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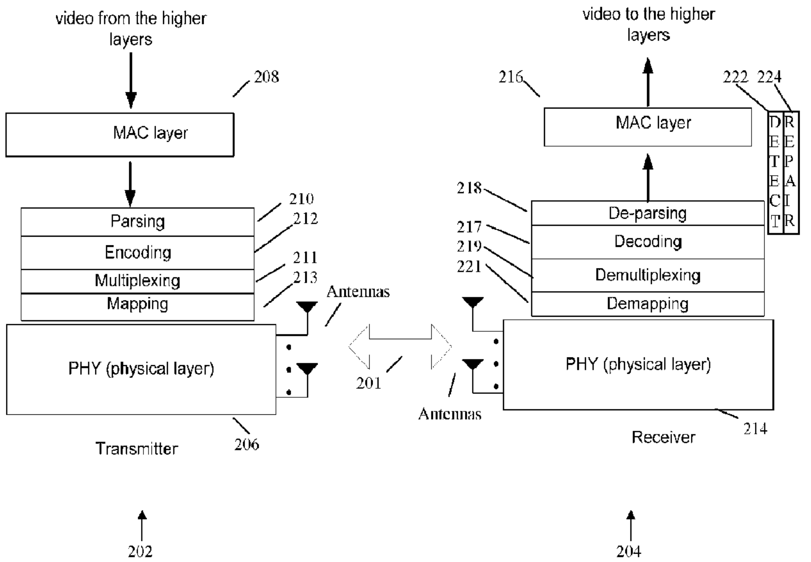
(54) Title: METHOD AND SYSTEM FOR APPLICATION OF UNEQUAL ERROR PROTECTION TO UNCOMPRESSED VIDEO FOR TRANSMISSION OVER WIRELESS CHANNELS



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(57) Abstract: A method and system of wireless communication is provided which involves inputting information bits, wherein certain bits have higher importance level than other bits, and applying unequal protection to the bits at different importance levels. As such, important bits are provided with more protection for transmission and error recovery. Applying unequal protection involves using skewed constellations such that more important bits are provided with more error recovery protection.

WO 2007/094634 A1

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Description

METHOD AND SYSTEM FOR APPLICATION OF UNEQUAL ERROR PROTECTION TO UNCOMPRESSED VIDEO FOR TRANSMISSION OVER WIRELESS CHANNELS

Technical Field

[1] The present invention related to wireless communications and in particular, to video transmission over wireless channels.

Background Art

[2] With the proliferation of high quality video, an increasing number of electronics of high quality video, an increasing number of electronics devices (e.g., consumer electronics devices) utilize high-definition (HD) video, which has an overall data throughput requirement on the order of multiple Gbps. In most wireless communications, HD video is compressed first before transmission over a wireless medium. Compression of the HD video is attractive because the overall required communication bandwidth and power can be significantly reduced, relative to transmission of the original, uncompressed video. However, with each compression and subsequent decompression of the video, some video information can be lost and the picture quality is degraded. Furthermore, compression and decompression of the video signal incurs significant hardware cost.

[3] It is desirable to transmit uncompressed HD video in certain scenarios. The High-Definition Multimedia Interface (HDMI) specification defines an interface for uncompressed HD transmission between devices through HDMI cables (wired links). Three separate channels are used to transmit three pixel component streams (e.g., R, B, G). For each channel, pixels are transmitted in a pixel-by-pixel order for each video line and line-by-line for each video frame or field. The HDMI provide pixel-repetition functionality which repeats each pixel one or multiple times. Copies of each pixel directly follow the original pixel during the transmission at each pixel component channel.

[4] However, existing Wireless Local Area Networks (WLANs) and similar technologies do not the bandwidth needed to support uncompressed HD video. Further, existing wireless networks may suffer from undesirable interference originated from nearby/neighboring devices, either in the same network or in other networks. As such, new frequency bands are needed for transmission of uncompressed HD video over wireless channels.

[5] Further, forward error correction (FEC) codes are widely used in wireless communication systems for error protection and allow correction of bit errors due to noise,

channel fading as well as other system imperfections. Normally, all information bits have equal importance and are thus equally protected. However, for communication of uncompressed video, the information bits have different levels of priority in terms of importance of visual information they represent. Losing higher priority bits in transmission, results in more visual degradation than lower priority bits. There is, therefore, a need for a method and a system for efficient, reliable transmission of uncompressed HD video wirelessly.

Disclosure of Invention

Technical Solution

[6] The present invention provides a method and a system for efficient and reliable process for communication of uncompressed video over wireless channels, wherein certain bits have higher importance level than other bits.

Advantageous Effects

[7] According to the present invention, important bits are provided with more protection for transmission and error recovery.

[8] As is known to those skilled in the art, the aforementioned example architectures described above, according to the present invention, can be implemented in many ways, such as program instructions for execution by a processor, as logic circuits, as an application specific integrated circuit, as firmware, etc.

[9] The present invention has been described in considerable detail with reference to certain preferred versions thereof; however, other versions are possible. Therefore, the spirit and scope of the appended claims should not be limited to the description of the preferred versions contained herein.

Description of Drawings

[10] Fig. 1 shows a conventional constellation distance computaation for QPSK modulation, in a wireless communication system.

[11] Fig. 2 shows a conventional Gray coded 16 QAM constellation.

[12] Fig. 3 show decision regions used for calculating soft decision metrics for soft Viterbi decoding of the received symbols in Fig. 2.

[13] Fig. 4 shows a 16 QAM constellation example wherein the constellation points are determined by four independent design parameters for unequal error protection, according to an embodiment of the present invention.

[14] Fig. 5 shows an[SNI] unequal error protection function module which maps input bits to output constellations, according to an embodiment of the present invention.

[15] Fig. 6 show another example of an unequal error protection function module, according to an embodiment of the present invention.

[16] Fig. 7A-B show examples of unequal error protection constellations for QPSK

modulation, together with the decision regions, according to an embodiment of the present invention.

[17] Fig. 8A-B show examples of unequal error protection constellations for 16 QAM modulation, together with the decision regions, according to the present invention.

[18] Fig. 9 shows a functional block diagram of an encoding section of a transmitter in a wireless communication system employing unequal error protection, according to an embodiment of the present invention.

[19] Fig. 10 shows a functional block diagram of an example receiver.

[20] Fig. 11 shows a functional block diagram of an example wireless communication system, according to an embodiment of the present invention.

Best Mode

[21] In one embodiment, such a communication process involves applying unequal protection to the bits at different importance levels such that important bits are provided with more protection for transmission and error recovery. Applying unequal protection further includes applying unequal protection to bits at different importance levels using skewed constellations such that more important bits are provided with more protection for transmission error recovery. As such, an unequal error protection (UEP) scheme is implemented using asymmetric coding and/or asymmetric constellation mapping for wireless transmission of video signals, and in particular wireless transmission of uncompressed HD video.

[22] The UEP mechanism enables efficient communication of video such as uncompressed HD video over communication links such as wireless channels.

[23] These and other embodiment, aspects and advantages of the present invention will become understood with reference to the following description, appended claims and accompanying figures.

Mode for Invention

[24] The present invention provides a method and a system for efficient and reliable transmission of uncompressed video over wireless channels. An unequal error protection (UEP) scheme is implemented using asymmetric coding and/or asymmetric constellation mapping for wireless transmission of video signals, and in particular wireless transmission of uncompressed HD video.

[25] One implementation involves inputting information bits, wherein certain bits have higher importance (priority) than other bits, and applying unequal error protection using FEC codes, to the bits according to importance levels of the information bits. FEC codes encode information bits by adding some redundancy bits. Both the original information bits and the redundancy bits are transmitted from a transmitter over the wireless channel and colleted at a receiver. The receiver then determines the type of in-

formation bits. Using the redundancy bits, at least a portion of the bit errors can be corrected, leading to a controllable bit error rate.

[26] Apart form FEC codes, error protection of the information bits can also be controlled by adjusting constellation mapping of the FEC-encoded bits, which equivalently changes signal-to-noise ratio (SNR) of the targeted information bits. It is straightforward that higher SNR would lead to better error protection of the information bits.

[27] Since as mentioned uncompressed video bits have different importance levels, applying UEP by adding strong protection for important bits and less strong protection for less important bits, the important bits can be corrected at the receiver without the need for retransmission from the transmitter, thereby improving efficiency.

[28] In one implementation, different coding rates are used for the most significant bit (MSB) and the least significant bit (LSB) information. Additional unequal error protection is achieved with constellation mapping wherein an asymmetric constellation mapping is used for wireless transmission.

[29] An example of an unequal error protection scheme using priority encoding and constellation mapping, for wireless transmission of uncompressed video according to the present invention is described below. In this example, uncompressed video is represented by 24 bits per pixel (i.e., 8 bits per pixel component such as Red, Green, and Blue). Uncompressed video can also be represented by 30 bits per pixel, corresponding to 10 bits per pixel component Red, Green, and Blue, or by 36 bits per pixel, corresponding to 12 bits per pixel component Red, Green, and Blue. Representation of uncompressed video by more or less bits is also possible and the present invention is not limited to any particular representation.

[30] Bits at higher video importance levels have a more significant contribution in terms of video information than bits at lower video importance levels. In this example, where uncompressed video is represented by 24 bits per pixel, among the 8 bits per pixel component, the MSB is at a higher importance level than the LSB. Let bit 7 be the most significant bit and bit 0 be the least significant bit. Bit 7, 6, 5, 4 thus are more important than bits 3, 2, 1, 0. For this reason, stronger error protection is applied to bits 7, 6, 5, 4, while less strong (or no) error protection is applied to bits 3, 2, 1, and 0. In this example, unequal error protection is realized by an asymmetric Quadrature Amplitude Modulation (QAM) symbol mapping.

