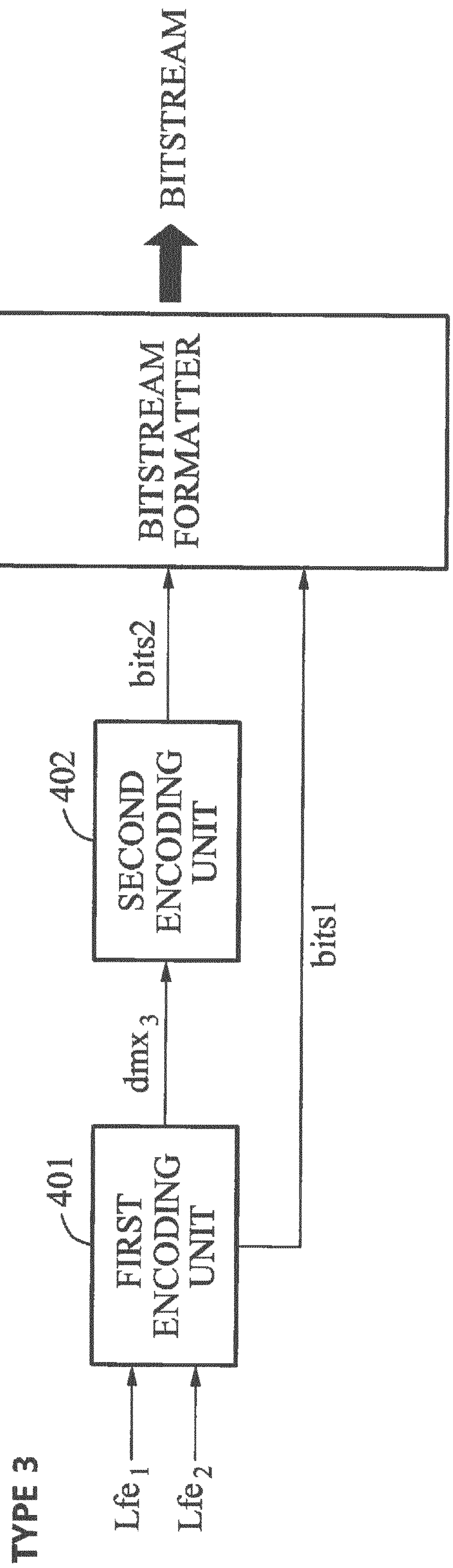

TYPE 3
Lfe_1
Lfe_2
401
FIRST ENCODING UNIT
dmx_3
402
SECOND ENCODING UNIT
bits1
bits2
403
BITSTREAM FORMATTER
BITSTREAM

FIG. 5

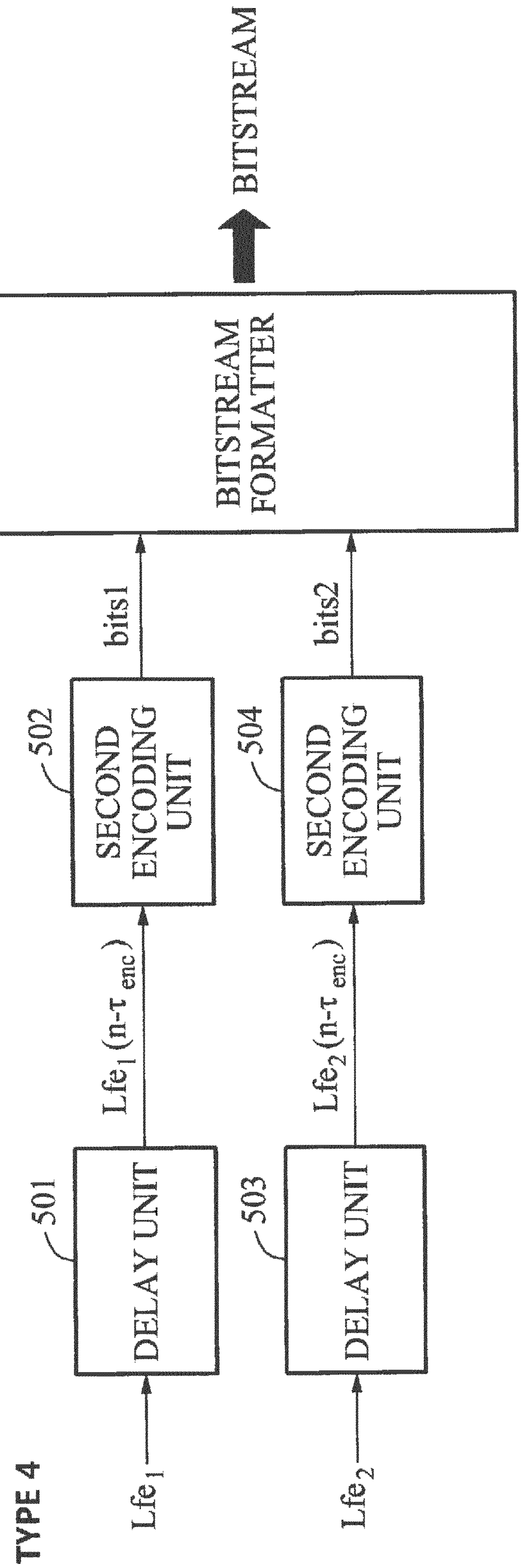
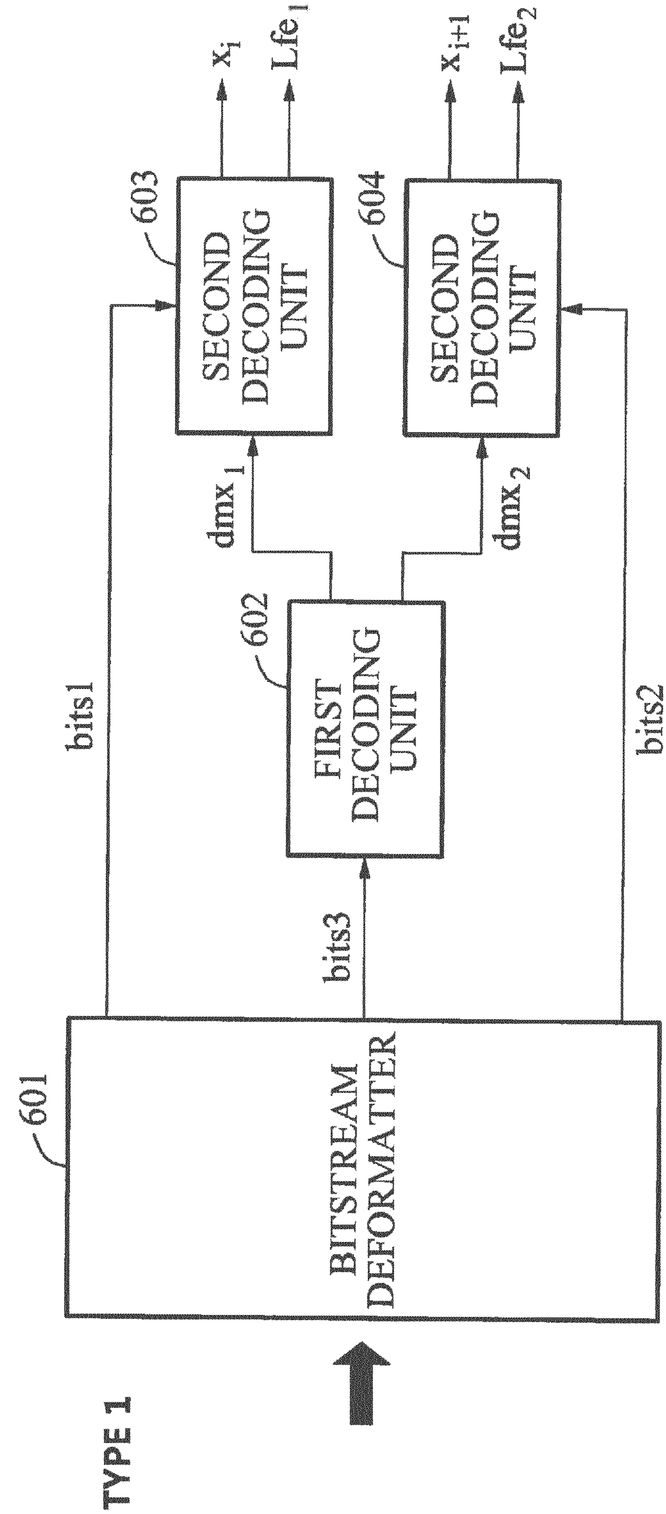

TYPE 4
Lfe_1
Lfe_2
501
DELAY UNIT
503
DELAY UNIT
$Lfe_1(n-\tau_{enc})$
$Lfe_2(n-\tau_{enc})$
502
SECOND ENCODING UNIT
504
SECOND ENCODING UNIT
bits1
bits2
505
BITSTREAM FORMATTER
BITSTREAM

FIG. 6



TYPE 1
601
BITSTREAM DEFORMATTER
bits1
bits3
bits2
602
FIRST DECODING UNIT
dmx_1
dmx_2
603
SECOND DECODING UNIT
604
SECOND DECODING UNIT
x_i
Lfe_1
x_{i+1}
Lfe_2

