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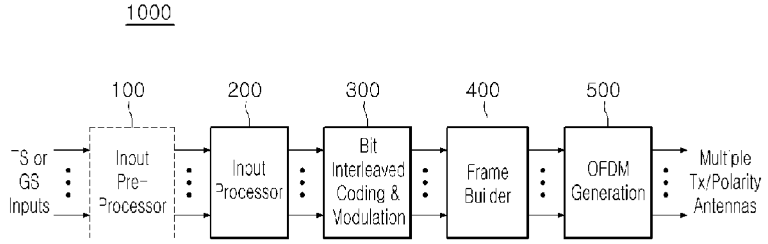
(54) Title: TRANSMITTING AND RECEIVING DIGITAL BROADCASTING SIGNALS

[Fig. 1]



(57) Abstract: The present disclosure relates to a digital broadcasting system which employs MIMO (Multi Input Multi Output) scheme to enhance transmission efficiency especially in a mobile environment. The present disclosure provides method of transmitting and receiving by splitting the broadcasting signals to transmit by polarity paths and processing the split broadcasting independently to replace FRFD (Full Rate Full Diversity) scheme.

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Description

Title of Invention: TRANSMITTING AND RECEIVING DIGITAL BROADCASTING SIGNALS

Technical Field

[1] The present disclosure relates to transmitting and receiving digital broadcasting signals. More particularly, the present disclosure relates to a digital broadcasting system which can employ MIMO (Multi Input Multi Output) scheme to enhance transmission efficiency especially in a mobile broadcasting environment.

Background Art

[2] Conventionally, in order to implement both the terrestrial broadcasting system and a mobile broadcasting system, two independent systems are designed for terrestrial broadcast and mobile broadcast, respectively. The two separate systems for terrestrial and mobile broadcast may employ different broadcast architectures and different spectra, respectively.

[3] Recently, a new approach has been suggested to implement a mobile digital broadcasting system using the pre-existing broadcasting systems, such as satellite or terrestrial digital broadcasting system, etc.

Disclosure of Invention

Technical Problem

[4] If one tries to implement and commercialize a new mobile digital broadcasting system based upon pre-existing terrestrial broadcasting system, there exist some challenges to overcome. To successfully commercialize mobile broadcasting system using the pre-existing terrestrial, it is necessary to maximize commonality with the pre-existing terrestrial broadcasting system so that the network provider can use the pre-existing infrastructure for terrestrial broadcasting system and the device manufacturer can easily manufacture mobile devices using the pre-existing platform for the receiver of the terrestrial broadcasting system.

Solution to Problem

[5] The present disclosure provides solutions to transmit mobile broadcasting signals using platform or infrastructure of a pre-existing terrestrial broadcasting system. Specifically, the present disclosure provides solution to transmit DVB-NGH (Digital Video Broadcasting-Next Generation Handheld) (hereinafter "NGH") signals using platform or infrastructure of the pre-existing DVB-T2 (Digital Video Broadcasting for a Second Generation Digital Terrestrial Television Broadcasting) (hereinafter "T2") system.

[6] According to the present disclosure, the NGH signals may be transmitted using frame

formats or modified frame formats of the T2 system.

[7] Specifically, the present disclosure provides three schemes to achieve the above mentioned purposes. The first one is to transmit and receivee NGH frames using a PLP (Physical Layer Pipe) provided by the pre-existing T2 system. The second one is to employ FEF (Future Extension Frame) for transmitting and receiving NGH frames, which is advantageous in that it can employ MIMO or MISO scheme for each of FEFs. The third one is to introduce new independent system for transmitting and receiving NGH frames, which can provide the full flexibility for employing MIMO or MISO scheme or in terms of capacity.

[8] According to an embodiment of the present disclosure, a method for transmitting digital broadcasting signal to a receiver is provided. The method comprises: demultiplexing input data bits into cells; mapping the cells into a constellation; demultiplexing the cells into a pair of cells of dual polarity paths to generate a first constellation and a second constellation; rotating the cells in complex planes of the first constellations and the second constellation of the dual polarity paths by a predetermined angle; remapping the rotated cells of the dual polarity paths; building a signal frame based on the remapped cells; modulating the signal frame by an Orthogonal Frequency Division Multiplexing (OFDM) method; and transmitting the modulated signal frame.

[9] According to another embodiment of the present disclosure, a transmitter for transmitting digital broadcasting signal to a receiver is provided. The transmitter comprises: a demultiplexer configured to demultiplex input data bits into cells; a mapper configured to map the cells into a constellation; a demultiplexer configured to demultiplex the cells into a pair of cells by dual polarity paths to generate a first constellation and a second constellation; a rotation and remapping unit configured to rotate the cells in complex planes of the first constellations and the second constellation of the dual polarity paths by a predetermined angle, and to remap the rotated cells of the dual polarity paths; a frame builder configured to build a signal frame based on the remapped cells; a modulator configured to modulate the signal frame by an Orthogonal Frequency Division Multiplexing (OFDM) method; and a transmission unit configured to transmit the modulated signal frame.

[10] According to another embodiment of the present disclosure, a method of receiving digital broadcasting signal is provided. The method comprises: receiving signals of dual polarity paths; detecting preamble symbol to indicate type of the received signals; performing time and frequency synchronization upon the received signals; performing channel estimation upon the received signals; demodulating received signals for each of the dual polarity paths by use of an Orthogonal Frequency Division Multiplexing(OFDM) method; extracting a signal frame comprising cells having dual

polarity paths from the demodulated signal; multiplexing the cells of the dual polarity paths into one cell stream; and multiplexing the cell stream into data bits.

[11] According to another embodiment of the present disclosure, a receiver for receiving broadcasting signal is provided. The receiver comprises: a receiving unit configured to receive signals of dual polarity paths; a preamble detection module configured to detect a preamble symbol to indicate type of the received signals; a time and frequency synchronization module configured to perform time and frequency synchronization upon the received signals; a channel estimation module configured to perform channel estimation upon the received signals; a demodulator configured to demodulate received signals for each of the dual polarity paths by use of an Orthogonal Frequency Division Multiplexing(OFDM) method; an extracting unit configured to extract a signal frame comprising cells having dual polarity paths from the demodulated signal; a multiplexer configured to multiplex the cells of the dual polarity paths into one cell stream; and a multiplexer configured to multiplex the cell stream into data bits.

Advantageous Effects of Invention

[12] According to the present disclosure, MIMO scheme can be employed in a mobile broadcasting system such as NGH system, and accordingly complexity of the receiver can increase but better receiving performance in various channel environment and receiving conditions can achieved.

Brief Description of Drawings

[13] Fig. 1 shows a high level block diagram for a transmitter 1000 for NGH system according to an embodiment of the present disclosure.

[14] Fig. 2 shows an input processor 200 for single PLP input according to an embodiment of the present disclosure.

[15] Fig. 3 shows a mode adaptation module 230 for multiple PLP inputs of the processor 200 according to an embodiment of the present disclosure.

[16] Fig. 4 shows a stream adaptation module 240 for multiple PLP inputs of the input processor 220 in Fig. 2 according to an embodiment of the present disclosure.

[17] Fig. 5 illustrates block diagrams for a BICM module 300 according to an embodiment of the present disclosure.

[18] Fig. 6 illustrates constellation rotation and remapping according to an embodiment of the present disclosure.

[19] Fig. 7 shows a frame builder 400 according to an embodiment of the present disclosure.

[20] Fig. 8 shows an OFDM modulation module 500 including blocks for each of the dual polarity paths 500a and 500b.

[21] Fig. 9 illustrates an exemplary NGH frame structure according to an embodiment of

the present disclosure, which is based upon PLPs of the conventional T2 system.

[22] Fig. 10 illustrates another exemplary NGH frame structure according to an embodiment of the present disclosure, which is based upon FEF(Future Extension Frame) of the conventional T2 system.

[23] Fig. 11 shows P1 symbol structure of the T2 system.

[24] Fig. 12 shows how the P1 symbol is generated in T2 system.

[25] Fig. 13 shows a flow chart for a method of transmitting broadcasting signals according to an embodiment of the present disclosure.

[26] Fig. 14 shows high level block diagram of a receiver 2000 for NGH system according to an embodiment of the present disclosure.

[27] Fig. 15 shows detailed block diagram for OFDM demodulation module 600.

[28] Fig. 16 shows a detailed block diagram for frame demapper module 700 according to an embodiment of the present disclosure.

[29] Fig. 17 shows a detailed block diagram for BICM decoder 800 according to an embodiment of the present disclosure.

[30] Fig. 18 shows a detailed block diagram for output processor 900 for single PLP inputs according to an embodiment of the present disclosure.

[31] Fig. 19 shows a detailed block diagram for output processor 910 for multiple PLP inputs according to an embodiment of the present disclosure.

[32] Fig. 20 shows a flow chart for a method of receiving broadcasting signals according to an embodiment of the present disclosure.

Best Mode for Carrying out the Invention

[33] As aforementioned, the present disclosure provides three schemes to enhance transmission efficiency for a mobile digital broadcasting system such as DVB-NGH system.

[34] The first one is to transmit and receive mobile broadcasting signals such as NGH frames, using upon PLP (Physical Layer Pipe) of the frame provided by the pre-existing broadcasting system such as T2 system. This scheme is advantageous in that it is possible to combine and use transmission parameters of the pre-existing broadcasting system such as T2 as necessary to transmit mobile broadcasting signal.

[35] The second one is to employ FEF(Future Extension Frame) of the frame provided by the pre-existing broadcasting system such as T2 system to transmit and receive mobile broadcasting signals such as NGH frames, which is advantageous in that it can employ MIMO or MISO scheme independently from the pre-existing system frame structure.

[36] The third one is to introduce new independent system for mobile broadcasting signals such as NGH frames, which can provide the full flexibility in employing MIMO or MISO scheme or in terms of capacity. It is possible to maximize the commonality with

the pre-existing system such as T2 depending upon the design of the newly constituted system.