[31] The communication system input-output model in the example can be represented as $y=hs+n$, wherein y represents the received signal, h represents complex wireless channel coefficient, s represents a transmitted symbol selected from the constellation according to the input information bits, and n represents additive white Gaussian noise. At the receiver side, soft bit decision decoding metrics can be calculated by finding the

distance between the received symbol y and all the constellation points via the log-likelihood ratio (LLR) per (1):

[32] $$LLR_{ji} = m_{ji}^{1} - m_{ji}^{0} = \min_{a \in c_i^1} \left\| y_j - ha \right\|^2 - \min_{a \in c_i^0} \left\| y_j - ha \right\|^2$$

[33] Where

$$c_i^p$$

represents the subset of the constellation points such that for every constellation point in this subset, bit i is equal to value p with p with $p \in \{0,1\}$. Fig. 1 shows a diagrammatical example of a conventional distance computation process 10 using Quadrature Phase Shift Keying (QPSK) modulation. Each constellation point (show as a solid circle ·) is represented by two binary bits b0, b1. Fig. 1 also shows the decision regions for bits b0 and b1.

[34] Fig. 2 shows a conventional gray coded 16 QAM constellation, while Fig. 3 shows decision regions used for calculating soft decision metrics for soft Viterbi decoding of received symbols in Fig. 2. For a regular QPSK constellation mapping, all four constellation points form a symmetric square shape, with regard to the center of the constellation. It can be shown that such a symmetric QPSK mapping leads to equal error protection for all information bits. Because different bits of the video signal have different priority, applying equal error protection would either lead to under-protection for MSBs, or over-protection for LSBs which causes inefficiency.

[35] According to the present invention, shape of the constellation can be optimize, which typically leads to an asymmetric constellation mapping, to provide unequal error protection for different bits. Particularly, unequal error protection is achieved by skewed constellation mapping such as those shown in Fig. 4-6. Fig. 4 shows a 16 QAM UEP example constellation 40 wherein the 16 constellation points 42 (shown as solid circles ·) are represented as $\{(d_I + r_I \pm r_I, d_Q + r_Q \pm r_Q), (-d_I - r_I \pm r_I, d_Q + r_Q \pm r_Q), (-d_I - r_I \pm r_I, -d_Q - r_Q \pm r_Q), (d_I + r_I \pm r_I, -d_Q - r_Q \pm r_Q)\}$ which are determined by four independent design parameters $\{d_I, r_I, d_Q, r_Q\}$.

[36] A constellation points is transmitted through two separated and orthogonal channels. For example, to transmit the constellation point 42 $(d_I + 2r_I, d_Q)$, the x-axis component (or the I-component), $d_I + 2r_I$, is transmitted over one channel (also know as the I-channel), and the y-axis component (or the Q-component), d_Q, is transmitted over another channel (also know as the Q-channel), which is orthogonal to the I-channel. In the special case where parameters $d_I = r_I = d_Q = r_Q$, a perfect square 16 QAM is achieved.

[37] Note that there are two cases of unequal error protection in general. In the first case, by having $d_I = r_I = d_Q = r_Q$ not valid, unequal error protection is created on purpose for

different bits on the I channel and the Q channel. In the second case, even with $d_I = r_I = d_Q = r_Q$ valid, certain degree of unequal error protection still exists for different bits on the I channel and the Q channel. This can be evidenced from Figs. 2 and 3. Fig 2 shows an example of a Gray coded (Gray labeled) square 16 QAM constellation 20 with $d_I = r_I = d_Q = r_Q$, and Fig. 3 shows the decision regions 30, 32, 34, and 36 for the four bits b0, b1, b2, and b3, respectively, of each symbol, for calculating the soft decision metrics in soft Viterbi symbol decoding. Bits b0 and b2 have only one closest neighbor while bits b1 and b3 have 2 closest neighbors. Normally, the closer the neighbors are, the higher the likelihood of an incorrect decoding decision. Therefore, it is less likely that bits b0, b2 will be mistakenly decoded and thus, buts b0 and b2 are better protected than bits b1 and b3.

[38] The difference between said two cases of creating unequal error protection is that the first case can control the degree of error protection disparity by adjusting the system parameters d_I, r_I, d_Q, r_Q, while the second case has to live with fixed degree of error protection disparity. Furthermore, the first case for unequal error protection can be applied for all possible constellations, while the second case for unequal error protection can not be applied toward QPSK constellation mapping. In the following example, the first case is utilized for application of unequal error protection, due its flexibility in adjusting error protection disparity. By choosing different design parameters d_I, r_I, d_Q, r_Q, different constellation shapes can be generated, and different levels of unequal error protection can be provided to data on the I and Q channels.

[39] Fig. 5 show an example UEP function 50 for mapping input bits to output constellation based on the four independent parameters $\{d_I, r_I, d_Q, r_Q\}$. Many different UEP schemes can be developed by changing the four independent parameters $\{d_I, r_I, d_Q, r_Q\}$. One example of UEP mapping is defined by: $d_I = d_Q$ and $r_I = r_Q$, whereby for each two bits on the I channel (or the Q channel), the bits are unequally protected. The resulting constellation generally has a square shape.

[40] Another example of UEP mapping is defined by: $d_I = r_I$ and $d_Q = r_Q$, whereby every two bits on the same channel (either I or Q channel) are equally protected relative to each other. However, the bits on the I channel as a whole, are provided with different protection than the bits on the Q channel as a whole. The resulting constellation generally has a rectangular shape. Fig. 6 shows an example function 60 for the second example UEP mapping scheme (i.e., $d_I = r_I$, $d_Q = r_Q$), utilizing gain parameters $g1 = d_I = r_I$ and $g2 = d_Q = r_Q$ for adjusting the error protection level for the I channel and the Q channel, respectively. In Fig. 6, the inputs are the I and Q components (i.e., above-mentioned x-axis and y-axis components) for the current constellation point before the application of UEP. The I and Q components are multiplied by the gain factors g1 and g2, respectively, to generate I and Q component outputs with UEP applied thereto.

[41] Though in the above two example UEP mapping scheme, 16 QAM modulation is used as an example, as those skilled in the art will recognize, similar UEP mapping schemes can be developed for 64 QAM and other modulation.

[42] Example applications of UEP for a QPSK constellation are diagrammatically shown in FIGS. 7A-B, according to the present invention. Specifically, FIG. 7A shows the QPSK constellation 70 with enhanced unequal error protection, and FIG. 7B shows decision regions 72 and 74 for the bits b1 and b0, respectively. For bit b1, all the received symbols above the horizontal 72A line are decided as b1 = 0. Similarly for bit b0, all the received symbols falls left of the vertical line 74A are decided as b0 = 0. As the distance between 0 and 1 for b1 is larger than b0, bit b1 is more protected than bit b0.

[43] Example applications of UEP for a 16 QAM constellation are diagrammatically shown in FIGS. 8A-B, according to the present invention. Specifically, FIG. 8A shows a 16 QAM constellation 80 with unequal error protection and FIG. 8B shows the decision regions 82, 84, 86 and 88 for bits b0, b1, b2, and b3, respectively, for the constellation 80. In FIG. 8B, bits b0 and b2 are more protected than bits b1 and b3. For bit b0, all the received symbols falling to the left of the vertical line 82A are decided as 0. Similarly for b2, all of the received symbols below the horizontal line 84A are decided as 0. On the other hand, for bit b1, the inner distance between 0 and 1 is much shorter compared to b0 and b2, which provides less error protection for b1 compared to b0 and b2. Bit b3 has the same error performance as b1. For a 64 QAM constellation, similar unequal protection can also be applied, as those skilled in the art will recognize. Particularly for 16 QAM constellation mapping, FIG. 3 shows the conventional constellation mapping scheme, while FIG. 8B shows the corresponding UEP constellation mapping scheme according to the present invention.

[44] A wireless communication system, according to the present invention, functions by inputting information bits for transmission from a transmitter to a receiver over a wireless channel. Because certain input bits have higher importance levels than other bits, unequal protection is applied to the bits at different importance levels, such that more important bits are provided with more protection for transmission and error recovery. Applying unequal protection involves using skewed constellations, such that more important bits are provided with more error recovery protection.

[45] The input bits are parsed into different data paths and encoded based on importance level. The encoded bits from different paths are then multiplexed into one stream using a selected multiplexing pattern. Then skewed constellation mapping is applied in order to generate unequal protection to coded bits according to their respective importance levels. As such, more important bits are provided with more protection for transmission to provide better error recovery.

[46] The skew-mapped bits are transmitted as symbols over a wireless channel. At a receiver, the received symbols are processed suing decision decoding metrics and demodulation, to determine the transmitted information bits.

[47] FIG. 9 shows a functional block diagram of an encoding section 100 of an example transmitter in such a wireless communication system employing unequal error protection, according to the present invention.

[48] The encoding section 100 includes a parser 102, two data paths 103A and 103B, a multiplexer 108, an interleaver 110, and a QAM mapper 110. The first data path 103A includes a FEC encoder 104A and a puncturer 106A. The second data pattern 103B includes a FEC encoder 104B and a puncturer 106B.