FIG. 7

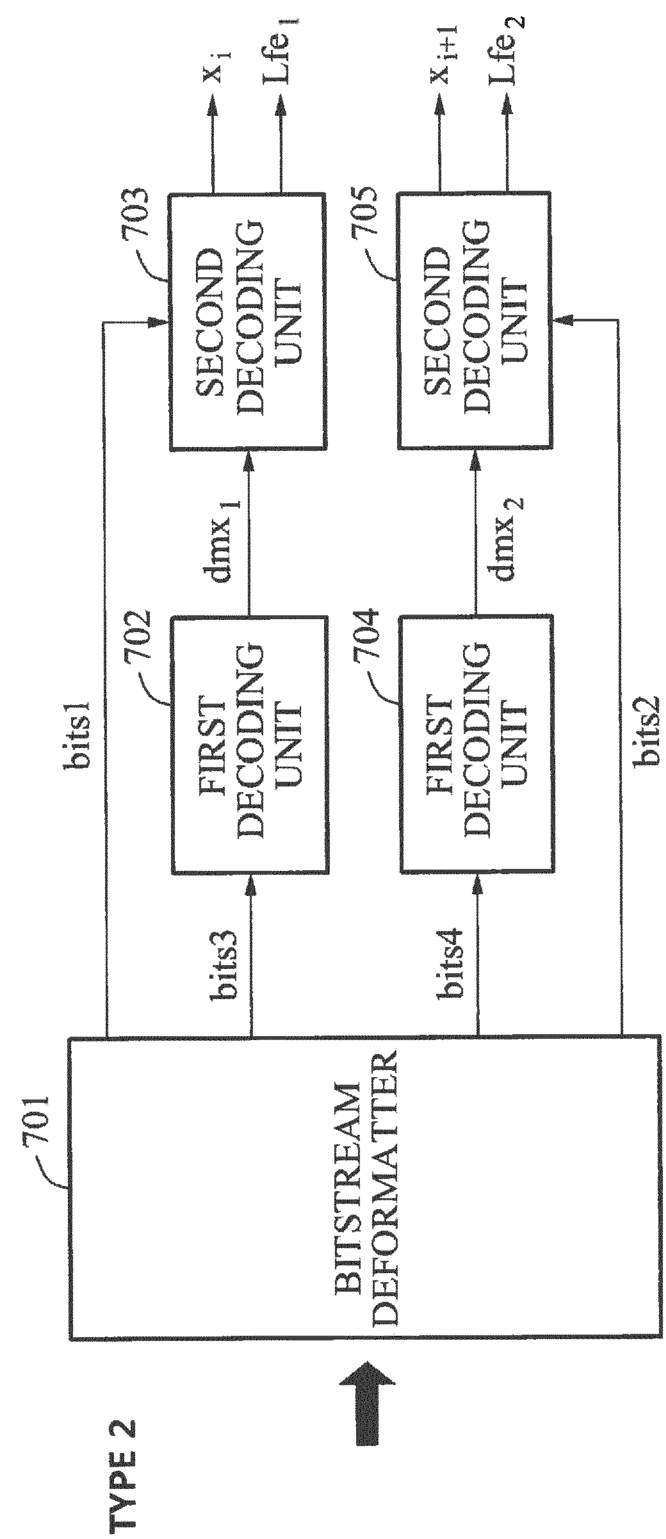

TYPE 2
701
BITSTREAM DEFORMATTER
bits1
bits3
bits4
bits2
702
FIRST DECODING UNIT
704
FIRST DECODING UNIT
dmx 1
dmx 2
703
SECOND DECODING UNIT
705
SECOND DECODING UNIT
x i
Lfe 1
x i+1
Lfe 2