[37] The technical requirements for employing MIMO scheme are as follow:

[38] 1) Capacity increase through multiplexing gain

[39] 2) Robust working even under highly-correlated channel condition, for example LOS (Line of Sight)

[40] 3) Maximum gain under so-called rich scattering condition

[41] 4) Robust reception under very low SNR condition (indoor reception)

[42] 5) Doppler-resistant MIMO decoding even in high speed

[43] 6) Robustness over SFN-oriented issues like unequal receiving power from each transmission

[44]

[45] The present disclose provides some specific schemes for meeting the above requirements as follow:

[46] 1) Full-rate full-diversity code for maximum gain (eg. Golden code)

[47] 2) Dual polarity MIMO to overcome LOS condition

[48] 3) Transmit diversity (eg. Alamouti code) to combat SFN-oriented issues

[49] 4) Combinations of three schemes above as a whole MIMO system

[50] 5) Lower coderates for robust indoor reception

Mode for the Invention

[51] Reference will now be made in detail to the preferred embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings for the aforementioned schemes. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

[52] Fig. 1 shows a high level block diagram for a transmitter 1000 for a NGH system according to an embodiment of the present disclosure.

[53] Referring to Fig. 1, the input to the transmitter 1000 may be one or more Transport Stream(s)(TS) and/or one or more Generic Stream(s)(GS). The input pre-processor 100 may generate PLP inputs by a service unit to which robustness will be given for the input streams. The input processor 200 may form baseband frame. The BICM (Bit Interleaved Coding & Modulation) module 300 may add redundancy to the input streams for overcoming transmission errors and noise which can occur in channels and may perform interleaving. The frame builder 400 may map each of PLPs into transmission frames. The OFDM generation module 500 may modulate the input data and generate baseband signal which can be transmitted through antennas.

[54] Fig. 2 shows an input processor 200 for single PLP input according to an embodiment of the present disclosure. The input processor 200 can be divided into mode

adaptation module 210 and stream adaptation module in terms of their functions.

[55] In mode adaptation module 210 of Fig. 2, input interface module 211 may classify and map the input bit streams into logical units for performing FEC(Forward Error Correction) encoding such as BCH encoding or LDPC encoding. CRC-8 encoder 212 may perform CRC encoding, BB header insertion module 213 may insert header including Mode Adaptation Type (TS or GS), User Packet Length, Data Field Length, User Packet Sync Byte, Start Address of User Packet Sync Byte in Data Field, High Efficiency Mode Indicator, Input Stream Synchronization Field, etc.

[56] In stream adaptation module 220, Padding insertion module 214 may insert padded bit when the input stream does not fill a whole baseband frame for a FEC encoding. BB scrambler module 215 may perform XOR operation on the input stream with PRBS(Pseudo Random Binary Sequence) to randomize the input stream.

[57] Fig. 3 shows a mode adaptation module 230 of the input processor 200 in Fig. 1 for multiple PLP inputs according to an embodiment of the present disclosure.

[58] In Fig. 3, input interface module 231 may classify and map the input bit streams into logical units for performing FEC (Forward Error Correction) encoding such as BCH encoding or LDPC encoding. The input stream synchronizer module 232 in mode adaptation module 230 of Fig. 3 may generate and insert ISCR (Input Stream Clock Reference) information which is timing information required to recover TS or GS on the receiving side. Compensating delay module 233 may add delays between groups of PLPs based upon the timing information to synchronize the group of PLPs. Null packet deletion module 234 may delete null packets which are useless and otherwise would be transmitted and instead insert the number of null packet deleted into the location where the null packets were deleted.

[59]

[60] Fig. 4 shows a stream adaptation module 240 of the input processor 200 in Fig. 1 for multiple PLP inputs according to an embodiment of the present disclosure. Compared with the stream adaptation module 220 for single PLP input in Fig. 2, scheduler module 241, frame delay module 242 and in-band signalling insertion module 243 are added.

[61] Scheduler module 241 may perform scheduling for dual polarity MIMO scheme. For example, scheduler module 241 may generate various parameters to be used in dual polarity paths for cell to polarity demultiplexer, cell interleaver, time interleaver as will be discussed below. Frame delay module 242 may delay the input data by one transmission frame so that scheduling information for the next frame can be transmitted by the current frame for in-band signalling. In-band signalling or padding insertion module 243 may insert undelayed L1 dynamic signalling information into the one transmission frame delayed data. In this case, if there is a space available for

padding (see padding insertion module 214 in Fig. 2), padded bit or in-band signalling information can be inserted into the available space. Scheduler module 241 may output L1 dynamic signalling information for the current frame separately from the in-band signalling so that the cell mapper as will discussed below can perform mapping according to scheduling information.

[62]

[63] Fig. 5 illustrates block diagrams for a BICM module 300 according to an embodiment of the present disclosure.

[64] In order to implement a function of FRFD (Full Rate Full Diversity) which gives both multiplexing and diversity gain, the present disclosure employs a combination of schemes of spatial multiplexing, and constellation rotation and remapping instead of using FRFD MIMO coding. This is because if FRFD MIMO code is employed, ML(Maximum Likelihood) decoding complexity is highly increased on the receiving end, for example, as in the case of Golden code which is known as the optimal code for 2x2 MIMO scheme. This causes considerable complexities for a system and a cost rise for devices. As a consequence, the present disclosure provides a modified rotation constellation and remapping scheme to decrease complexities of the system. The modified scheme of the present disclosure will not introduce any additional complexity compared to SISO system with a conventional constellation rotation and remapping scheme.

[65] The BICM module 300 comprises modules for data PLPs 310 and modules for L1 signalling 320.

[66] In the modules for data PLPs 310, FEC encoding module 301 may add redundancy to correct errors which occur over the transmission channel, and support low code rate such as 1/4, 1/3 and 2/5. Bit interleaver module 302 may perform inverleaving on the input bit stream and output them. Bit to cell demultiplexer 303 may adjust robustness for each bit by adjusting order of the bits constituting a cell. Constellation mapper module 304 may map the input cells into QAM (Quadrature Amplitude Modulation) constellation.

[67] And then, cell to polarity demultiplexer 305 may split the input cell stream into two separate streams by physical characteristic such as polarity path characteristics. The input cell stream may be split by cell to polarity demultiplexer 305 into streams of horizontal polarity path and vertical polarity path. The streams of horizontal polarity path and the vertical polarity path may be processed and transmitted independently from each other to achieve full rate full diversity without using codes such as Golden code.

[68] Cell interleaver module 306 may perform interleaving upon cells within an LDPC block and time interleaver module 307 may perform time interleaving upon cells

belonging to a plurality of LDPC blocks. In this case, the cell interleaver 306 and the time interleaver 307 may perform interleaving upon cells only within each polarity path.

[69] Constellation rotation and remapper module 308 may rotate the constellations for each of dual polarity paths.

[70] The normalized values of cells of dual polarity paths coming from the cell to polarity demultiplexer are rotated in the complex plane and remapped into new constellations to give diversity across the dual polarity paths for preventing multi-path fading etc.

[71] According to an embodiment of the present disclosure, the remapping can be performed by crossing I phase and Q phase of the constellation of dual polarity paths.

[72] Specifically, referring to Fig. 6, upper left is shown a constellation 21 for horizontal polarity path and upper right is shown a constellation 22 for vertical polarity path after rotating a constellation. I phase and Q phase of each of the constellations 21 and 22 may be crossed each other and remapped into new constellations 23 and 24. For example, Q phase of constellation 21 for horizontal polarity path is mapped into Q phase of new constellation 23 and I phase of constellation 22 for vertical polarity path is mapped into I phase of new constellation 23. Likewise, I phase of constellation 21 for horizontal polarity path is mapped into I phase of new constellation 24 and Q phase of constellation 22 for vertical polarity path is mapped into Q phase of new constellation 24. By applying the constellation rotation and remapping as above, diversity across the dual polarity paths can be achieved.

[73] According to an embodiment of the present disclosure, the cell to polarity demultiplexer 305 and/or constellation rotation and remapper module 308 may be positioned anywhere after constellation mapper module 304 and before MISO processing module 510 in OFDM modulation module 500 of Fig. 8. That is, constellation rotation remapper module 308 may precede the cell to polarity demultiplexer 305. However, preferably, the cell to polarity demultiplexer 305 may precede the constellation rotation and remapper module 308.

[74] Alternatively, the remapping as above can be performed upon rotated cells in the constellations by cyclically delaying imaginary parts, that is, Q phase of the rotated cells by certain amount of cells, for example, by one cell for each of the dual polarity paths.

[75] Also, another embodiment of the present disclosure, remapping can be performed by a combination of the crossing an arbitrary I phase and an arbitrary Q phase with the cyclic delay of imaginary parts. That is, the remapping as above can be performed upon rotated cells in the constellations by mapping (k)th Q phase of one polarity path to (n)th Q phase of another polarity path and so on, where k and n are different cell indexes.

[76] For example, remapping can be performed upon rotated cells in the constellation by crossing I phase and Q phase of the rotated cells for each of the dual polarity paths and then cyclically delaying imaginary part of the rotated cells, or delaying imaginary part of the rotated cells and then crossing I phase and Q phase of the rotated cells for each of the dual polarity paths.

[77] In the modules for L1 signalling 320, L1 signalling generator 309 may encode L1-dynamic information and L1 configuration information to output L1-pre signaling and L1-post signaling. Shortened/Punctured FEC encoder (LDPC/BCH) 310 may perform FEC encoding including shortening and puncturing upon input bit streams.

[78] Bit interleaving 311 and bit to cell demultiplexing 312 may be performed upon L1-post signaling.

[79] And then, the bits of the L1-pre signaling and the cell words of the L1-post signaling are mapped into constellations respectively by constellation mapper 313.

[80] Cell to polarity demultiplexer 314 may split the L1-pre signaling and L1-post signaling into two streams by physical characteristics, such as polarity path cahracteristic and then constellation rotation and remapper module 315 may rotate the constellation in complex plane and remap the rotated constellation of each of dual polarity path.