[49] The parser 102 separates an input bit stream into two spatial steams, a MSB stream for the first data path 103A and a LSB stream for the second data path 103B. In the first data path 103A, the FEC encoder 104A can be a rate 1/2 convolutional code (or can be a convolutional code with some other rate or can be some other code) and the puncturer 106A is used to puncture the coded MSB bits to change the overall coding rate for MSBs. In the second data path 103B, the encoder 104B can be a rate 1/2 convolutional code as well (or can be a convolutional code with some other rate or can be some other code) and the puncturer 106B is used to pucture the bits to change the coding rate for LSBs. In this example, the four coded MSBs (i.e., bits 7, 6, 5, 4 of each 8 bit pixel component) are mapped to bits b0 and b2 of the 16 QAM constellation, and the four coded LSBs (i.e., bits 3, 2, 1, 0) are mapped to bits b1 and b3 of the 16 QAM constellation. Different mappings and/or more than two (2) streams are also possible.

[50] Specifically, the parser 102 receives a video data stream from a higher layer, and for every 8 bits inside each color of a pixel, and for every 8 bits inside each color of a pixel, parses 4 MSBs (i.e., bits 7, 6, 5, 4) to the first data path 103A, and pareses the other 4 LSBs (i.e., bits 3, 2, 1, 0) to the second data path 103B. Depending on the video data format from the higher layer, the parser 102 can be either a bit parser or a group parser.

[51] Each data path then performs FEC encoding and puncturing. Each data path can utilize different codes and puncturing patterns, than the other data paths, depending on bit importance level. Further, although only two data paths are shown in Fig. 9, the present invention contemplates parsing input bits into more than two data paths, depending on the number of importance levels for the bits (e.g., the number of data paths can be equal to the number of importance levels). The punctured and encoded bits are then provided to the multiplexer 108.

[52] The MSBs and LSBs may be coded at different coding rates on the data paths 103A and 103B, resulting in a differing number of coded bits on the two data paths 103A and 103B. A multiplexer is utilized in handling any data rate mismatch over the two data

paths.

[53] The channel interleaver 110 provides channel interleaving, in order to decorrelate the adjacent channel coefficients and to reduce the overall error rate probability. The interleaving operation preserves the bit pattern of MSBs and LSBs. The QAM mapper 112 may use either a standard non-skewed constellation mapping (e.g., Figs. 2 and 3) or a skewed unequal error protection constellation (e.g., Figs. 4-6). The detailed constellation design and labeling (i.e., how asymmetrical the constellation is) depends on the channel condition and implementation, and can be configured by system parameters, (e.g., $\{d_I, r_I, d_Q, r_Q\}$) for the 16QAM modulation.

[54] Referring to Fig. 10, an example receiver 150 according to the present invention performs the reverse steps of the transmitter. A demapper 152 demaps (or demodulates) received symbols into demodulated binary bits. The demapper can 152 can implement either a hard decision or a soft decision process. The demodulated bits are then deinterleaved by a channel deinterleaver 154 to restore bits into their original positions. A parser 156 then de-parses the deinterleaved bits into two or more bit streams, each bit stream including bits of different levels of importance in relation to other bit streams (e.g., bit stream 1 including bits of importance level 1, ..., bit stream n including bits of importance level n). In the example of Fig. 10, two bit streams MSB and LSB are shown. Each bit stream is decoded by a corresponding FEC decoder (e.g., the Viterbi decoder). As such, the MSB bit stream is decoded by a decoder 158A and the LSB bit stream is decided by a decoder 158B. The separately decoded bits are multiplexed together by a multiplexer (de-multiplexer) 160 to recover the transmitted information.

[55] FIG. 11 shows a functional block diagram of an example wireless communication system 200, according to an embodiment of the present invention, including a wireless communication station 202 functioning as a transmitter (a sender) and a wireless communication station functioning as a receiver 204, which implements an example process for communicating uncompressed video, as discussed above. The transmitter 202 includes a PHY layer 206 and a MAC layer 208. Similarly, the receiver 204 includes a PHY layer 214 and a MAC layer 216. The PHY and MAC layers provide wireless communication between the transmitter 202 and the receiver 204 via antennas through a wireless channel 201.

[56] The transmitter 202 further includes: a parsing module 210 parsing input video bits into separate streams based on importance level, such as the function of the above-mentioned parser 102 (Fig. 9); an encoding module 212 implementing encoding on the different bit streams, such as the function of the above-mentioned encoders 104A, 104B; a multiplexing module 211 that combines the encoded bit stream into one stream, such as the function of the multiplexing module 108; a mapper module 213

that performs constellation mapping using skewed constellations for unequal error protection, such as the functions of the QAM mapper 112. The bits are then converted to frequency band signals transmitted by the PHY layer 206 via one or more antennas over the wireless channel 201 to the receiver 204. The steps of parsing, encoding, multiplexing and mapping takes place in the PHY layer 206.

[57] In the wireless receiver 204, the PHY layer 214 receives the signals and converts them to bits. A de-mapping module 221 then demaps the received bits by implementing the reverse steps of the mapping module 213 of the transmitter. Then, the demultiplexing module 219 de-multiplexes the bits into different streams at different priority levels by reverse steps of the multiplexer 211. A decoding module 217 then decodes the bits in each stream by reverse steps of the encoding module 212. A de-parsing module 218 then de-parses the multiple bit streams into one video bit stream by reverse steps of the parsing module 210, thereby reconstructing the transmitted vide. The steps of de-parsing, decoding, demultiplexing and demapping takes place in the PHY layer 214.

[58] The receiver 204 further includes an error detection module 222 and an error correction module 224. The error detection module 222 detects lost or damaged bits (e.g., using Cyclic Redundancy Code (CRC) information provided by the transmitter). The correction module 224 utilizes the encoding and UEP information to compensate for the lost or damaged bits.

[59] Although in relation of Fig. 11, the stations 202 and 204 have been described as a transmitter and a receiver, respectively, each is a type of wireless communication station (as noted) capable of transmitting and/or receiving over a wireless channel in a wireless communication system. Therefore, a wireless communication station herein can function as a transmitter, a sender, a receiver, an initiator and/or a responder. As such, the present invention provides unequal error protection without significant additional implementation cost and improves the uncompressed video quality.

Claims

[1] 1. A method of wireless communication, comprising the steps of:
inputting video information bits, wherein certain bits have a higher importance level than other bits;
parsing the bits based on their importance levels; and
applying unequal protection to the bits according to importance level such that more important bits are provided with more protection for transmission error recovery.

2. The method of claim 1 wherein applying unequal protection further includes applying unequal protection to bits at different importance levels using asymmetric coding and/or asymmetric constellation mapping including skewed constellations such that more important bits are provided with more protection for transmission error recovery.

3. The method of claim 1 wherein the information bits comprise uncompressed video information represented by multiple bits per video pixel, such that higher order bits per pixel are of a higher video importance.

4. The method of claim 3 wherein applying unequal protection further includes applying unequal error protection for higher order bits by quadrature amplitude modulation (QAM) symbol mapping.

5. The method of claim 3 wherein applying unequal protection further includes using skewed constellations to provide better protection for higher order bits and less protection for lower order bits.

6. The method of claim 1 further comprising the steps of:
receiving the transmitted bits; and
detecting and decoding the received bits.

7. A wireless transmitter including:
a parser that is configured to parse input bits into different streams, wherein bits in different streams have different importance levels;
multiple encoders that are configured to encode the bits from different streams;
a multiplexer that is configured to multiplex the encoded bits from the streams to form a single stream; and
a mapper that is configured to apply unequal protection to bits at different importance levels in the stream, such that more important bits are provided with more protection for transmission error recovery.

8. The transmitter of claim 7 wherein the mapper is further configured to apply unequal protection to bits at different importance levels using skewed constellations such that more important bits are provided with more protection for

transmission error recovery.

9. The transmitter of claim 8 wherein the information bits represent uncompressed video information.

10. The transmitter of claim 8 wherein the information bits comprise uncompressed video information represented by multiple bits per video pixel, such that higher order bits per pixel are of a higher video importance.

11. The transmitter of claim 10 wherein the mapper is further configured to apply unequal error protection for higher order bits by QAM symbol mapping.

12. The transmitter of claim 8 wherein the mapper is further configured to use skewed constellations to provide better transmission error recovery for higher order bits than for lower order bits.

13. A wireless communication system, comprising:

a wireless transmitter including:

a parser that is configured to parse input bits into multiple streams, wherein the bits in different streams have different importance levels for encoding;

multiple data paths corresponding to the multiple data path streams, wherein each data path includes an encoder that is configured to encode the bits in a corresponding stream to generate encoded bits;

a multiplexer that is configured to multiplex the encoded bits from the multiple stream bit-by-bit;

a mapper that is configured to apply unequal protection to the multiplexed bits at different importance levels such that more important bits are provided with more protection for transmission;

a transmission module for transmitting the bits to a wireless receiver over a wireless channel; and

a wireless receiver that is configured to receive the transmitted bits and decode the received bits.

14. The system of claim 13 wherein the mapper is further configured to apply unequal protection to bits at different importance levels by using skewed constellations such that more important bits are provided with more protection for transmission error recovery.

15. The system of claim 14 wherein each data path further comprises a puncturer that punctures the encoded bits to change the coding rate.

16. The system of claim 15 further comprising an interleaver between the multiplexer and the mapper, wherein the interleaver is configured to perform interleaving to increase channel noise robustness.

17. The system of claim 16 wherein the input bits comprise uncompressed video information represented by multiple bits per video pixel, such that higher order

bits per pixel component are of a higher video importance level.