FIG. 8

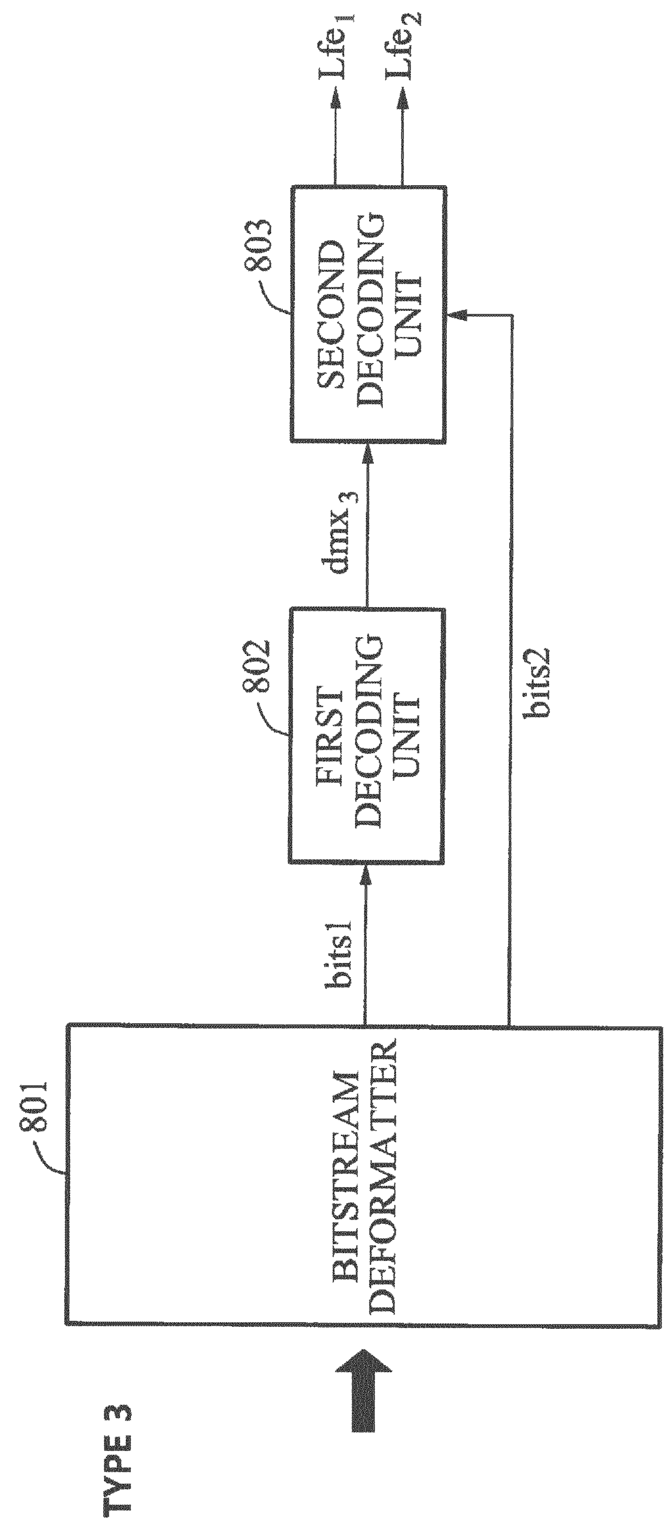

TYPE 3
801
BITSTREAM DEFORMATTER
bits1
bits2
802
FIRST DECODING UNIT
dmx_3
803
SECOND DECODING UNIT
Lfe_1
Lfe_2

FIG. 9

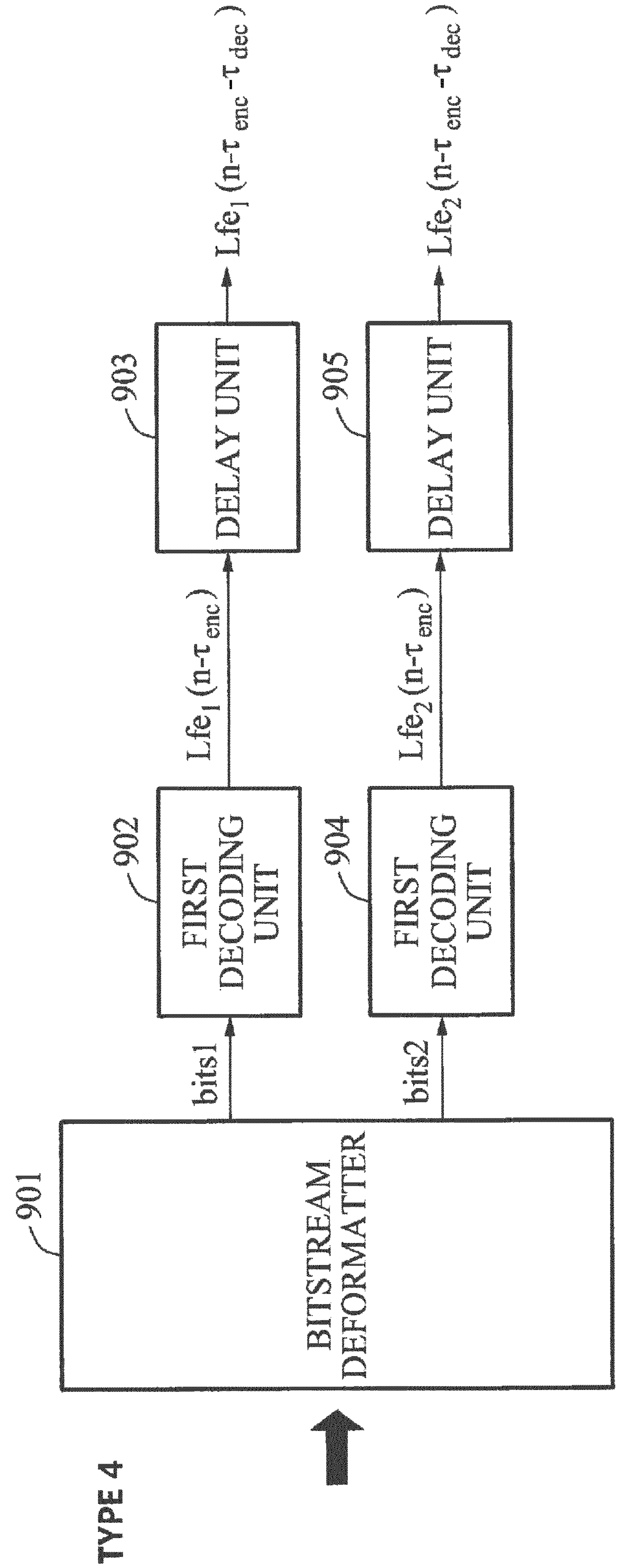

TYPE 4
901
BITSTREAM DEFORMATTER
bits1
bits2
902
FIRST DECODING UNIT
904
FIRST DECODING UNIT
$Lfe_1(n-\tau_{enc})$
$Lfe_2(n-\tau_{enc})$
903
DELAY UNIT
905
DELAY UNIT
$Lfe_1(n-\tau_{enc}-\tau_{dec})$
$Lfe_2(n-\tau_{enc}-\tau_{dec})$

FIG. 10

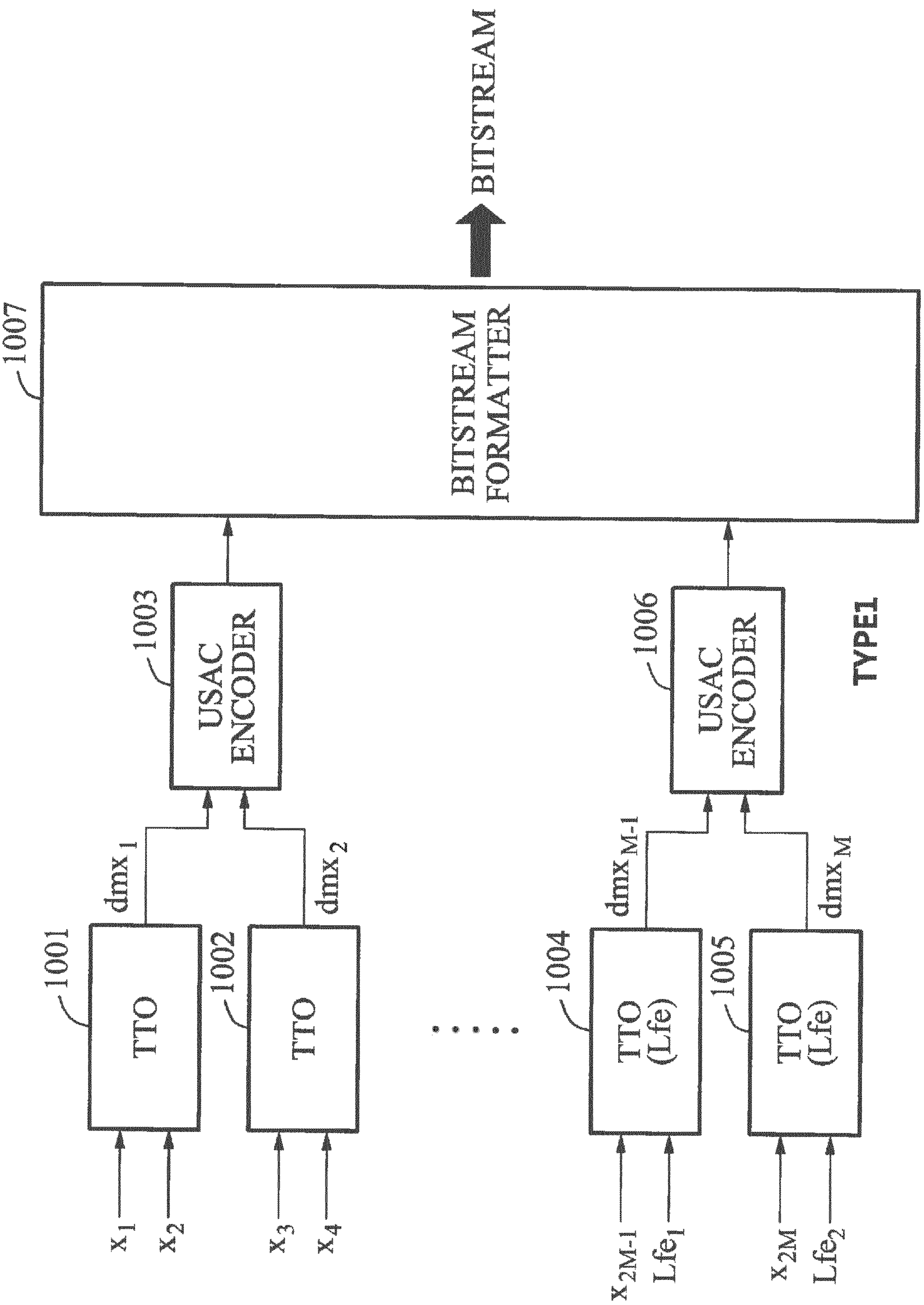

BITSTREAM
1007
BITSTREAM FORMATTER
1003
USAC ENCODER
1006
USAC ENCODER
TYPE1
dmx_1
dmx_2
dmx_{M-1}
dmx_M
1001
TTO
1002
TTO
1004
TTO (Lfe)
1005
TTO (Lfe)
x_1
x_2
x_3
x_4
x_{2M-1}
Lfe_1
x_{2M}
Lfe_2

FIG. 11

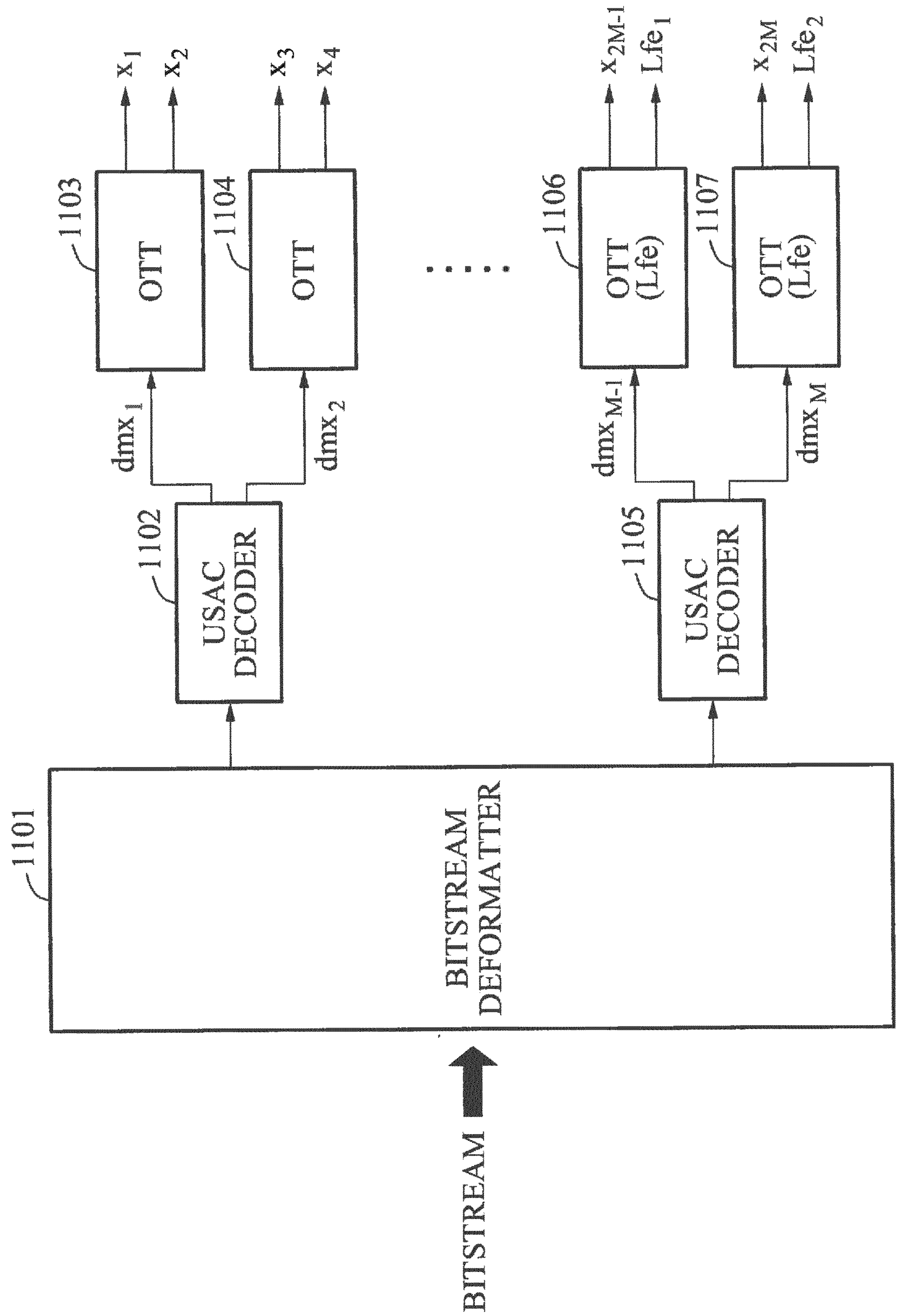

BITSTREAM
1101
BITSTREAM DEFORMATTER
1102
USAC DECODER
1105
USAC DECODER
dmx_1
dmx_2
dmx_{M-1}
dmx_M
1103
OTT
1104
OTT
1106
OTT (Lfe)
1107
OTT (Lfe)
x_1
x_2
x_3
x_4
x_{2M-1}
Lfe_1
x_{2M}
Lfe_2