[81] The cell to polarity demultiplexer 314 and the constellation rotation and remapper module 315 may perform the same functions on the L1-pre signaling and the L1-post signaling as that of cell to polarity demultiplexer 315 and constellation rotation and remapper 318 on data PLPs as described above.

[82] Alternatively, the cell to polarity demultiplexer 314 and the constellation rotation and remapper module 315 for the L1-pre signaling and L1-post signaling may omitted.

[83]

[84] Fig. 7 shows a frame builder 400 according to an embodiment of the present disclosure. For L1 signalling input, delay compensator 401 may compensate for frame delay which occurred in stream adaptation module 240 of Fig. 4 to synchronize time with PLP input data. Cell mapper 402 may arrange the input common PLP cells, data PLP cells and L1 cells in an array of OFDM symbols assigned to transmission frames, and arrange sub-slices appropriately. The arranged cells in the array of OFDM symbols may be frequency interleaved by frequency interleaver 403 and outputted.

[85] In this case, cell mapper 402 may apply the same cell mapping rule or different cell mapping rules to the cells of different polarity paths in the MIMO scheme provided by the present disclosure. These mapping rules can be changed depending upon the scheduling of stream adaptation module 240 of Fig. 4.

[86] Fig. 8 shows an OFDM modulation module 500 including blocks for each of the dual polarity paths 500a and 500b. In each of the polarity paths 500a and 500b, the input

symbols may be MISO (Multiple Input Single Output) encoded to have transmission diversity by MISO processing module 520. Pilot insertion module 520 may insert pilots so that the receiving end can perform transmission channel estimation and time and frequency synchronization. Also, the pilot insertion module 520 may reserve dummy tone for some carriers to reduce PAPR(Peak to Average Power Ratio) of OFDM signals in time domain. IFFT module 530 may convert freqenncy domain signals to time domain signals. PAPR reduction module 540 may measure PAPR in time domain and reduce the PAPR by replacing all or the part of reserved tones with appropriate signals or null signals according to PAPR reduction algorithm. Guard interval module 550 may add prefix by copying the tail part of the effective OFDM symbol in front of the head part of the OFDM symbol. P1 symbol insertion module 560 may insert P1 symbol carrying parameters required for the receiving end to detect NGH signals and decode NGH signals. DAC(Digital Analog Conversion) module 570 may convert input digital signal to analog signal. Finally, each signals of the dual polarity paths may be transmitted through corresponding polarity antennas of the transmitter.

[87] To transmit NGH frames using the pre-existing broadcasting system such as T2 system, it is necessary to indicate NGH frames so that the receiver can find out if the received frame is a T2 frame or an NGH frame. P1 symbol can be used for this purpose. P1 can carry information to indicate the type of frames, T2 frame or NGH frame. To this end, the conventional P1 symbol of T2 can be modified to indicate NGH frame. The examples of modifying P1 symbol will be discussed with reference to Figs. 11 and 12.

[88]

[89] Hereinafter, various embodiments of frame structures will be discussed for transmitting mobile digital broadcasting signals such as NGH signals.

[90] Fig. 9 illustrates an exemplary NGH frame structure according to an embodiment of the present disclosure, which is based upon PLPs provided by the conventional T2 system. The NGH frames can be included and transmitted in data PLPs of conventional T2 system, for example, in PLP type 1 or PLP type 2. In Fig. 9, PLP M1 of PLP type 1 and PLP (M1+M2) of PLP type 2 were used to transmit the NGH PLP.

[91] Fig. 10 illustrates another exemplary NGH frame structure according to an embodiment of the present disclosure, which is based upon FEF (Future Extension Frame) of the conventional T2 system. In Fig. 10, structures of a super frame are shown. White boxes represent conventional T2 frames and boxes marked with hatching represent NGH frames.

[92] According to the conventional T2 system, a super-frame can carry T2-frames and may also have FEF parts, The number of T2-frames in a super-frame is a configurable

parameter and the number of T2 frames in a super frame is signalled in L1-pre signaling. The number of T2 frames in a super frame must be chosen so that for every data PLP there is an integer number of Interleaving Frames per super-frame.

[93] An FEF may be inserted between T2-frames. There may be several FEF parts in the super-frame, but an FEF shall not be adjacent to another FEF. The location in time of the FEF parts is signalled based on the super-frame structure. If FEFs are used, the super-frame ends with a FEF part. The L1-pre signalling and the configurable part of the L1-post signalling can be changed only on the border of two super-frames. A data PLP does not have to be mapped into every T2-frame. It can jump over multiple frames.

[94] As shown in Fig. 10, NGH frames can be included and transmitted in FEF frames, which may be placed between T2 frames. As shown in Fig. 10(a), NGH frames can be included every N T2 frames, that is, by interval of N T2 frames. In this case, the ratio of NGH frames to T2 frames is 1:N. The maximum number of NGH frames can be transmitted with the NGH frames inserted every T2 frames, as shown in Fig. 10(b). In this case, the ratio of NGH frames to T2 frames is 1:1. In order to maximize commonality of NGH frames and the conventional T2 frames, the NGH frames carried by FEFs can have similar to or almost the same structure as T2 frames.

[95]

[96] According to one embodiment of the present disclosure, a new frame for transmitting NGH frames can be defined. The new frame for transmitting NGH frames can be defined and used independently from the conventional T2 frames. When applying this scheme, in order for receiver to detect NGH frames, new P1 symbol which is different from conventional P1 symbol of T2 system can be used. According to embodiments of the present disclosure, modified P1 symbol of T2 can be used to enable the receiver to detect NGH frames. P1 symbol for NGH system can be acquired by modifying the symbol structure of the conventional P1 symbol or modifying the generation scheme of P1 symbol of the conventional P1 symbol.

[97] In T2 system, preamble symbol P1 has four main purposes. First it is used during the initial signal scan for fast recognition of the T2 signal, for which just the detection of the P1 is enough. Construction of the symbol is such that any frequency offsets can be detected directly even if the receiver is tuned to the nominal centre frequency. This saves scanning time as the receiver does not have to test all the possible offsets separately.

[98] The second purpose for P1 is to identify the preamble itself as a T2 preamble. The P1 symbol is such that it can be used to distinguish itself from other formats used in the FEF parts coexisting in the same super-frame.

[99] The third task is to signal basic TX parameters that are needed to decode the rest of

the preamble which can help during the initialization process. The fourth purpose of P1 is to enable the receiver to detect and correct frequency and timing synchronization.

[100] Fig. 11 shows a P1 symbol structure of the T2 system.

[101] Referring to Fig. 11, P1 is a 1K OFDM symbol with two 1/2 "guard interval-like" portions added. The total symbol may last 224 μs in 8 MHz system, comprising 112 μs, the duration of the useful part 'A' of the symbol plus two modified 'guard-interval' sections 'C' and 'B' of roughly 59 μs (542 samples) and 53 μs (482 samples).

[102] The length of the P1 is fixed, regardless of the FFT mode and guard-interval configurations of the payload OFDM symbols. This makes it easier to detect: there is only one thing to look for. The P1 signal is designed so that it can be detected despite the presence of a substantial frequency offset. This offset will occur for two reasons: tolerances in the receiver's frequency reference and deliberate offsets introduced at the transmitter as part of the planning process to control mutual interference between networks, especially those carrying different types of transmissions. Detection is possible because the P1 signal contains sections which are frequency-shifted repetitions of the ‘main' part of the P1, which is itself a 1K OFDM symbol. These shifted repetitions can be distinguished despite the presence of a global frequency offset.

[103]

[104] According to an embodiment of the present disclosure, to modify symbol structure from that of the conventional T2 system, frequency shift value f_{SH} used for prefix or postfix can be modified from that used for the conventional P1 symbol. Alternatively, the length of prefix or postfix T_{P1C} or T_{P1B} can be modified from that used for the conventional P1 symbol. Or the length of P1 symbol can be changed from 1K to 512, 256, 128 etc. In this case, the parameters f_{SH}, T_{P1C}, T_{P1B} etc. used in P1 structure of Fig. 11 would need to be modified accordingly.

[105] Fig. 12 shows how the P1 symbol is generated in T2 system.

[106] Out of the 853 useful carriers of a 1K symbol, only 384 are used, leaving others set to zero. The used carriers occupy roughly 6.83 MHz band from the middle of the nominal 7.61 MHz signal bandwidth. Design of the symbol is such that even if a maximum offset of 500 kHz is used, most of the used carriers in P1 symbol are still within the 7.61 MHz nominal bandwidth and the symbol can be recovered with the receiver tuned to nominal centre frequency. The first active carrier corresponds to 44, while the last one is 809.

[107] The active carriers are distributed using the following algorithm: out of the 853 carriers of the 1K symbol, the 766 carriers from the middle are considered. From these 766 carriers, only 384 carry pilots; the others are set to zero. In order to identify which of the 766 carriers are active, three complementary sequences are concatenated: the length of the two sequences at the ends is 128, while the sequence in the middle is 512

chips long. The last two bits of the third concatenated sequence are zero, resulting in 766 carriers where 384 of them are active carriers.

[108] Active carriers are DBPSK modulated with a modulation pattern. The patterns encode two signaling fields S1 and S2. Up to 8 values (can encode 3 bits) and 16 values (can encode 4 bits) can be signalled in each field, respectively. Patterns to encode S1 are based on 8 orthogonal sets of 8 complementary sequences of length 8 (total length of each S1 pattern is 64), while patterns to encode S2 are based of 16 orthogonal sets of 16 complementary sequences of length 16 (total length of each S2 pattern is 256).

[109] To modify symbol generation for P1 symbol of the conventional T2 system, in the P1 symbol generation module 560, distribution of active carriers used for P1 symbol can be modified by changing modules 561,562 and 567 which are marked with bold lines. Specifically, the distribution of active carriers can be modified by changing CSS(Complementary Set of Sequence) used by CDS(Carrier Distribution Sequence) tabe module 561. Alternatively, pattern for encoding the information carried by P1 symbol can be modified. Pattern for encoding the information carried by P1 symbol can be modified by changing CSS used by signalling MSS (Modulation Signalling Sequences) module 562.