18. The system of claim 17 wherein MSB bits per pixel component are of a higher video importance level than the LSB bits.

19. The system of claim 18 wherein the parser is further configured to parse the bits into multiple data paths, wherein each data path carries bits at a different level of importance relative to other data paths.

20. The system of claim 18 wherein the parser is further configured to parse the MSB bits into a first data path, and to parse the LSB bits into a second data path.

21. The system of claim 13 wherein the receiver comprises:

a receiving module that is configured to receive the transmitted bits as symbols; and

a demapper that is configured to demap the received symbols into binary bits.

22. The system of claim 21 wherein the receiver further comprises:

a parser that is configured to parse the binary bits into multiple streams, wherein the bits in different streams have different importance levels; and

multiple decoders configured to decode the bits in each stream.

23. The system of claim 22, wherein the receiver decoders comprise FEC decoders.

24. The system of claim 23, further comprising a deinterleaver configured to restore the demapped bits into their original positions before decoding.

25. A wireless receiver comprising:

a receiving module that is configured t receive transmitted bits as symbols including encoded and unequally protected bits based on the bit importance level;

a demapper that is configured to demap the received symbols into binary bits; and

a FEC decoder that decodes the final binary bits.

26. The receiver of claim 25, further comprising:

a parser that is configured to parse the binary bits into multiple streams, wherein the bits in different streams have different importance levels; and

multiple decoders configured to decode the bits in each stream into separately decoded bits.

27. The system of claim 26, further comprising a deinterleaver configured to restore the damapped bits into their original positions before decoding.

28. The receiver of claim 26, further comprising a demultiplexer that is configured to multiplex the separately decoded bits, to recover the transmitted information.

29. A method of wireless communication, comprising the steps of:

inputting video information bits, wherein certain bits have a higher importance level than other bits;
parsing the bits based on their importance levels; and
applying unequal protection to bits at different importance levels using skewed constellation mapping such that more important bits are provided with more protection for transmission error recovery.

30. The method of claim 29, wherein applying unequal protection using skewed constellation mapping further includes performing QPSK skewed constellation mapping to bits b0, b1, wherein: for bit b1, all of the received symbols in a decision region are decided as b1= 0, and for bit b0, all of the received symbols in another decision regions are decided as b0=0, wherein as the distance between 0 and 1 for b1 is larger than b0, the bit b1 is more protected than bit b0.

31. The method of claim 29, wherein applying unequal protection using skewed constellation mapping further includes performing 16-QAM skewed constellation mapping to bits b0, b1, b2, b3 such that: for bit b0, all of the received symbols in decision regions are decided as 0, and for bit b2, all of the received symbols in another decision regions are decided as 0, wherein for bit b1, the inner distance between 0 and 1 is much shorter compared to that for bits b0 and b2, which provides less error protection for b1 compared to b0 and b2, and bit b3 has the same error performance as b1.

32. The method of claim 29, wherein:
each constellation point is transmitted through two separate and orthogonal channels, I-channel and Q-channel, in 16-QAM modulation, and
the constellation mapping is represented as a set $\{(d_I + r_I \pm r_I, d_Q + r_Q \pm r_Q), (-d_I - r_I \pm r_I, d_Q + r_Q \pm r_Q), (-d_I - r_I \pm r_I, -d_Q - r_Q \pm r_Q), (d_I + r_I \pm r_I, -d_Q - r_Q \pm r_Q)\}$, based on independent design parameters $\{d_I, r_I, d_Q, r_Q\}$, wherein the bits are unequally protected.

33. The method of claim 32, wherein UEP mapping is performed with $d_I = r_I$, $d_Q = r_Q$, utilizing gain parameters $g1= d_I = r_I$ and $g2= d_Q =r_Q$ for adjusting the error protection level for the I-channel and the Q-channel, respectively, such that I and Q components are multiplied by the gain factors g1 and g2, respectively, to generate I and Q component outputs with UEP applied thereto.

FIG. 1

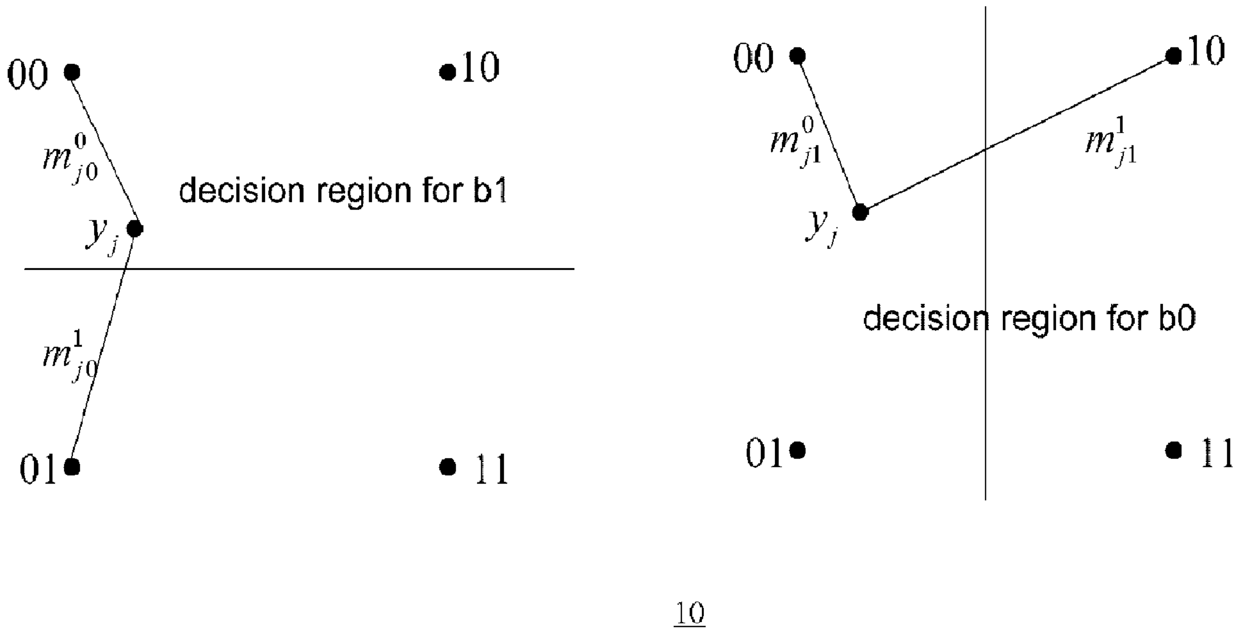

00
10
m_{j0}^{0}
decision region for b1
y_j
m_{j0}^{1}
01
11
00
10
m_{j1}^{0}
m_{j1}^{1}
y_j
decision region for b0
01
11
10

FIG. 2

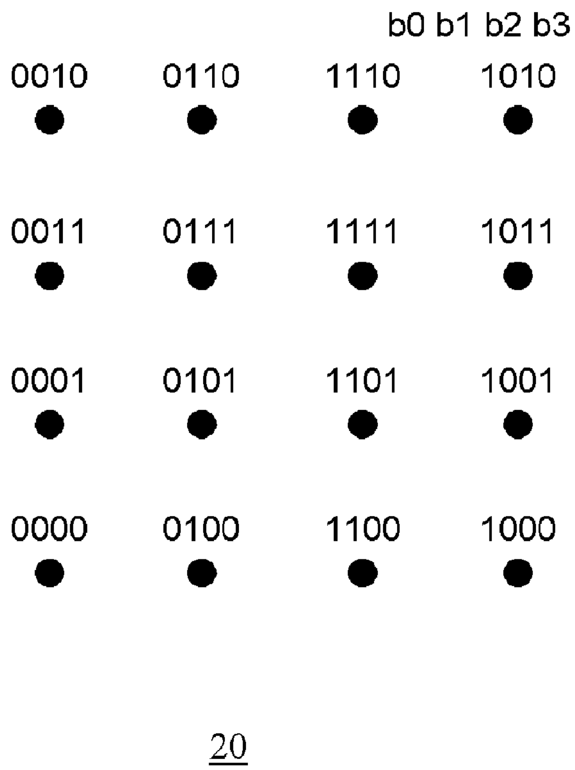

b0 b1 b2 b3
0010
0110
1110
1010
0011
0111
1111
1011
0001
0101
1101
1001
0000
0100
1100
1000
20