FIG. 12

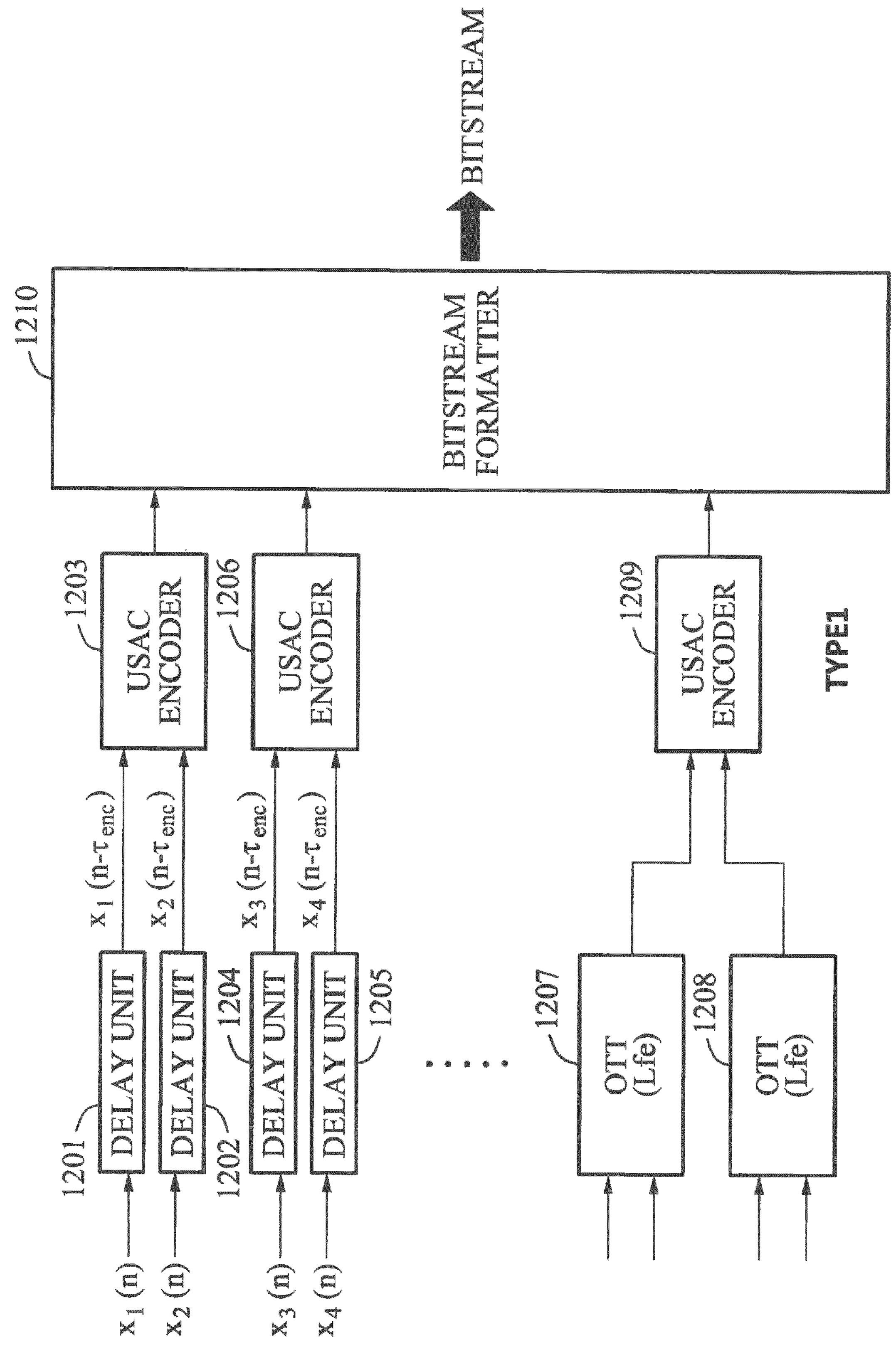

BITSTREAM
1210
BITSTREAM FORMATTER
1203
USAC ENCODER
1206
USAC ENCODER
1209
USAC ENCODER
TYPE1
$x_1(n-\tau_{enc})$
$x_2(n-\tau_{enc})$
$x_3(n-\tau_{enc})$
$x_4(n-\tau_{enc})$
1201
DELAY UNIT
1202
DELAY UNIT
1204
DELAY UNIT
1205
DELAY UNIT
1207
OTT (Lfe)
1208
OTT (Lfe)
$x_1(n)$
$x_2(n)$
$x_3(n)$
$x_4(n)$