[110] The modified P1 symbol as above can be used to enable the receiver detect NGH frames from received signals.

[111] Among the aforementioned schemes for transmitting NGH frames using the conventional T2 frames, defining new frame for NGH frames has advantages over other schemes that it can provide the maximum freedom of design when applying MIMO or MISO. In this scheme, P1 symbol to detect new NGH frames can be made by redesigning or modifying the conventional P1 symbol. But in this scheme, new NGH frames cannot be transmitted using the same RF spectrum as the conventional T2 system and necessitate obtaining new frequency band.

[112] Fig. 13 shows a flow chart for a method of transmitting broadcasting signals according to an embodiment of the present disclosure.

[113] In step S11, baseband frames are generated from input stream by input processing. In step S12, scheduling for dual polarity MIMO is performed and scheduling parameters are generated. In step S13, FEC encoding, bit to cell demultiplexing and constellation mapping are performed upon the signals of each PLP. In step S14, cells are demultiplexed to dual polarity paths and constellation rotation and remapping is performed.

[114] Steps S13 and S14 can be performed by BICM module 300 in Fig. 1 as described above.

[115] In step S15, cells are mapped into OFDM symbol array for dual polarity paths. In step S16, OFDM symbols for dual polarity paths are generated and transmitted in step

S17.

[116]

[117] Fig. 14 shows high level block diagram of a receiver 2000 for NGH system according to an embodiment of the present disclosure.

[118] Firstly, the signals received by a plurality of antennas may be demodulated by OFDM demodulation module 600. Before demodulation, P1 symbol may be detected to detect NGH frames and time and frequency synchronization can be peformed as will be described below. And then, PLPs for services as user selects may be outputted by frame demapper module 700. BICM decoder 800 may correct errors which occurred over transmission channels. Output processor 900 may perform necessary procedures required for generation output TS or GS. In this case, the input antenna can receive dual polarity signals and the output TS or GS stream may be one or more streams.

[119] Fig. 15 shows detailed block diagram for OFDM demodulation module 600. As shown in Fig. 15, the received signals of dual polarity paths are processed independently by OFDM demodulation modules 600a and 600b. The signal for horizontal path is processed by the first OFDM demodulation module 600a and the signal for vertical path is processed by the second OFDM demodulation module 600b.

[120] In each of OFDM demodulation modules 600a and 600b, the received signals may be converted to digital signals by ADC (Analog to Digital Converter) 601. And then, NGH signal may be detected by P1 symbol detector module for the digital signals. Time synchronization including guard interval detection and carrier frequency synchronization may be performed for the detected region of the signal by time and frequency synchronization module 603. After synchronization, guard interval may be removed from the received signals by GI remover module 604 and then the received signals may be converted into signals of frequency domain by FFT module 605. The channel estimation module 606 may estimate the transmission channels from the transmission antennas to receiving antennas by using the inserted pilot signals in frequency domain. The Equalization and MISO decoding module 607 may compensate for distortion of transmission channels and perform MISO decoding using the estimated transmission channels.

[121] Fig. 16 shows a detailed block diagram for frame demapper module 700 according to an embodiment of the present disclosure.

[122] Frequency deinterleaver 702 may perform frequency deinterleaving upon the received dual polarity signals for horizontal path and vertical path. Cell demapper 703 may extract common PLPs, data PLPs and L1 cells from the received transmission frames, and if the received data was split into a plurality of sub-slices the Cell demapper 703 may merge those sub-slices into one PLP.

[123] Fig. 17 shows a detailed block diagram for BICM decoder 800 according to an em-

bodiment of the present disclosure. BICM decoder 800 of Fig. 17 can be divided into two parts, part (a) for processing PLPs and part (b) for processing L1 signalling.

[124] For part (a) for processing PLPs, constellation demapper 801 may calculate 2D-LLR(2 Dimensional-Log Likelihood Ratio) for the inputted symbols and divide the signals into horizontal path signal and vertical path signal. Time deinterleaver 802 may perform deinterleaving upon the inputted symbols in time domain and cell deinterleaver 803 may perform deinterleaving upon the inputted symbols within an LDPC block to restore the positions of the inputted symbols to their original positions. Polarity to cell multiplexer 804 may merge the cells transmitted by horizontal path and vertical path into one cell streams, and cell to bit multiplexer 805 may restore the original bit streams from the cell streams. Bit deinterleaver 806 may perform deinterleaving upon input bit stream into original order and FEC decoder 807 may perform de-shortening and de-puncturing, and then perform FEC decoding.

[125] For part (b) for processing L1 signalling, constellation demapper 811 and 812, polarity to cell multiplexers 812 and 822, cell to bit multiplexer 813, bit deinterleaver 814 for L1-pre signalling or L1-post signalling may perform the same functions as for data PLPs as described above. Shortened/punctured FEC decoder 815 and 825 may perform de-shortening and de-puncturing, and then FEC decoding for L1 signalling. L1 signaling decoder 816 may restore L1 signalling information represented as L1-pre signalling or L1-post signalling to its original form to output L1-dynamic and L1 configuration information.

[126] As described before, at the transmitter, cell to polarity demultiplexing and constellation rotation and remapping for L1-pre signaling and L1-post signaling can be omitted. In that case, polarity to cell multiplexers polarity to cell multiplexers 812 and 822 may be omitted.

[127]

[128] Fig. 18 shows a detailed block diagram for output processor 900 for single PLP inputs according to an embodiment of the present disclosure.

[129] The inputted bit stream may be descrambled by BB descrambler 901 and then padding bits of the inputted bit stream may be removed by padding removal module 902. CRC-8 decoder 903 may perform CRC decoding for the inputted bit stream and BB frame processor may decode information contained in BB frame header, which is used for restoring TS or GS streams to be outputted.

[130] Fig. 19 shows a detailed block diagram for output processor 910 for multiple PLP inputs according to an embodiment of the present disclosure. Decoding of multiple PLP inputs is required when the receiver decodes data PLP related to common PLP, or when the receiver decodes a plurality of services including scalable video service at the same time. Functions of BB scrambler module 911,921, padding removal module

912,922, CRC-8 decoder 913,923 and BB frame processor 914,924 are the same as counterparts for single PLP input in Fig. 18. De-jitter buffer 915,925 may compensate for delay which was inserted for synchronization between multiple PLPs at the transmitter according to TTO(Time to output parameter). Null packet insertion module 916,926 may restore the removed null packets with reference to DNP(Deleted Null Packet) information. At this time, TS clock regeneration module 917 may restore specific time synchronization of output packet with reference to ISCR(Input Stream Time Reference). TS recombining module 918 may combine the data PLPs related to common PLPs which are restored as above to TS or GS streams. TTO, DNP and ISCR are contained in BB frame header. Finally, in-band signalling decoder module 927 may restore in-band signalling information transmitted by data PLP.

[131] Fig. 20 shows a flow chart for a method of receiving broadcasting signals according to an embodiment of the present disclosure.

[132] In step S21, NGH signal is detected from the received signals by detecting P1 symbol and time and frequency synchronization is performed. The received signals include signals which can be separately detected of dual polarity paths. In step S22, the received signals are demodulated by OFDM demodulation method. In step S23, the channel estimation may be performed upon the demodulated signals. In step 24, equalization and MISO or MIMO decoding may be performed. Steps S21 to 24 may be performed OFDM demodulation module 600 of Fig. 14.

[133] In step 25, the demodulated signals are demapped to obtain PLP and L1 cells.

[134] In step S26, constellation demapping to extract original signals is performed for each of the dual polarity paths. In step S27, cells of the dual polarity paths are merged into one cell stream. In step S28, cells multiplexed into bit streams and FEC decoding is performed upon the bit streams. In step S29, output processing upon the decoded bit streams and bit streams are outputted. Steps S26 to S28 can be performed by BICM decoder 800 of Fig. 14.

[135]

Claims

[Claim 1] A method for transmitting digital broadcasting signal to a receiver, comprising:
demultiplexing input data bits into cells;
mapping the cells into a constellation;
demultiplexing the cells into a pair of cells of dual polarity paths to generate a first constellation and a second constellation;
rotating the cells in complex planes of the first constellations and the second constellation of the dual polarity paths by a predetermined angle;
remapping the rotated cells of the dual polarity paths;
building a signal frame based on the remapped cells;
modulating the signal frame by an Orthogonal Frequency Division Multiplexing (OFDM) method; and
transmitting the modulated signal frame.

[Claim 2] The method of claim 1, wherein the remapping is performed by crossing I phase and Q phase of the first constellation and I phase and Q phase of the second constellation cells each other.

[Claim 3] The method of claim 1, wherein the remapping comprises cyclically delaying imaginary parts of the rotated cells by one cell.

[Claim 4] A transmitter for transmitting digital broadcasting signal to a receiver, comprising:
a demultiplexer configured to demultiplex input data bits into cells;
a mapper configured to map the cells into a constellation;
a demultiplexer configured to demultiplex the cells into a pair of cells by dual polarity paths to generate a first constellation and a second constellation;
a rotation and remapping unit configured to rotate the cells in complex planes of the first constellations and the second constellation of the dual polarity paths by a predetermined angle, and to remap the rotated cells of the dual polarity paths;
a frame builder configured to build a signal frame based on the remapped cells;
a modulator configured to modulate the signal frame by an Orthogonal Frequency Division Multiplexing (OFDM) method; and
a transmission unit configured to transmit the modulated signal frame.

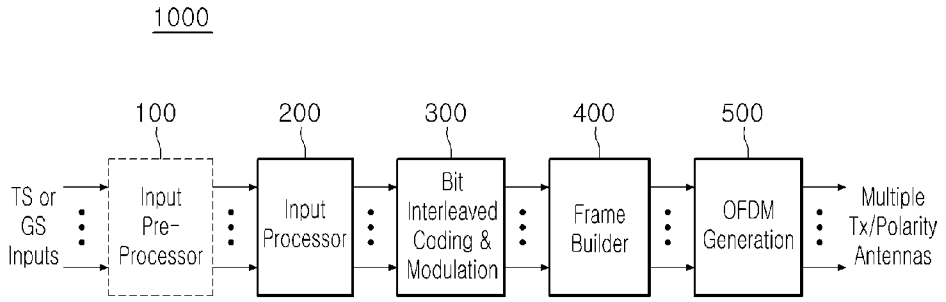
[Claim 5] The transmitter of claim 4, wherein the rotation and remapping unit remaps the rotated cells of the dual polarity paths by crossing I phase and Q phase of the first constellation and I phase and Q phase of the second constellation cells each other.