FIG. 3

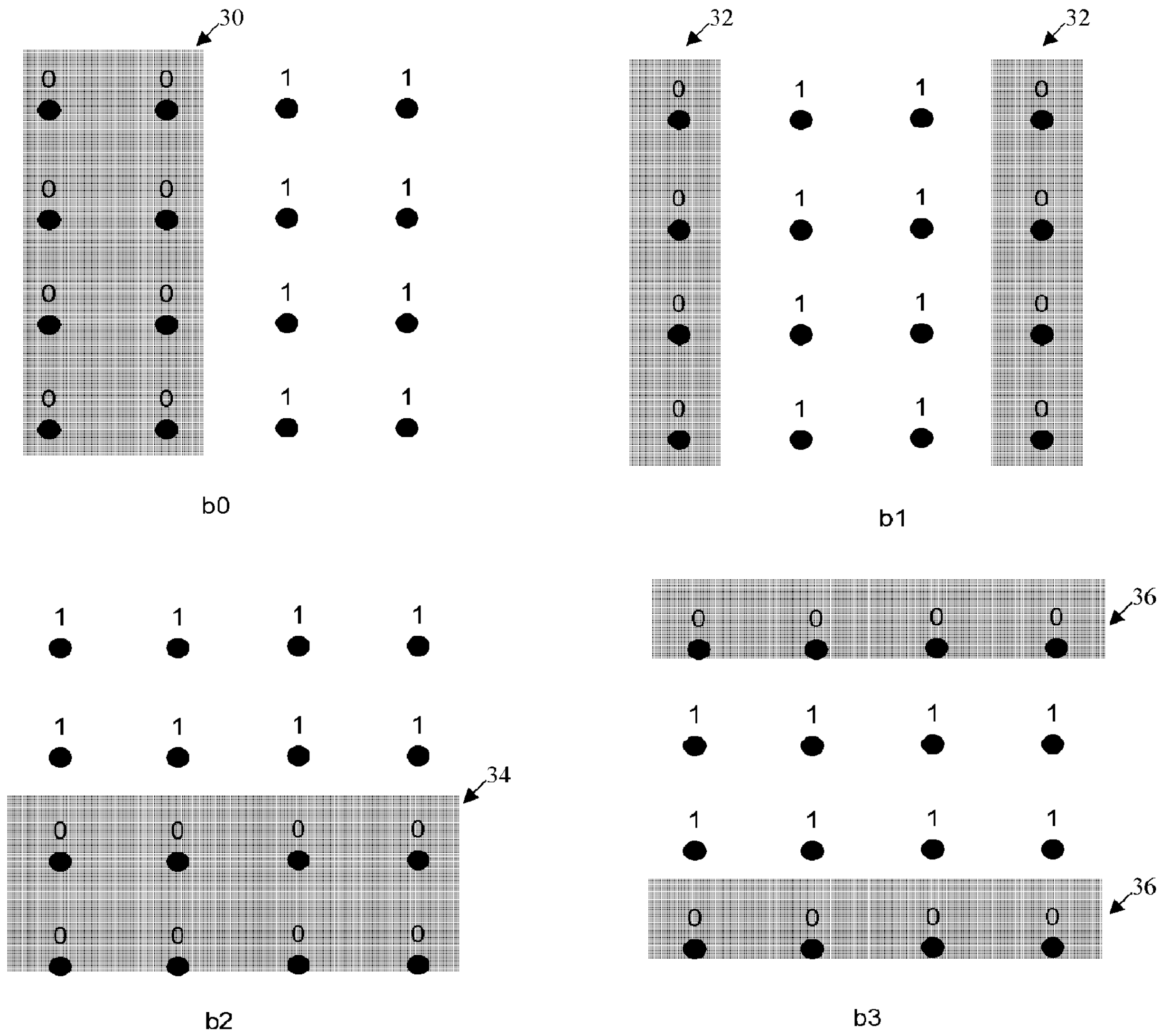
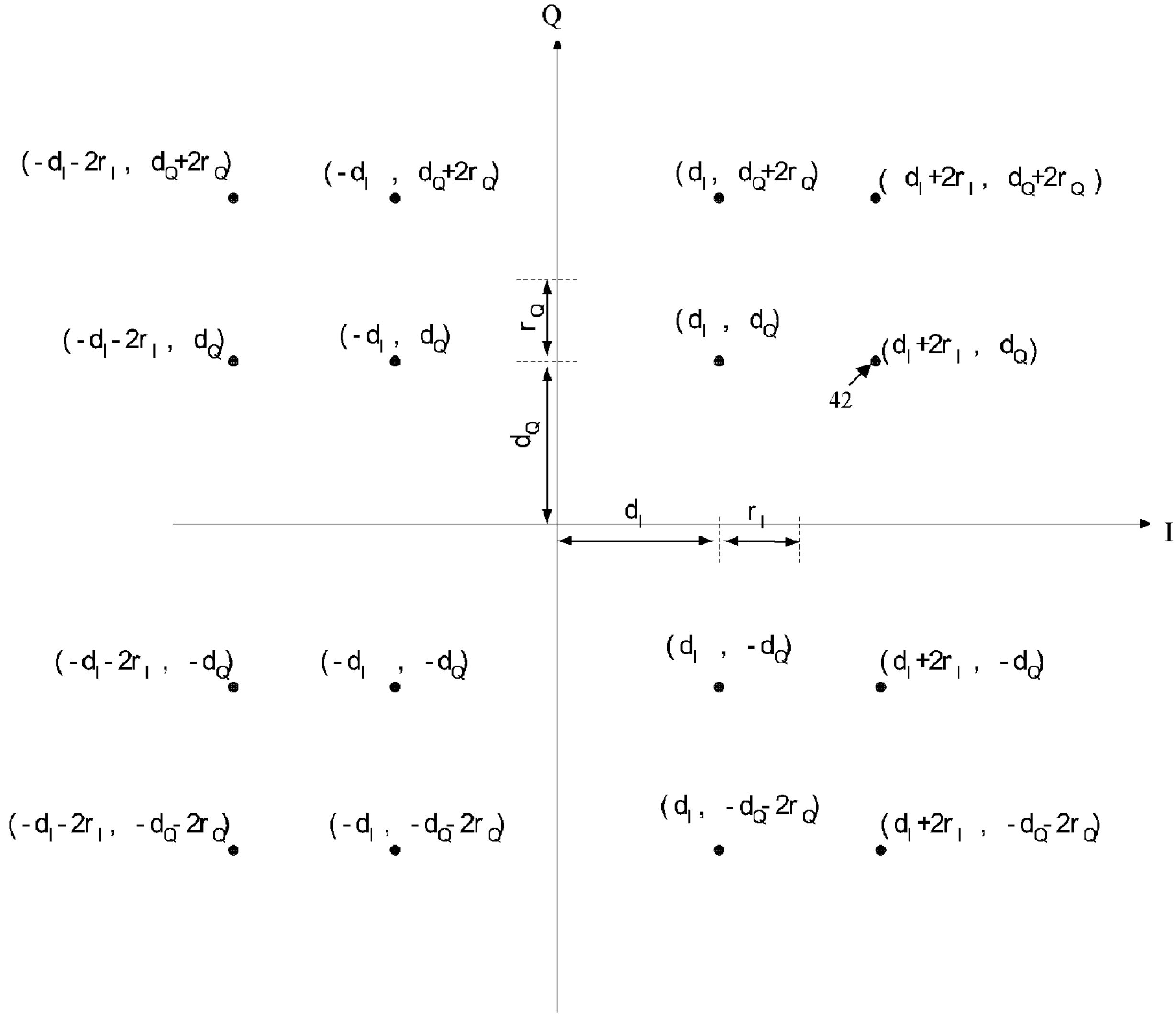
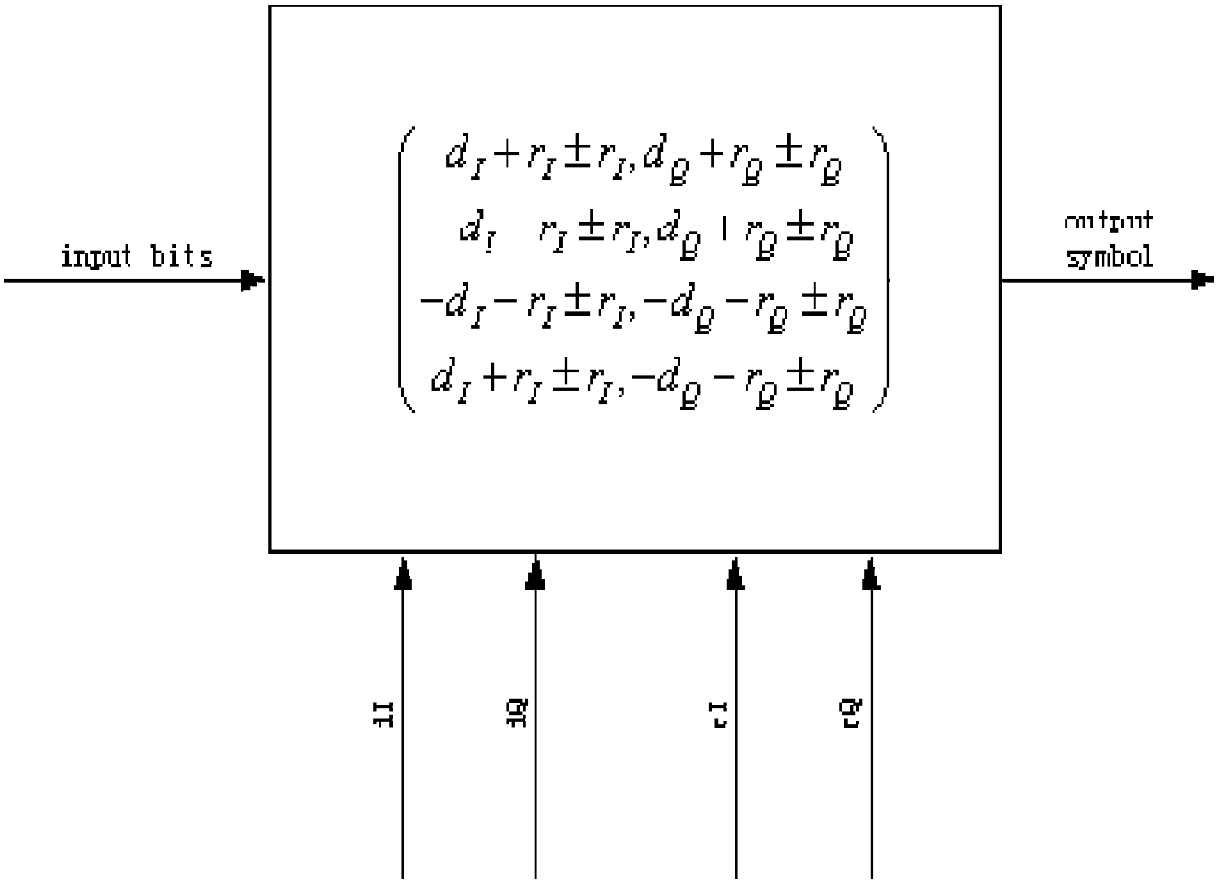