FIG. 13

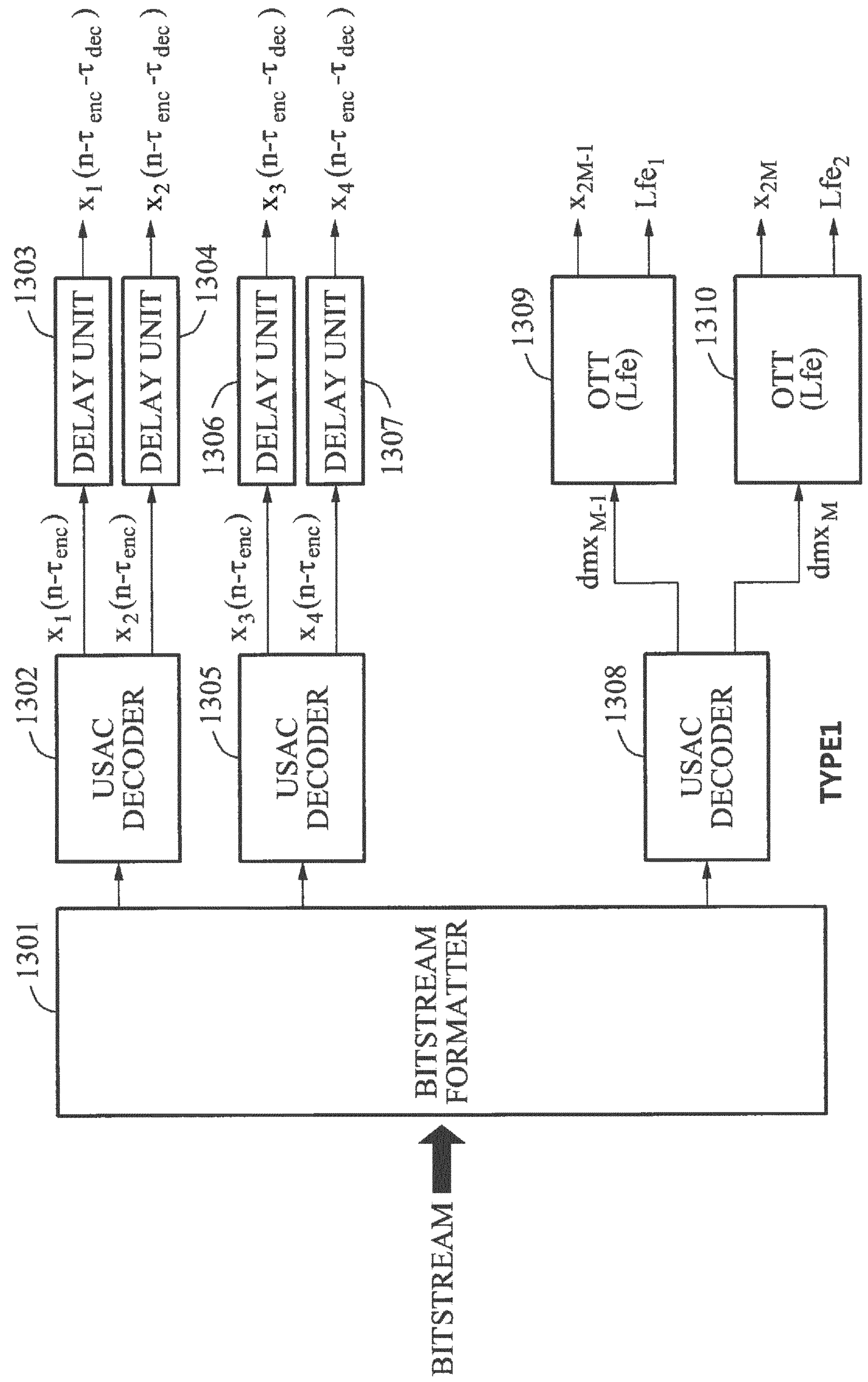

BITSTREAM
BITSTREAM FORMATTER
1301
USAC DECODER
1302
USAC DECODER
1305
USAC DECODER
1308
TYPE1
$x_1(n-\tau_{enc})$
$x_2(n-\tau_{enc})$
$x_3(n-\tau_{enc})$
$x_4(n-\tau_{enc})$
DELAY UNIT
1303
DELAY UNIT
1304
DELAY UNIT
1306
DELAY UNIT
1307
$x_1(n-\tau_{enc}-\tau_{dec})$
$x_2(n-\tau_{enc}-\tau_{dec})$
$x_3(n-\tau_{enc}-\tau_{dec})$
$x_4(n-\tau_{enc}-\tau_{dec})$
dmx_{M-1}
dmx_M
OTT (Lfe)
1309
OTT (Lfe)
1310
x_{2M-1}
Lfe_1
x_{2M}
Lfe_2

FIG. 14

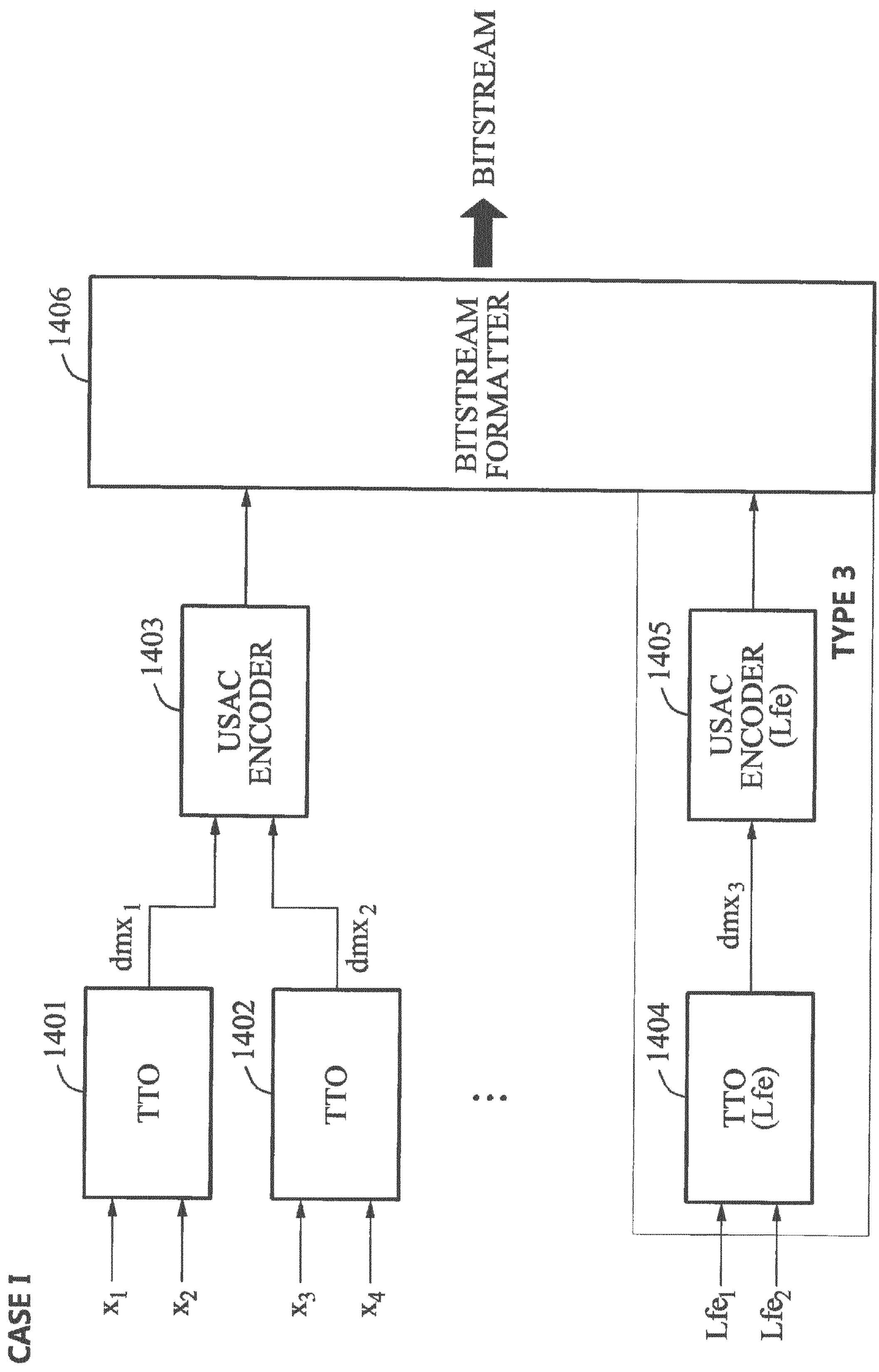

CASE I
x1
x2
x3
x4
1401
TTO
1402
TTO
...
dmx 1
dmx 2
1403
USAC ENCODER
1406
BITSTREAM FORMATTER
BITSTREAM
TYPE 3
Lfe1
Lfe2
1404
TTO (Lfe)
dmx 3
1405
USAC ENCODER (Lfe)

FIG. 15

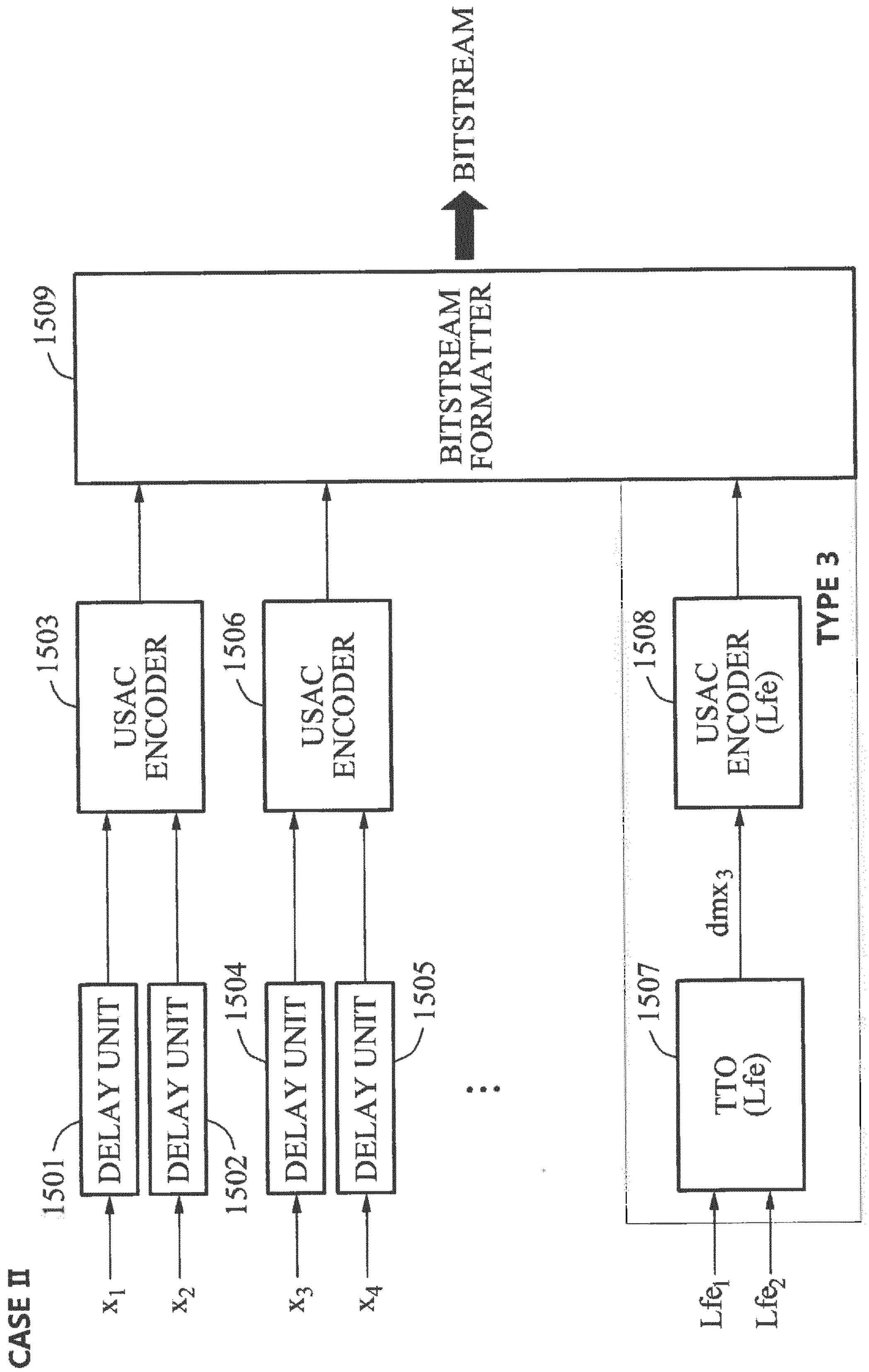

CASE II
x1
x2
x3
x4
1501
1502
1504
1505
DELAY UNIT
DELAY UNIT
DELAY UNIT
DELAY UNIT
1503
USAC ENCODER
1506
USAC ENCODER
1509
BITSTREAM FORMATTER
BITSTREAM
Lfe1
Lfe2
1507
TTO (Lfe)
dmx3
1508
USAC ENCODER (Lfe)
TYPE 3