[Claim 6] The transmitter of claim 4, wherein the rotation and remapping unit performs the remapping by delaying imaginary parts of the rotated cells by one cell.

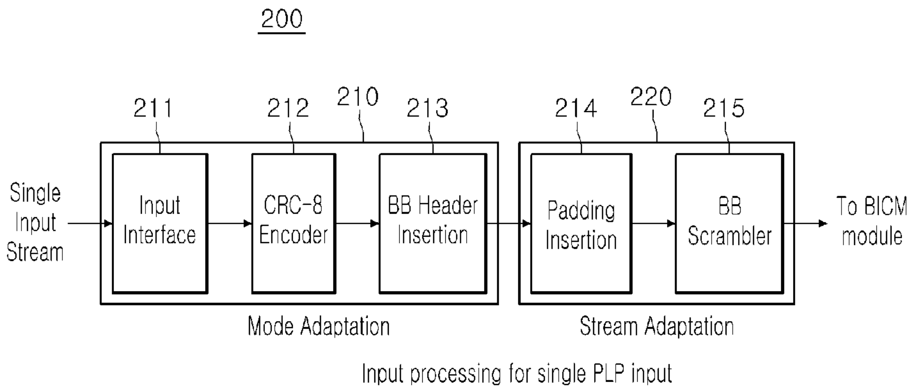
[Claim 7] A method of receiving digital broadcasting signal, comprising;
receiving signals of dual polarity paths;
detecting preamble symbol to indicate type of the received signals;
performing time and frequency synchronization upon the received signals;
performing channel estimation upon the received signals;
demodulating received signals for each of the dual polarity paths by use of an Orthogonal Frequency Division Multiplexing(OFDM) method;
extracting a signal frame comprising cells having dual polarity paths from the demodulated signal;
multiplexing the cells of the dual polarity paths into one cell stream; and
multiplexing the cell stream into data bits.

[Claim 8] A receiver for receiving digital broadcasting signal, the receiver comprising;
a receiving unit configured to receive signals of dual polarity paths;
a preamble detection module configured to detect a preamble symbol to indicate type of the received signals;
a time and frequency synchronization module configured to perform time and frequency synchronization upon the received signals;
a channel estimation module configured to perform channel estimation upon the received signals;
a demodulator configured to demodulate received signals for each of the dual polarity paths by use of an Orthogonal Frequency Division Multiplexing(OFDM) method;
an extracting unit configured to extract a signal frame comprising cells having dual polarity paths from the demodulated signal;
a multiplexer configured to multiplex the cells of the dual polarity paths into one cell stream; and
a multiplexer configured to multiplex the cell stream into data bits.

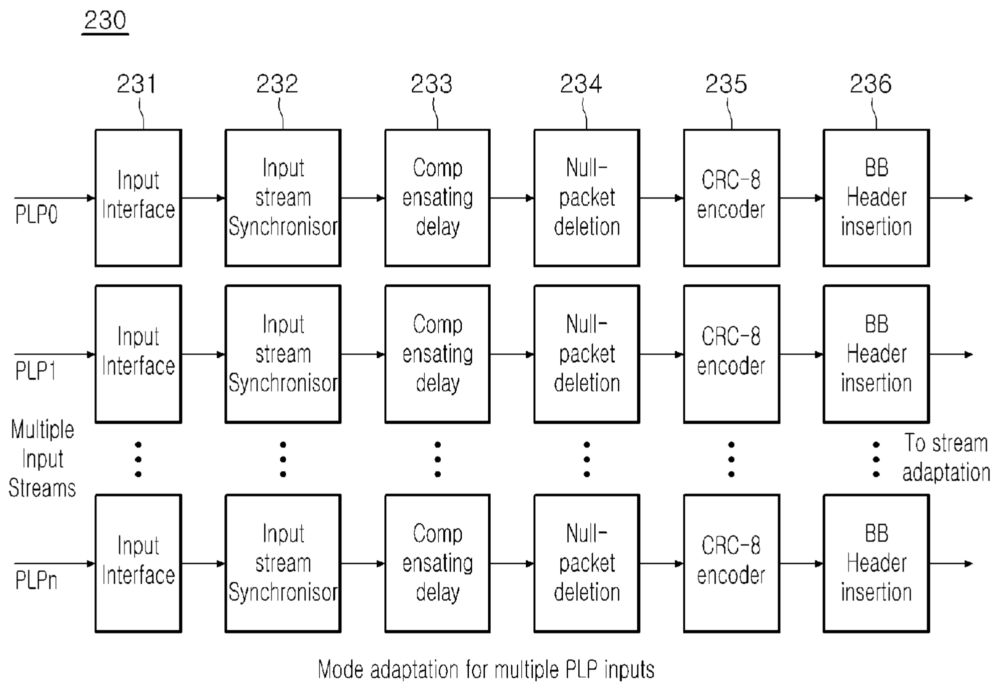
[Fig. 1]



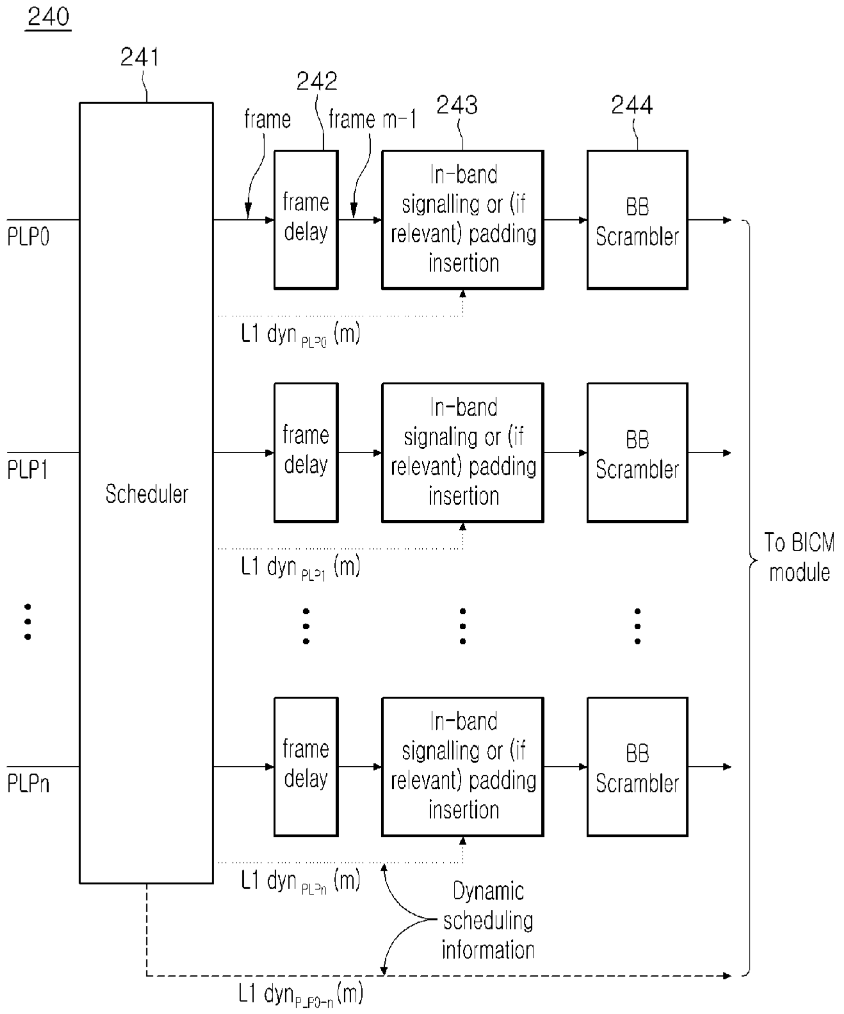
[Fig. 2]



[Fig. 3]

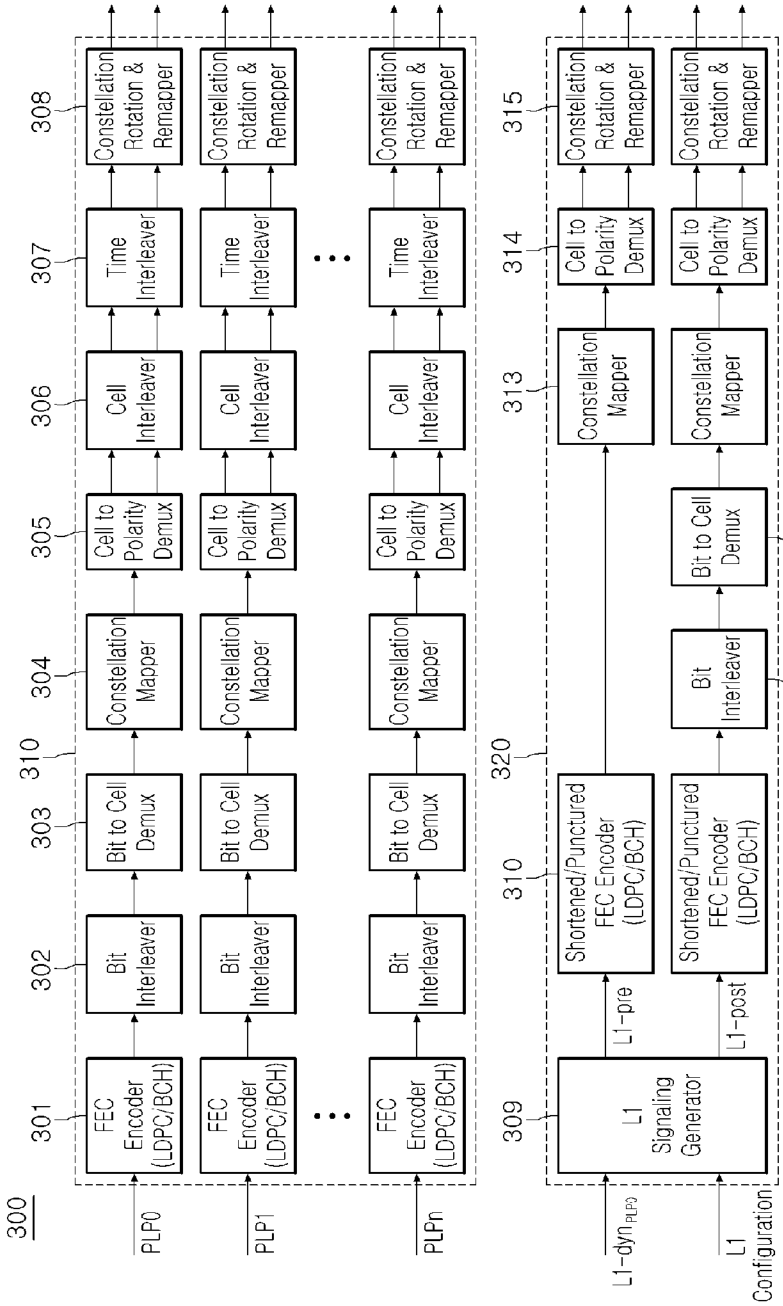


[Fig. 4]