30
0 0 1 1
0 0 1 1
0 0 1 1
0 0 1 1
b0
32
32
0 1 1 0
0 1 1 0
0 1 1 0
0 1 1 0
b1
1 1 1 1
1 1 1 1
34
0 0 0 0
0 0 0 0
b2
36
0 0 0 0
1 1 1 1
1 1 1 1
36
0 0 0 0
b3

FIG. 4


Q
I
(-dI-2rI, dQ+2rQ)
(-dI, dQ+2rQ)
(dI, dQ+2rQ)
(dI+2rI, dQ+2rQ)
(-dI-2rI, dQ)
(-dI, dQ)
(dI, dQ)
(dI+2rI, dQ)
42
rQ
dQ
dI
rI
(-dI-2rI, -dQ)
(-dI, -dQ)
(dI, -dQ)
(dI+2rI, -dQ)
(-dI-2rI, -dQ-2rQ)
(-dI, -dQ-2rQ)
(dI, -dQ-2rQ)
(dI+2rI, -dQ-2rQ)

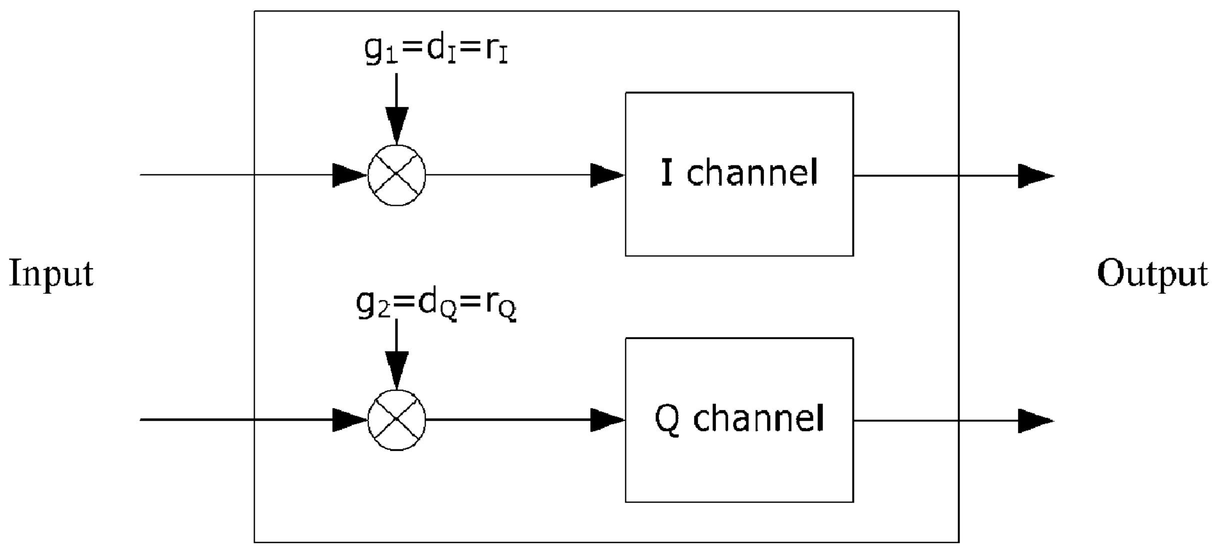
40

FIG. 5



50

FIG. 6



60

FIG. 7a

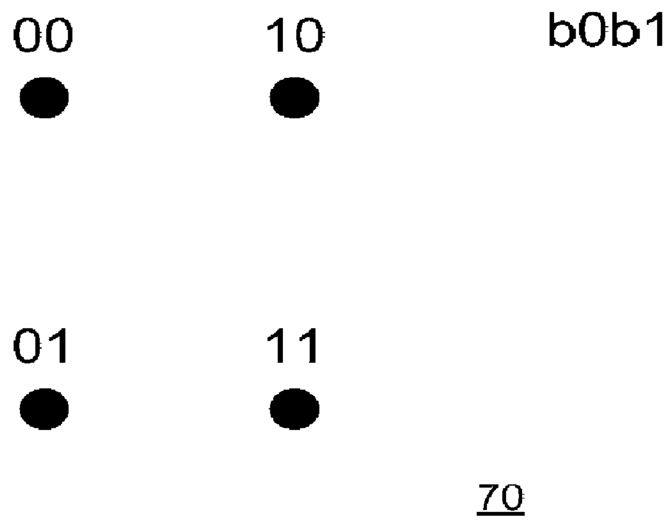


FIG. 7b

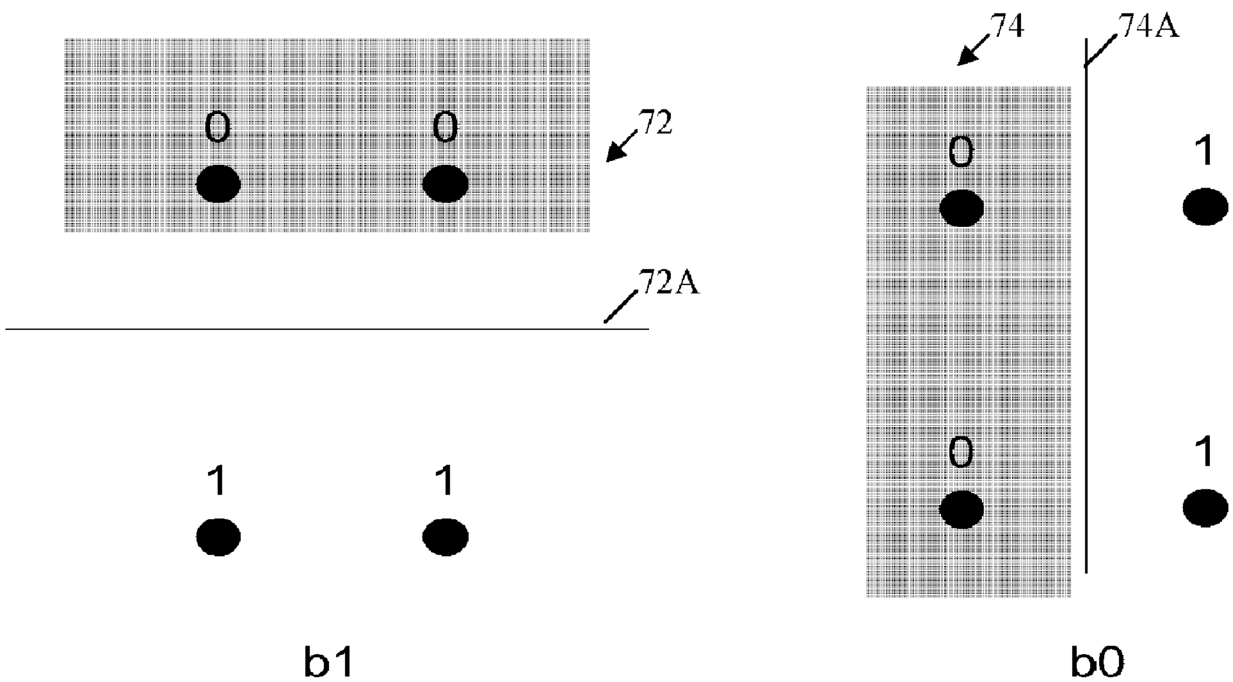