FIG. 16

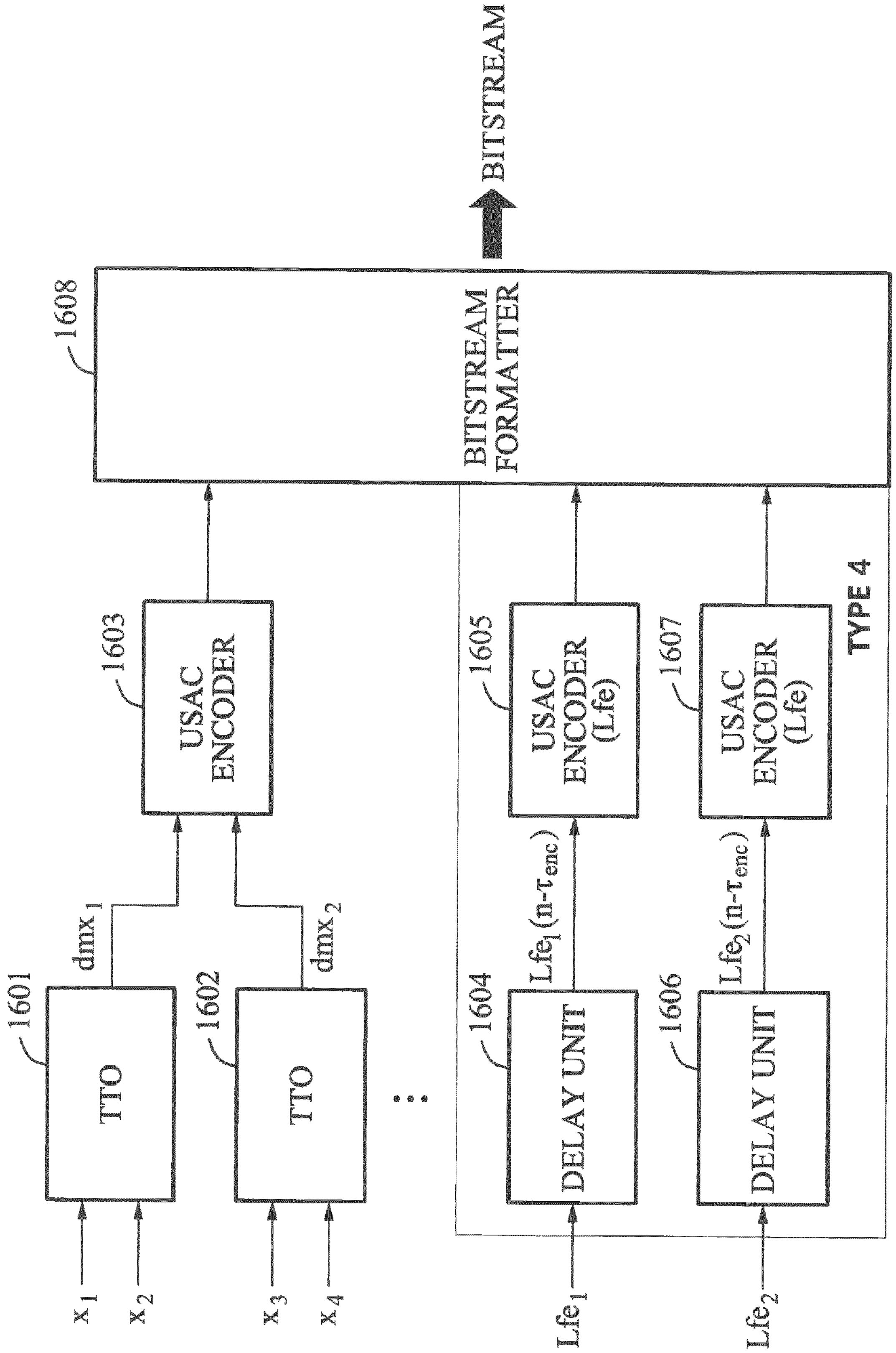

BITSTREAM
1608
BITSTREAM FORMATTER
1603
USAC ENCODER
1605
USAC ENCODER (Lfe)
1607
USAC ENCODER (Lfe)
TYPE 4
dmx 1
dmx 2
Lfe1 (n-τenc)
Lfe2 (n-τenc)
1601
TTO
1602
TTO
1604
DELAY UNIT
1606
DELAY UNIT
x 1
x 2
x 3
x 4
Lfe1
Lfe2

FIG. 17

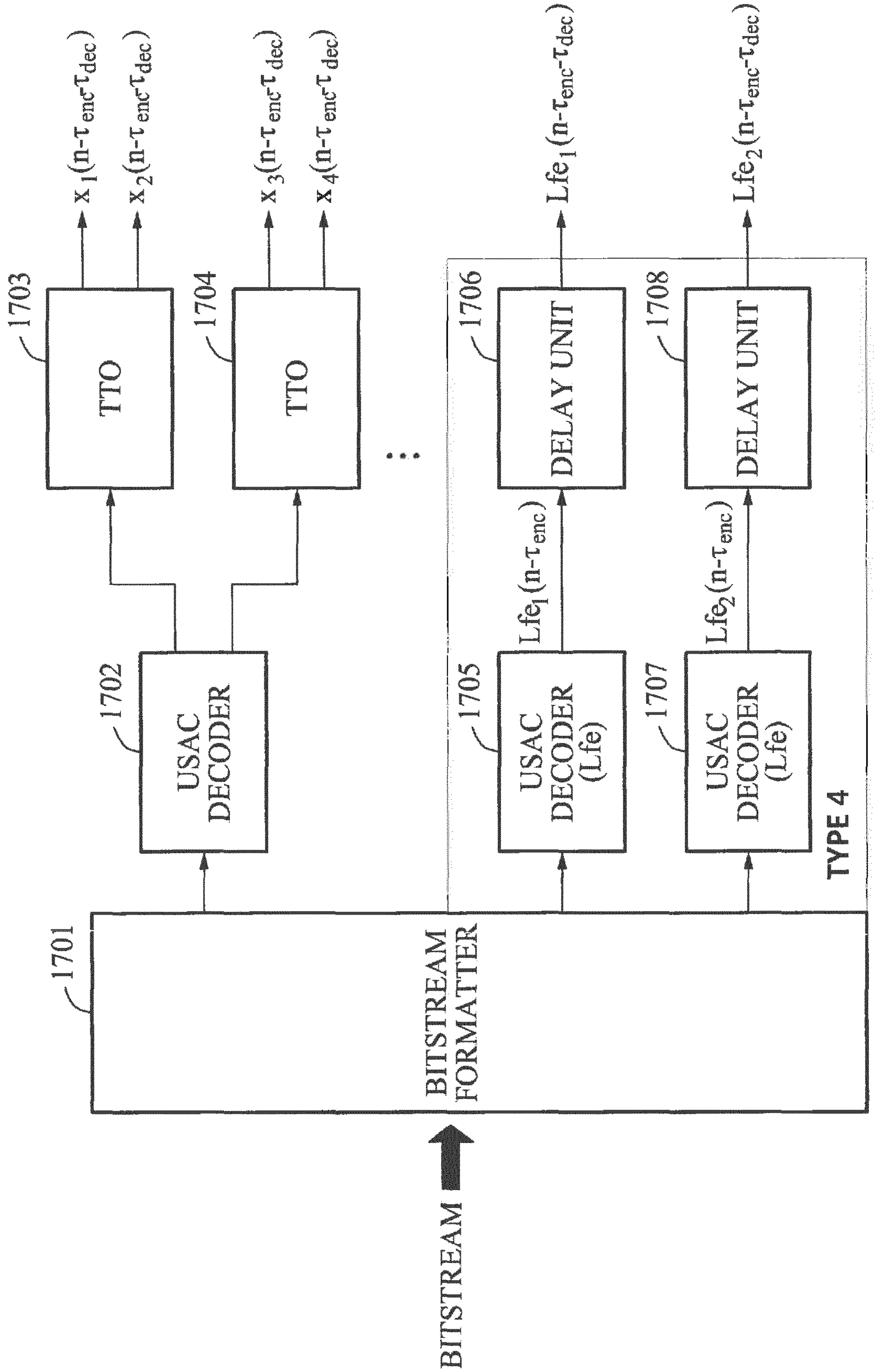

BITSTREAM
BITSTREAM FORMATTER
1701
USAC DECODER
1702
TTO
1703
TTO
1704
USAC DECODER (Lfe)
1705
DELAY UNIT
1706
USAC DECODER (Lfe)
1707
DELAY UNIT
1708
TYPE 4
$Lfe_1(n-\tau_{enc})$
$Lfe_2(n-\tau_{enc})$
$x_1(n-\tau_{enc}-\tau_{dec})$
$x_2(n-\tau_{enc}-\tau_{dec})$
$x_3(n-\tau_{enc}-\tau_{dec})$
$x_4(n-\tau_{enc}-\tau_{dec})$
$Lfe_1(n-\tau_{enc}-\tau_{dec})$
$Lfe_2(n-\tau_{enc}-\tau_{dec})$