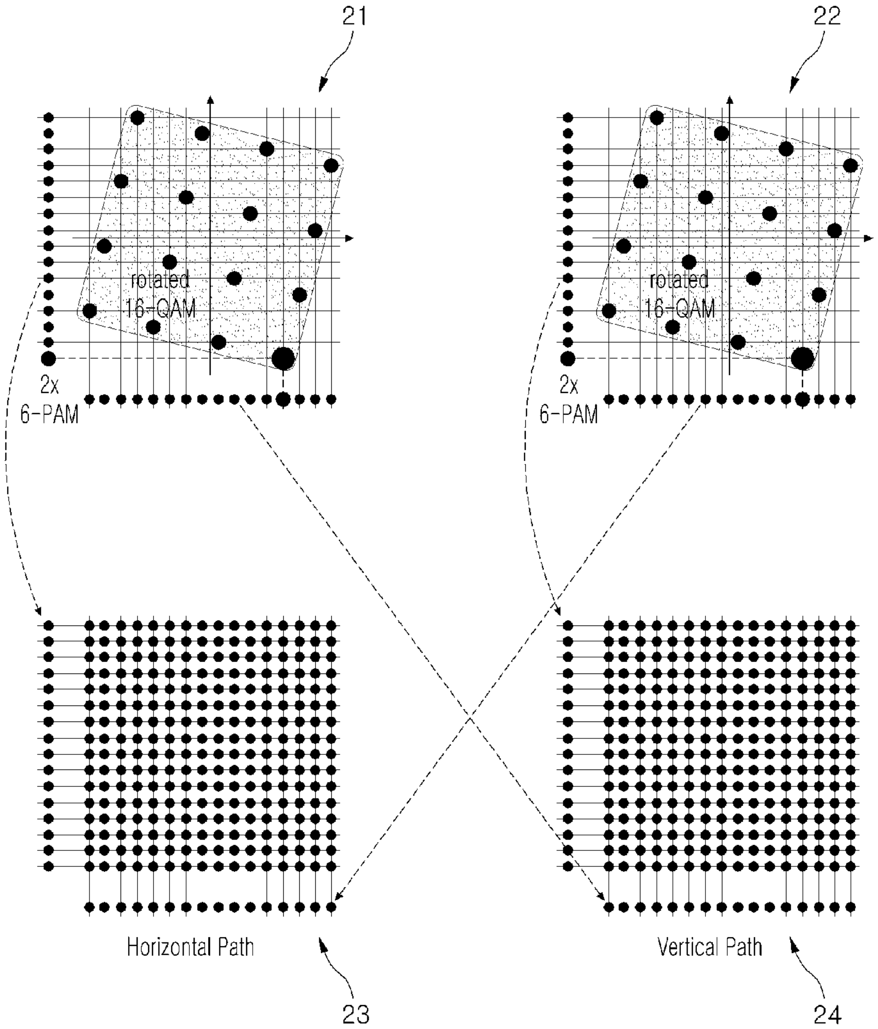


Stream adaptation for multiple PLP inputs

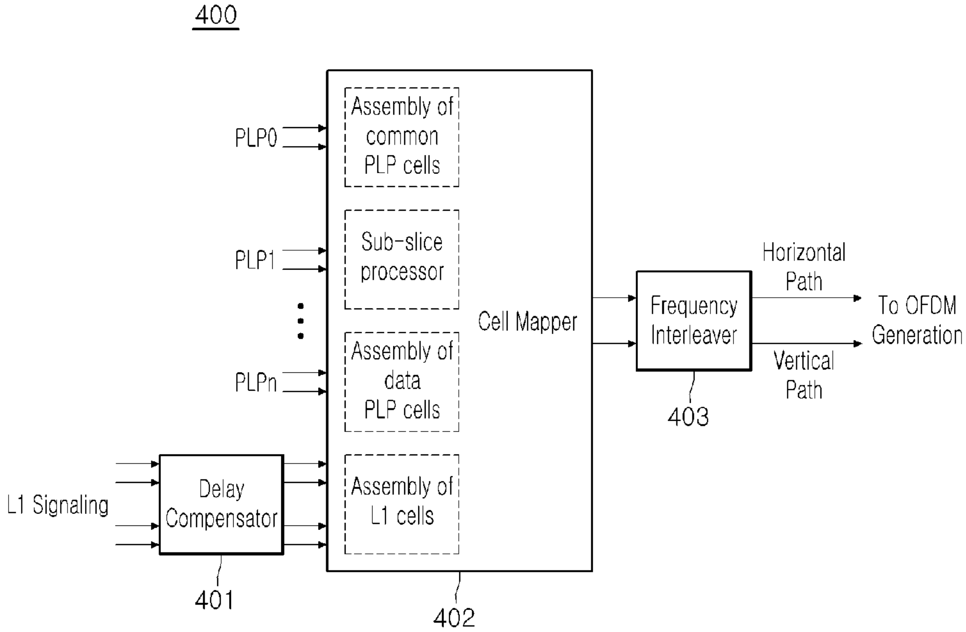
[Fig. 5]


300
PLP0
PLP1
PLPn
310
FEC Encoder (LDPC/BCH)
Bit Interleaver
Bit to Cell Demux
Constellation Mapper
Cell to Polarity Demux
Cell Interleaver
Time Interleaver
Constellation Rotation & Remapper
301
302
303
304
305
306
307
308
L1-dyn PLP0
L1 Configuration
L1 Signaling Generator
L1-pre
L1-post
Shortened/Punctured FEC Encoder (LDPC/BCH)
309
310
311
312
313
314
315
320

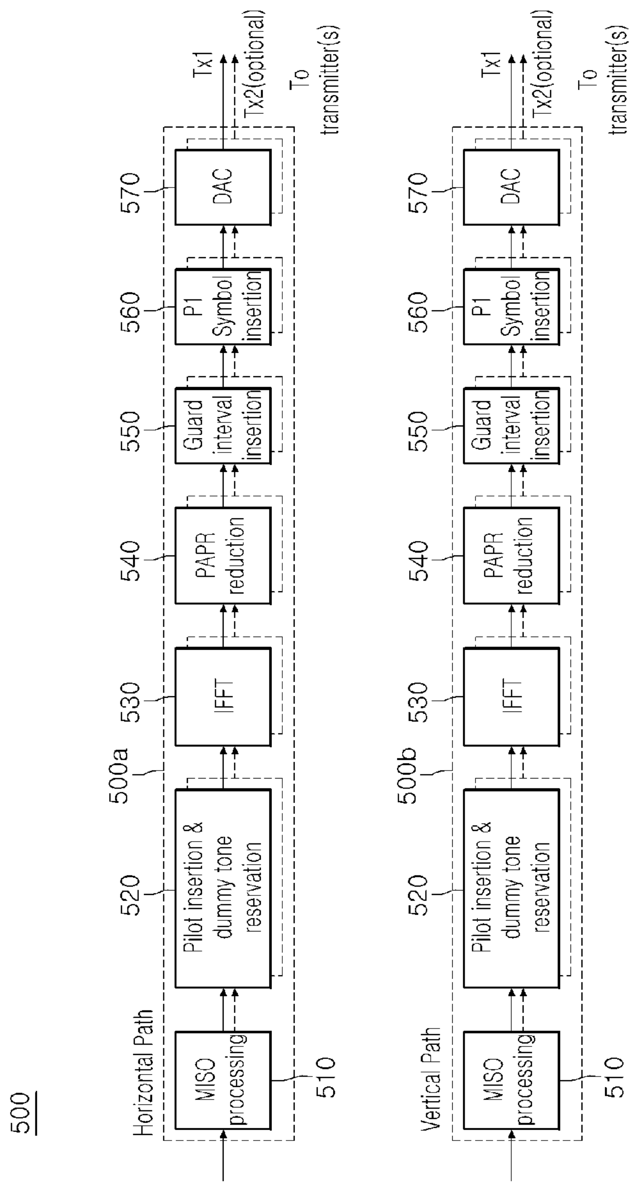
[Fig. 6]


21
22
rotated
16-QAM
2x
6-PAM
rotated
16-QAM
2x
6-PAM
Horizontal Path
Vertical Path
23
24