FIG. 8a

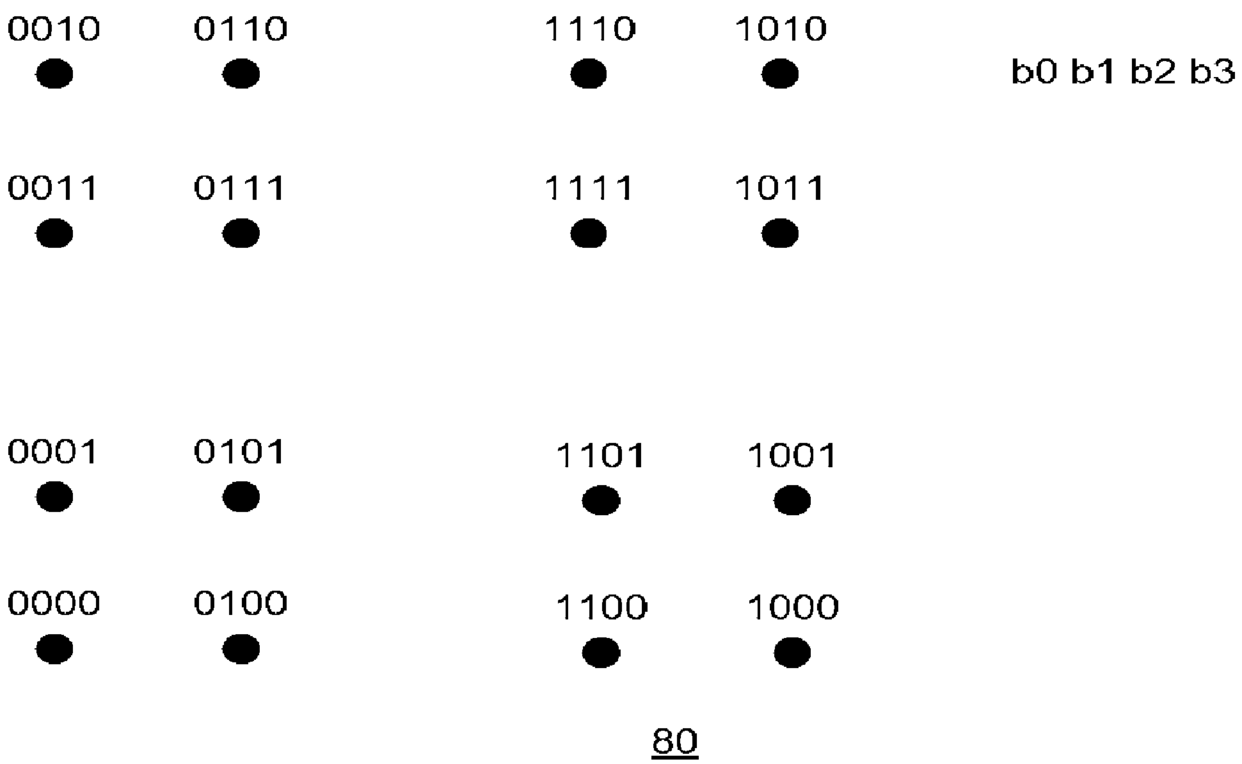

0010
0110
1110
1010
b0 b1 b2 b3
0011
0111
1111
1011
0001
0101
1101
1001
0000
0100
1100
1000
80

FIG. 8b

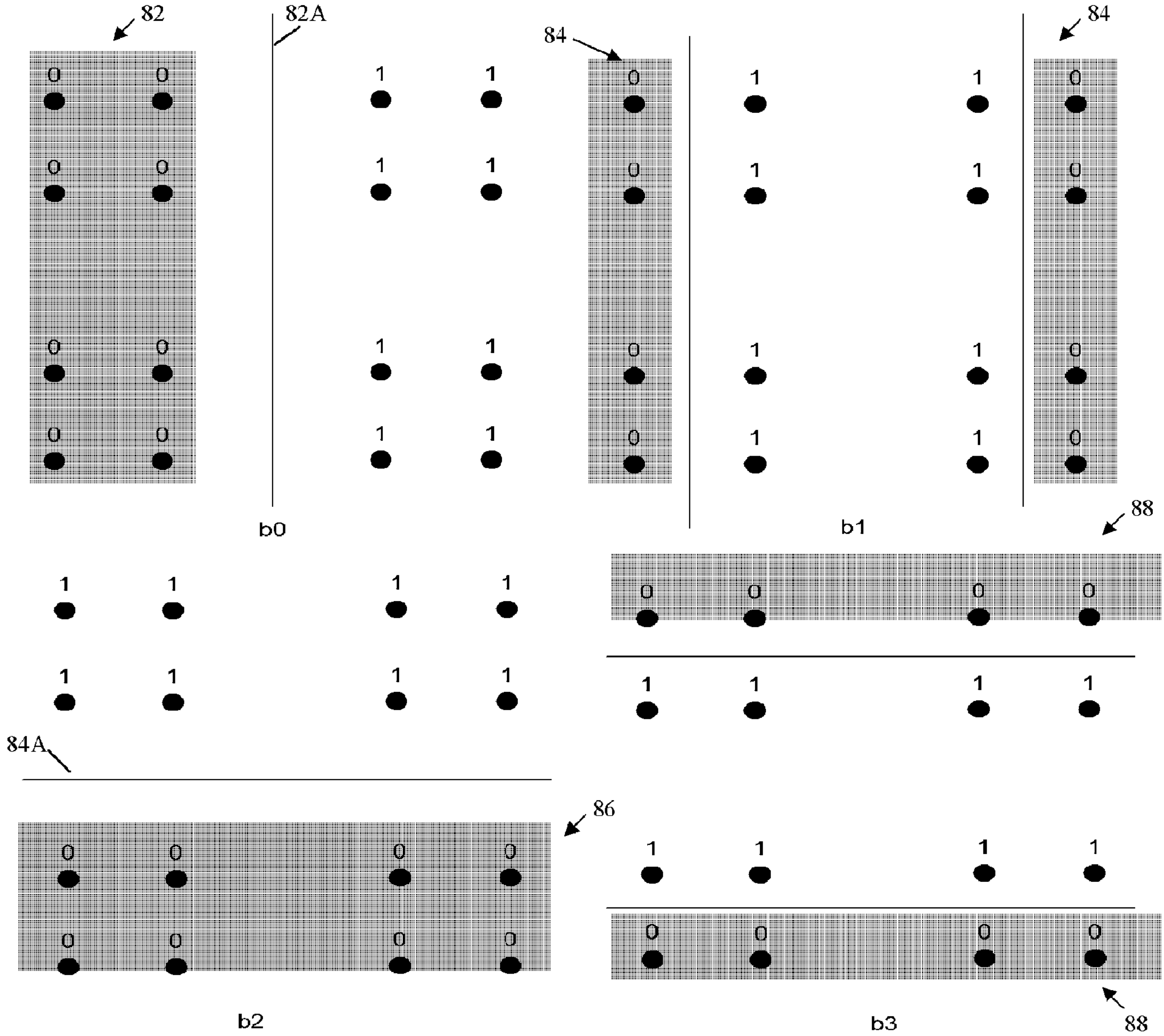

82
82A
84
84
0 0
0 0
0 0
0 0
1 1
1 1
1 1
1 1
0
0
0
0
1 1
1 1
1 1
1 1
0
0
0
0
b0
b1
88
1 1 1 1
1 1 1 1
0 0 0 0
1 1 1 1
84A
86
0 0 0 0
0 0 0 0
1 1 1 1
0 0 0 0
b2
b3
88

FIG. 9

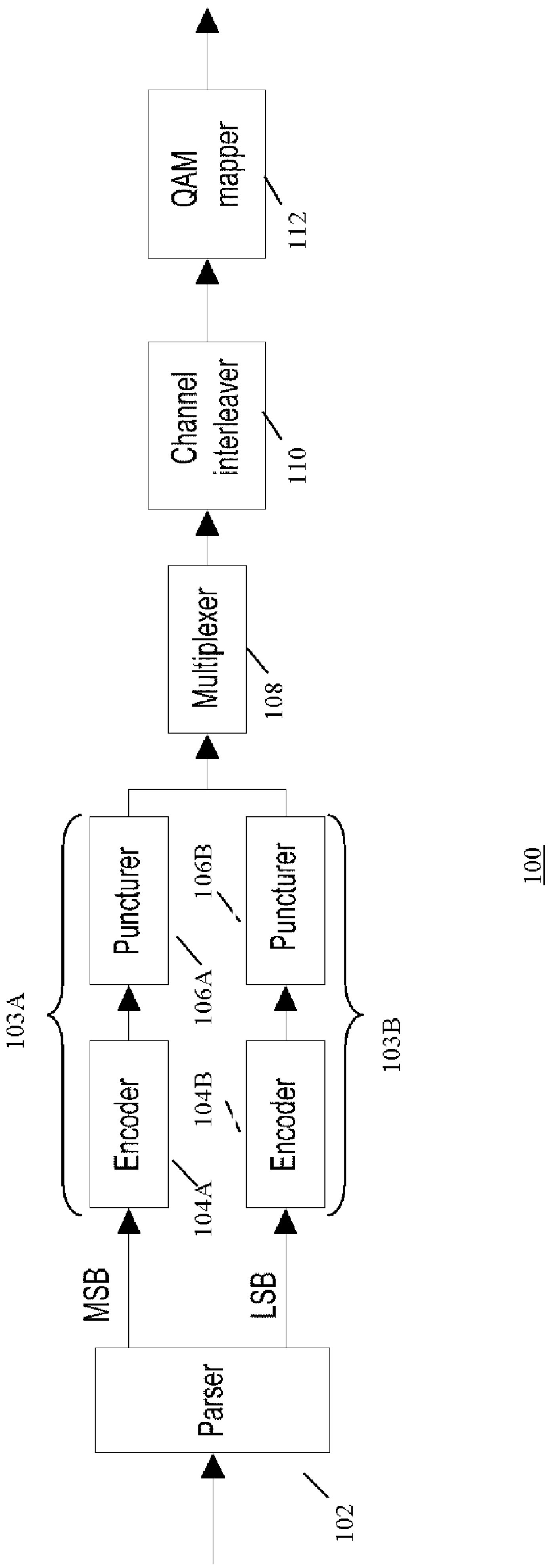

Parser
102
MSB
LSB
Encoder
104A
Encoder
104B
Puncturer
106A
Puncturer
106B
103A
103B
Multiplexer
108
Channel interleaver
110
QAM mapper
112
100