FIG. 18

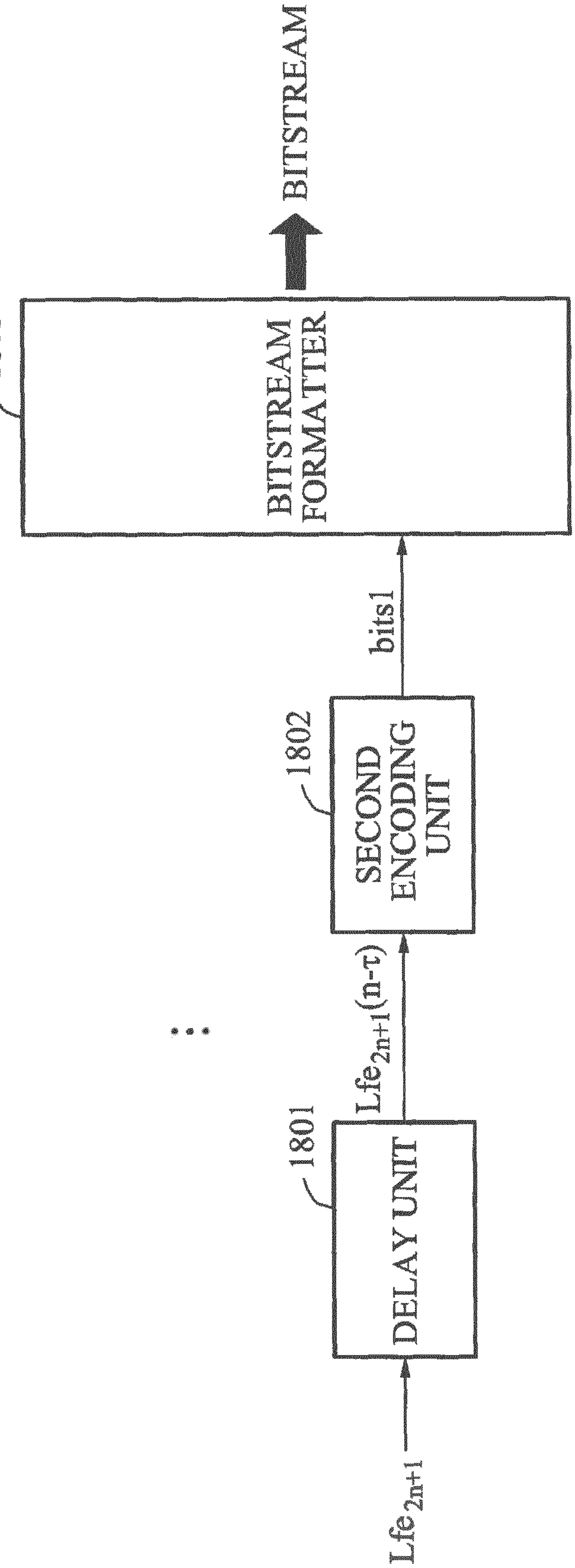

BITSTREAM
1803
BITSTREAM FORMATTER
bits1
1802
SECOND ENCODING UNIT
$Lfe_{2n+1}(n-\tau)$
...
1801
DELAY UNIT
Lfe_{2n+1}

FIG. 19

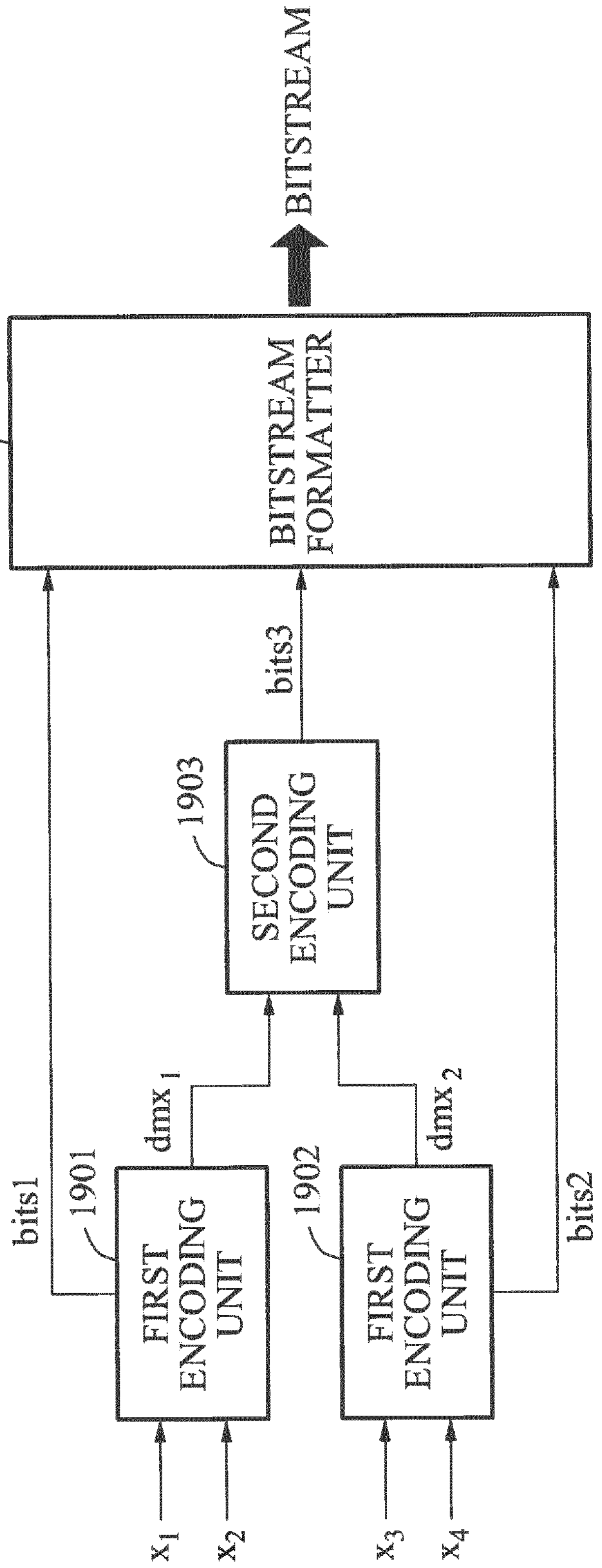

BITSTREAM
1904
BITSTREAM FORMATTER
bits3
1903
SECOND ENCODING UNIT
bits1
1901
dmx 1
FIRST ENCODING UNIT
1902
dmx 2
FIRST ENCODING UNIT
bits2
x1
x2
x3
x4