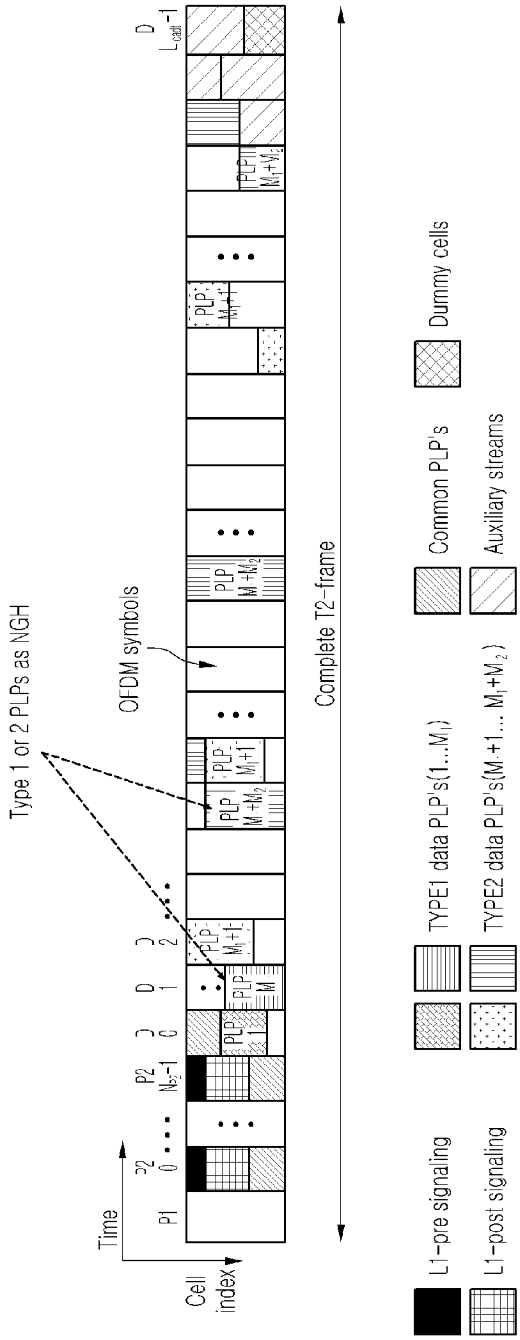
[Fig. 7]


400
PLP0
PLP1
PLPn
L1 Signaling
Assembly of common PLP cells
Sub-slice processor
Assembly of data PLP cells
Assembly of L1 cells
Cell Mapper
Delay Compensator
Frequency Interleaver
Horizontal Path
Vertical Path
To OFDM Generation
401
402
403

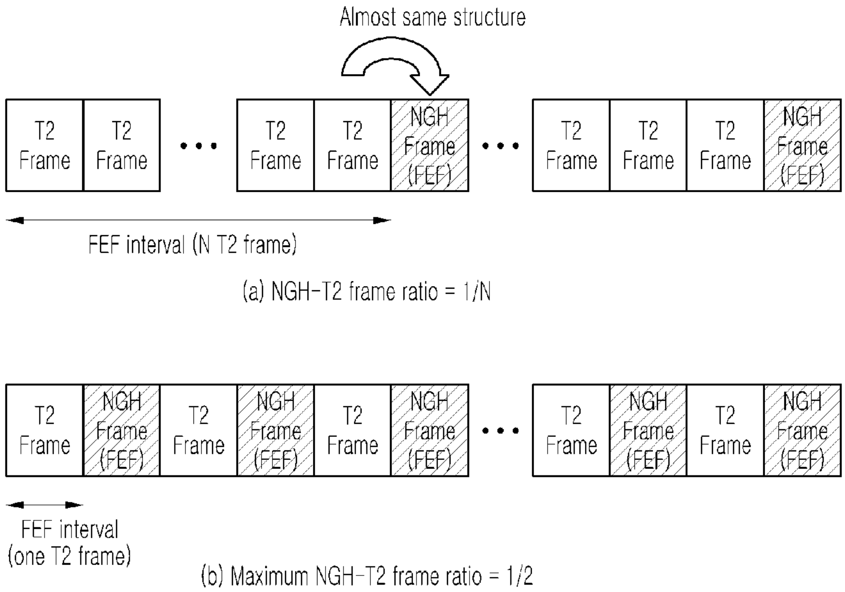
[Fig. 8]


500
Horizontal Path
500a
MISO processing
510
Pilot insertion & dummy tone reservation
520
IFFT
530
PAPR reduction
540
Guard interval insertion
550
P1 Symbol insertion
560
DAC
570
Tx1
Tx2(optional)
To transmitter(s)
Vertical Path
500b
MISO processing
510
Pilot insertion & dummy tone reservation
520
IFFT
530
PAPR reduction
540
Guard interval insertion
550
P1 Symbol insertion
560
DAC
570
Tx1
Tx2(optional)
To transmitter(s)

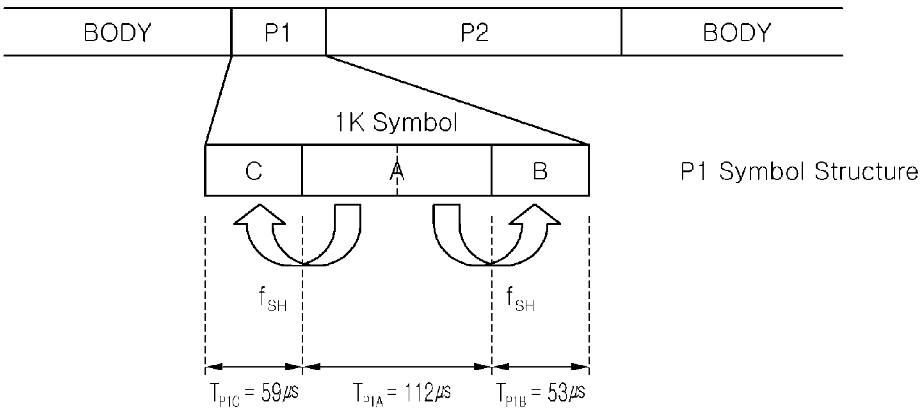
[Fig. 9]


Type 1 or 2 PLPs as NGH
OFDM symbols
Complete T2-frame
Time
Cell index
P1
L1-pre signaling
L1-post signaling
TYPE1 data PLP's(1...M1)
TYPE2 data PLP's(M1+1... M1+M2)
Common PLP's
Auxiliary streams
Dummy cells

[Fig. 10]

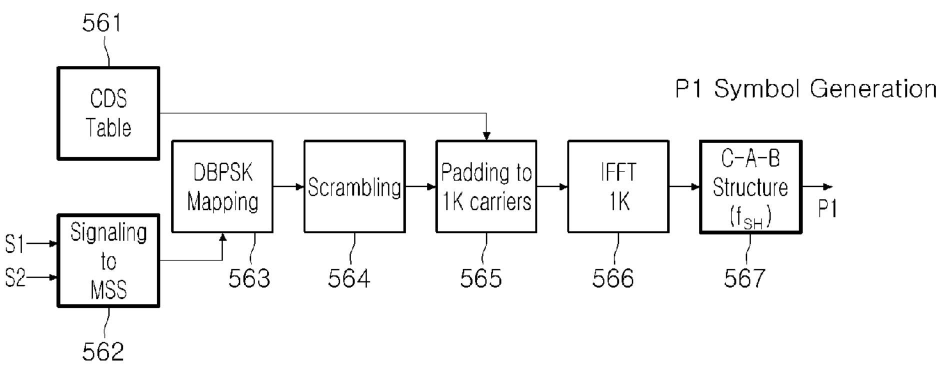


[Fig. 11]

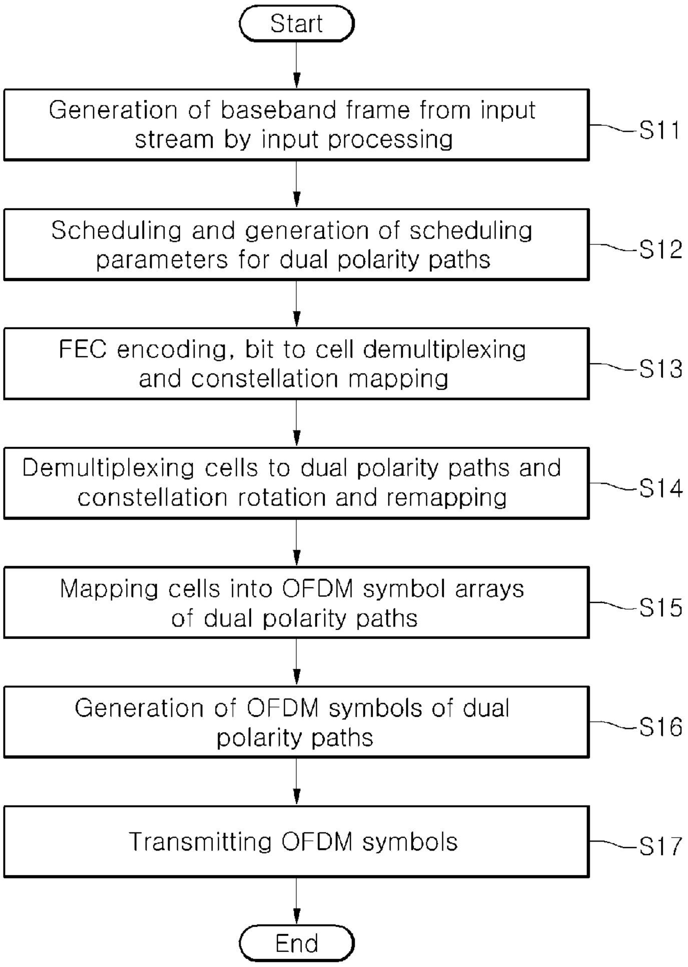


[Fig. 12]