FIG. 10

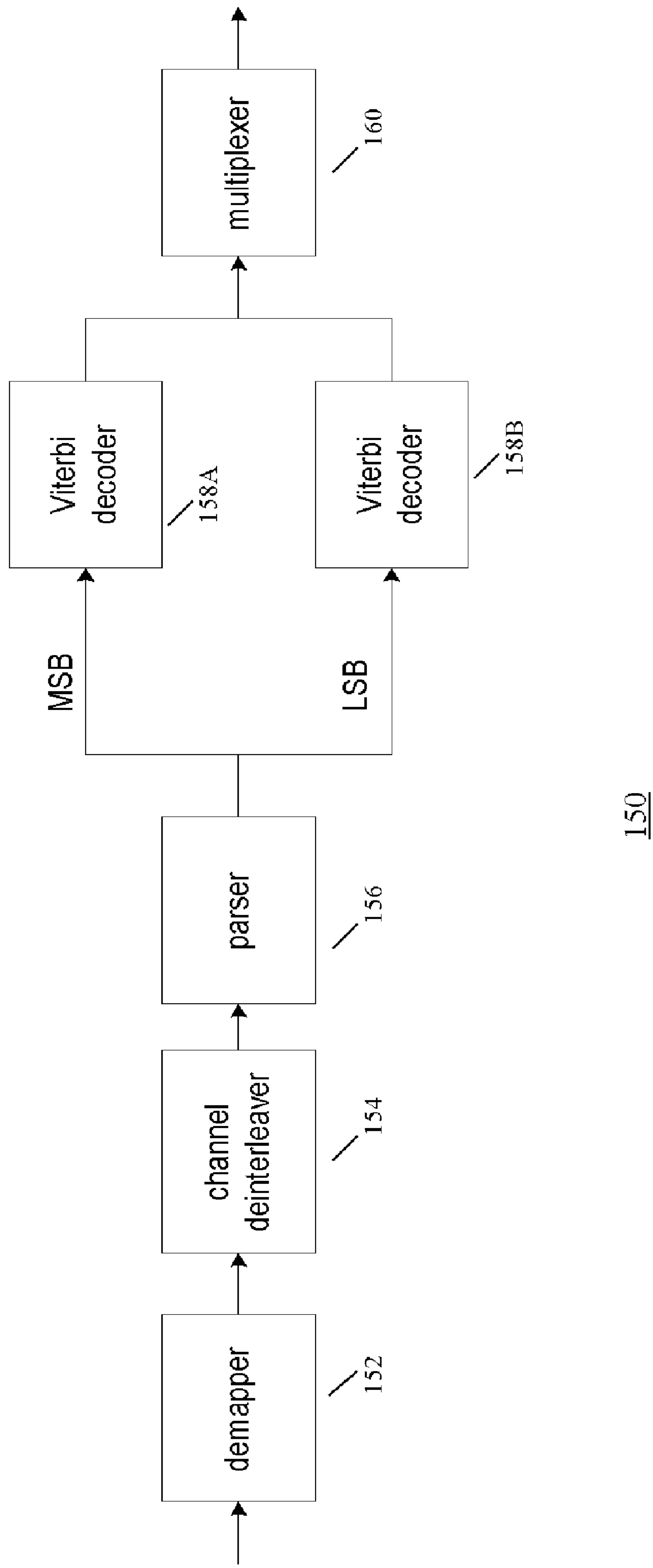
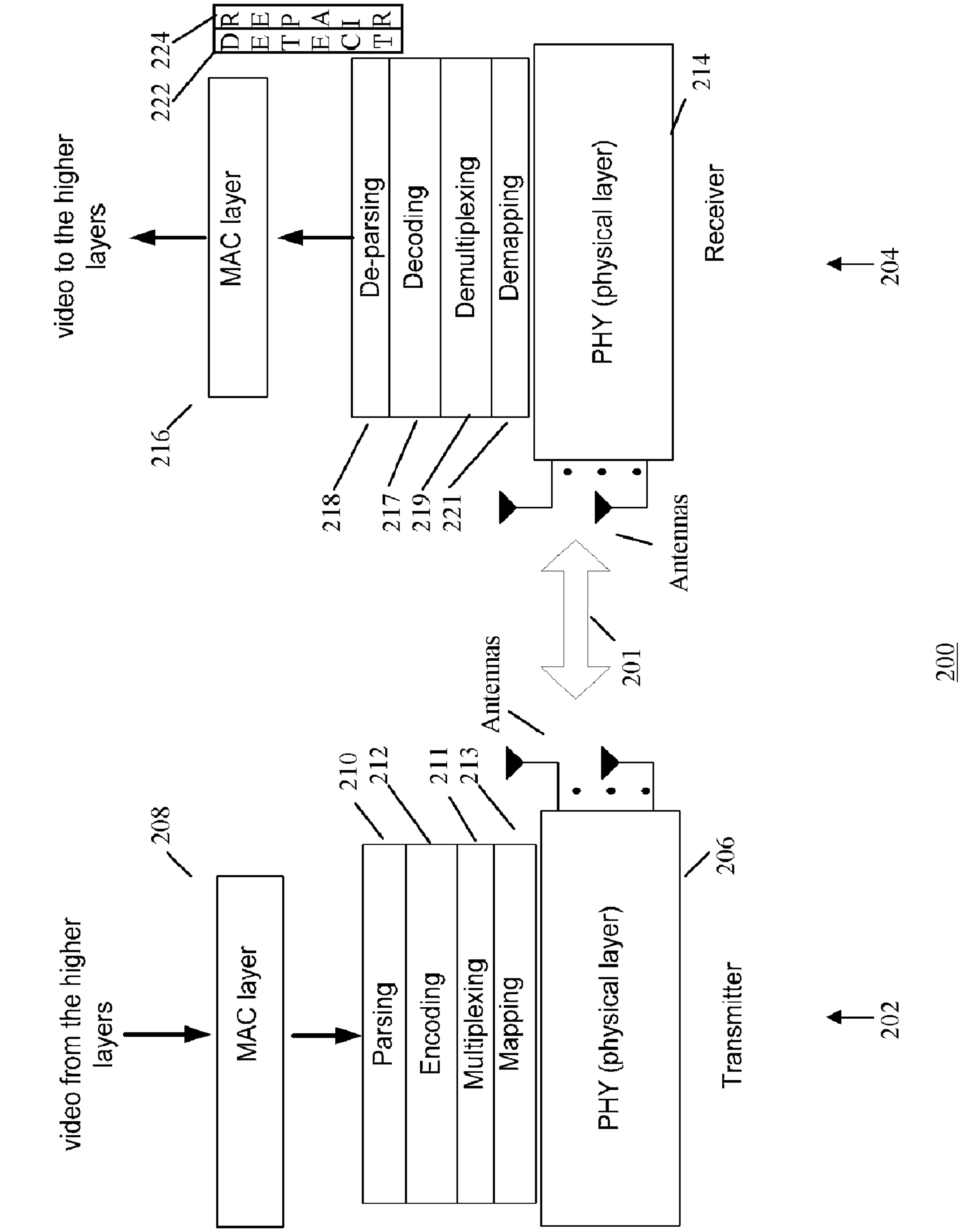

demapper
152
channel deinterleaver
154
parser
156
MSB
LSB
Viterbi decoder
158A
Viterbi decoder
158B
multiplexer
160
150

FIG. 11


video from the higher layers
MAC layer
208
Parsing
Encoding
Multiplexing
Mapping
210
212
211
213
PHY (physical layer)
206
Transmitter
202
Antennas
201
Antennas
video to the higher layers
MAC layer
216
De-parsing
Decoding
Demultiplexing
Demapping
218
217
219
221
222
224
DETECT
REPAIR
PHY (physical layer)
214
Receiver
204
200

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2007/000831

A. CLASSIFICATION OF SUBJECT MATTER

H04N 7/64(2006.01)i, H04L 1/00(2006.01)i, H04L 29/06(2006.01)i, H04L 29/02(2006.01)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)
IPC8: H04N 7/12-7/64, H03M 13/00

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 since 1975
Japanese Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKIPASS(KIPO internal) "bit, unequal, protection, QAM, constellation"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,214,656 A (Hong Y. Chung et al.) 25 May 1993 see columns 1~5, 7, figures 1-9	1, 2, 6, 7, 8, 13, 14, 21, 22, 29
Y		3-5, 9-12, 15-20, 23-28, 30-33
Y	US 2002/0097697 A1 (Sang-Min Bae et al.) 25 July 2002 see paragraphs [0045]~[0070], figures 2-8, 11, 14	15-20, 30-33
Y	US 6,651,210 B1 (Mitchell D. Trott et al.) 18 November 2003 see columns 5~10, figures 3-8	15-20, 30-33
Y	US 6,154,499 A (Bangalor R. Bhaskar et al.) 28 November 2000 see columns 11~13, figures 1A, 1B, 2, 4, 8	23-28
Y	US 2005/0180509 A1 (Stefano Olivieri et al.) 18 August 2005 see paragraphs [0002]~[0017]	3-5, 9-12, 17-20

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

* Special categories of cited documents:
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"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 MAY 2007 (21.05.2007)	**23 MAY 2007 (23.05.2007)**

Name and mailing address of the ISA/KR
Korean Intellectual Property Office
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Republic of Korea
Facsimile No. 82-42-472-7140

Authorized officer
LEE, Beaung Woo
Telephone No. 82-42-481-8227

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2007/000831

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		EP0490552A2	17.06.1992
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		CA2394957C	25.04.2002
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		JP2004512729T2	22.04.2004
		KR1020020031026	26.04.2002
		KR1020020031093	26.04.2002
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		WO200233856A1	25.04.2002
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		US6651210BA	18.11.2003
US06154499	28.11.2000	US6154499A	28.11.2000
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		AU2003201077AH	30.07.2003
		EP1472796A2	03.11.2004
		JP17515685	26.05.2005
		JP2005515685T2	26.05.2005
		KR1020040075938	30.08.2004
		US2005180509AA	18.08.2005
		US7165207BB	16.01.2007
		WO2003061137A2	24.07.2003
		WO2003061137A3	24.12.2003