FIG. 20

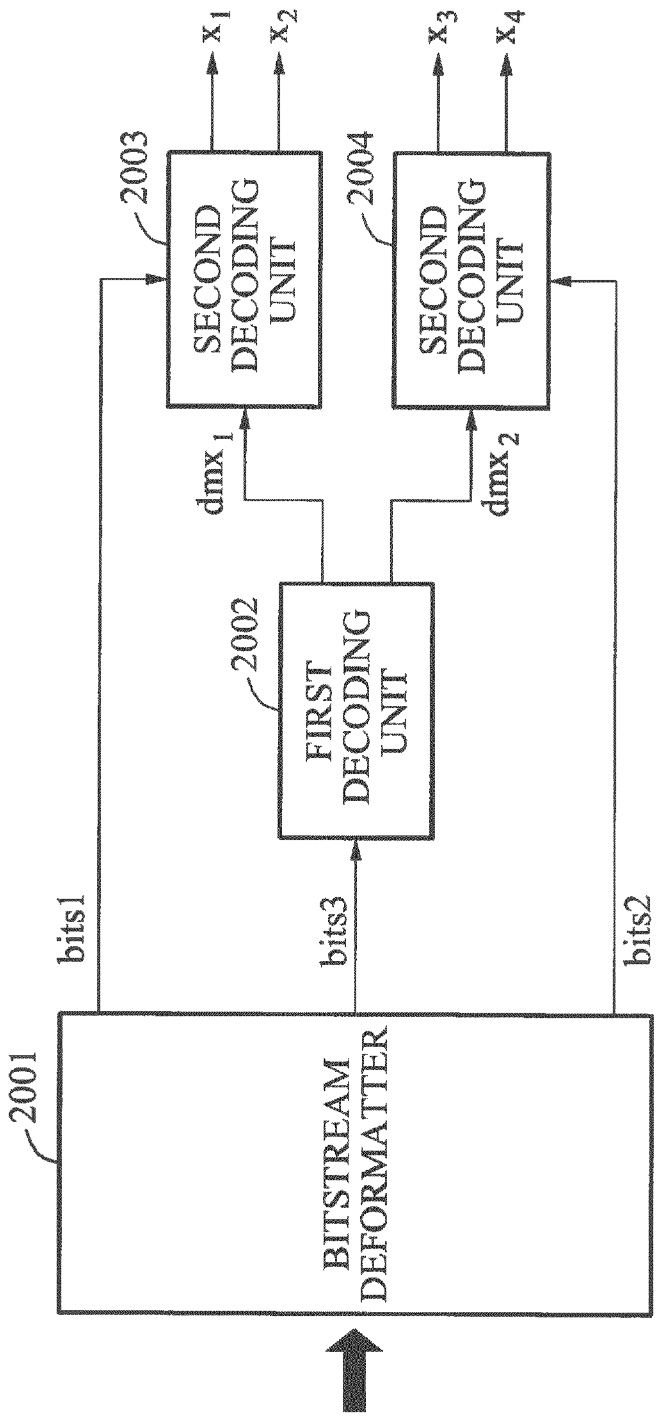

x1
x2
x3
x4
2003
SECOND DECODING UNIT
2004
SECOND DECODING UNIT
dmx1
dmx2
2002
FIRST DECODING UNIT
bits1
bits3
bits2
2001
BITSTREAM DEFORMATTER

FIG. 21

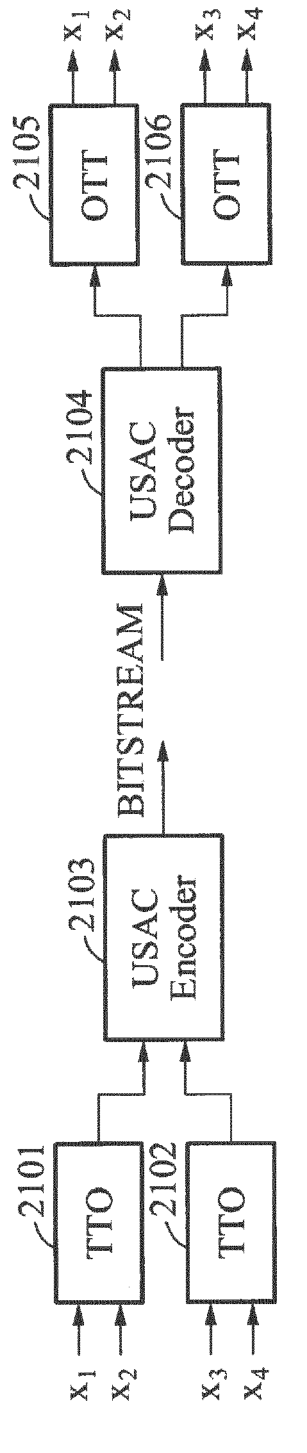

x_1
x_2
x_3
x_4
2101
TTO
2102
TTO
2103
USAC Encoder
BITSTREAM
2104
USAC Decoder
2105
OTT
2106
OTT
x_1
x_2
x_3
x_4

FIG. 22

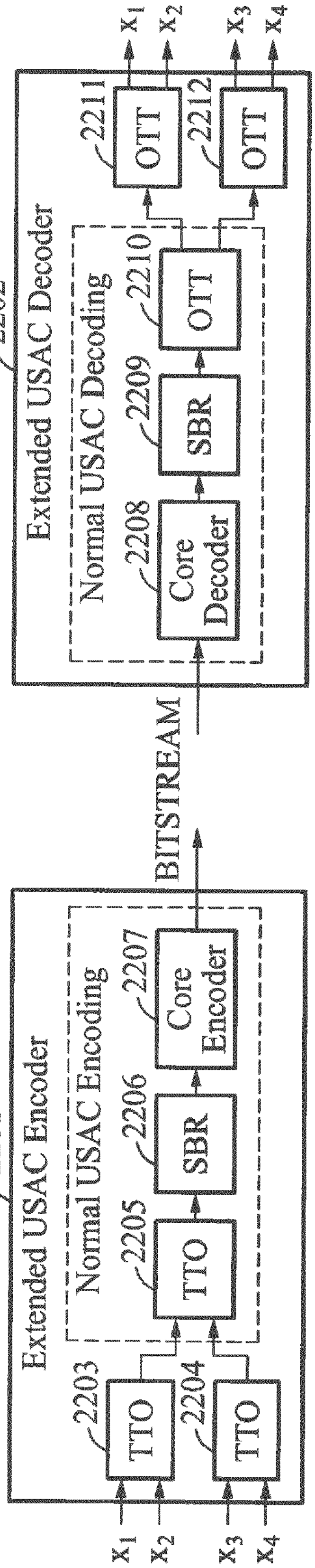
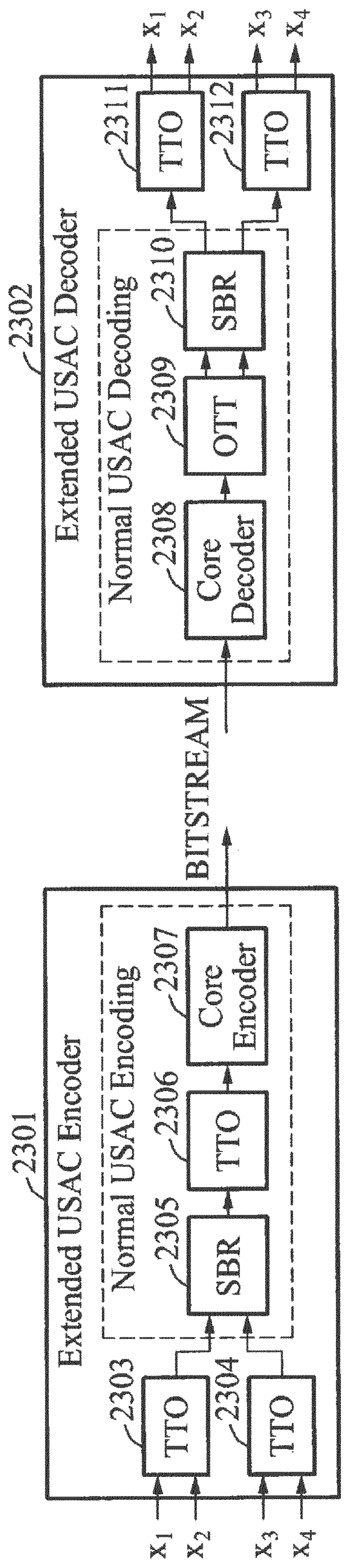

x1
x2
x3
x4
2201
Extended USAC Encoder
Normal USAC Encoding
2203
TTO
2204
TTO
2205
TTO
2206
SBR
2207
Core Encoder
BITSTREAM
2202
Extended USAC Decoder
Normal USAC Decoding
2208
Core Decoder
2209
SBR
2210
OTT
2211
OTT
2212
OTT
x1
x2
x3
x4

FIG. 23


x1
x2
x3
x4
2301
Extended USAC Encoder
Normal USAC Encoding
2303
TTO
2304
TTO
2305
SBR
2306
TTO
2307
Core Encoder
BITSTREAM
2302
Extended USAC Decoder
Normal USAC Decoding
2308
Core Decoder
2309
OTT
2310
SBR
2311
TTO
2312
TTO
x1
x2
x3
x4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2014/006406

A. CLASSIFICATION OF SUBJECT MATTER

G10L 19/008(2013.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G10L 19/008; H03M 7/30; G10L 19/08; H04R 5/00; G10L 19/00; G10L 19/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: Lfe, encoding, multi-channel, decoding, low frequency, down-mix, spatial cue, bit stream

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 10-2008-0049746 A (LG ELECTRONICS INC.) 04 June 2008 See paragraphs [0040]-[0046]; and figures 2, 3.	1-20
A	KR 10-2007-0120527 A (CODING TECHNOLOGIES AB et al.) 24 December 2007 See paragraphs [0097]-[0102]; and figures 3, 4.	1-20
A	KR 10-2009-0057131 A (DOLBY INTERNATIONAL AB) 03 June 2009 See paragraphs [0191]-[0209]; and figures 9, 10, 14.	1-20
A	US 2005-0195981 A1 (FALLER, Christof et al.) 08 September 2005 See paragraphs [0016]-[0033]; and figures 1, 2.	1-20
A	US 2010-0153097 A1 (HOTHO, Gerard Herman et al.) 17 June 2010 See paragraphs [0030]-[0087]; and figures 1-6.	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
20 OCTOBER 2014 (20.10.2014)	**21 OCTOBER 2014 (21.10.2014)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, 189 Seonsa-ro, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Telephone No.

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International application No.
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