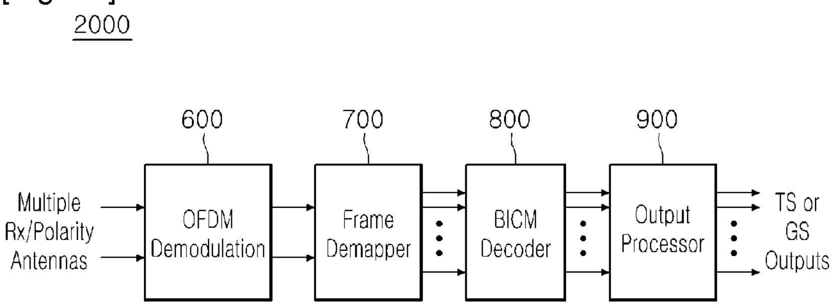
560



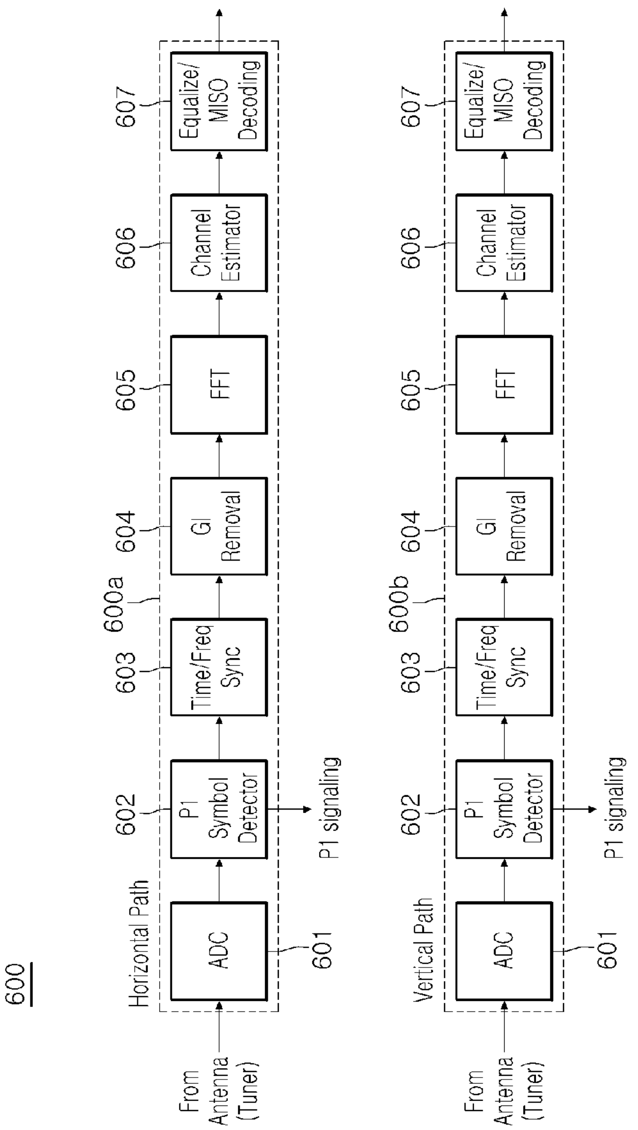
[Fig. 13]


Start
Generation of baseband frame from input stream by input processing
S11
Scheduling and generation of scheduling parameters for dual polarity paths
S12
FEC encoding, bit to cell demultiplexing and constellation mapping
S13
Demultiplexing cells to dual polarity paths and constellation rotation and remapping
S14
Mapping cells into OFDM symbol arrays of dual polarity paths
S15
Generation of OFDM symbols of dual polarity paths
S16
Transmitting OFDM symbols
S17
End

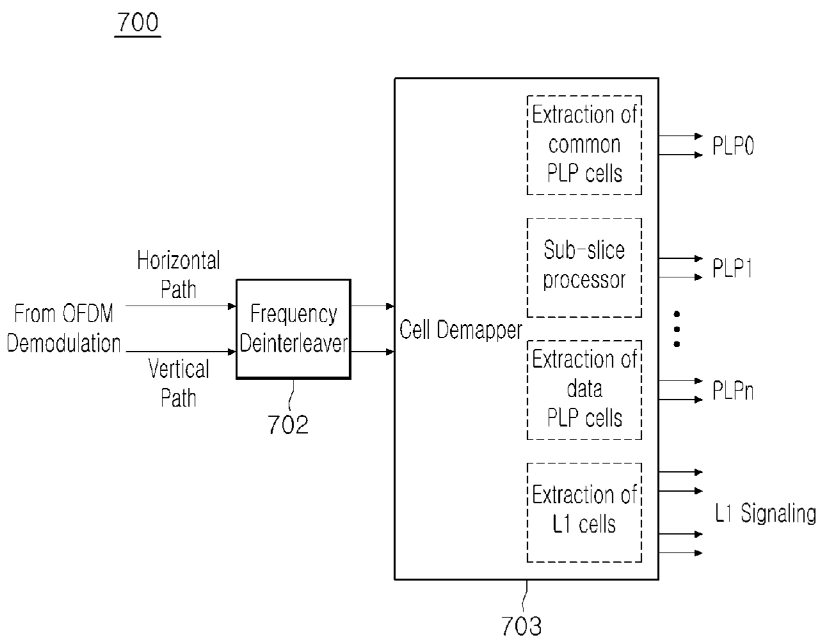
[Fig. 14]


2000
600
700
800
900
Multiple Rx/Polarity Antennas
OFDM Demodulation
Frame Demapper
BICM Decoder
Output Processor
TS or GS Outputs

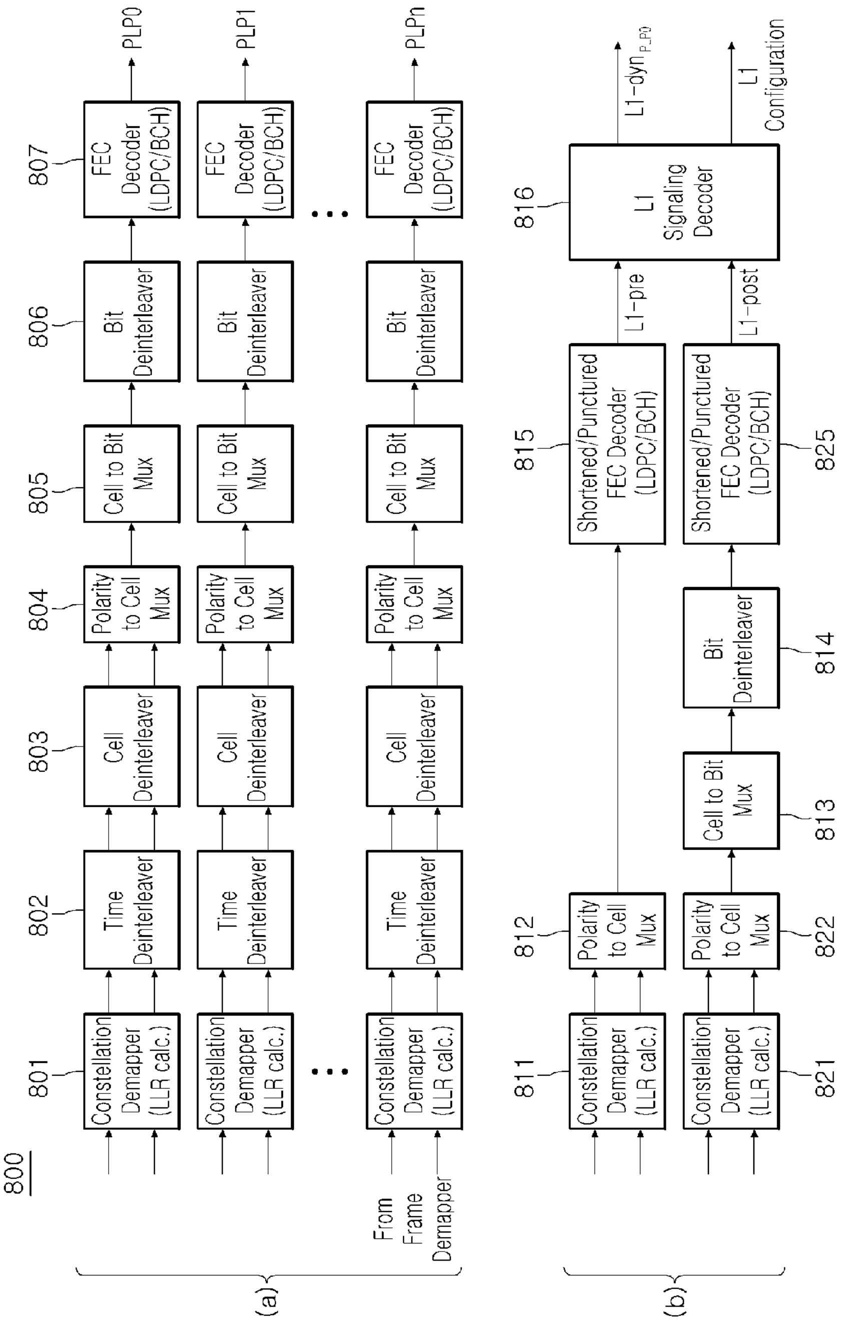
[Fig. 15]


600
Horizontal Path
600a
From Antenna (Tuner)
ADC
601
P1 Symbol Detector
602
P1 signaling
Time/Freq Sync
603
GI Removal
604
FFT
605
Channel Estimator
606
Equalize/ MISO Decoding
607
Vertical Path
600b
From Antenna (Tuner)
ADC
601
P1 Symbol Detector
602
P1 signaling
Time/Freq Sync
603
GI Removal
604
FFT
605
Channel Estimator
606
Equalize/ MISO Decoding
607

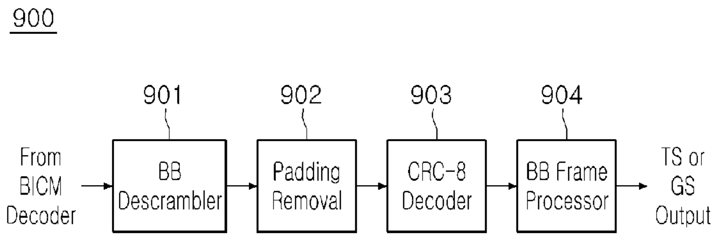
[Fig. 16]


700
From OFDM Demodulation
Horizontal Path
Vertical Path
Frequency Deinterleaver
702
Cell Demapper
703
Extraction of common PLP cells
PLP0
Sub-slice processor
PLP1
Extraction of data PLP cells
PLPn
Extraction of L1 cells
L1 Signaling

[Fig. 17]

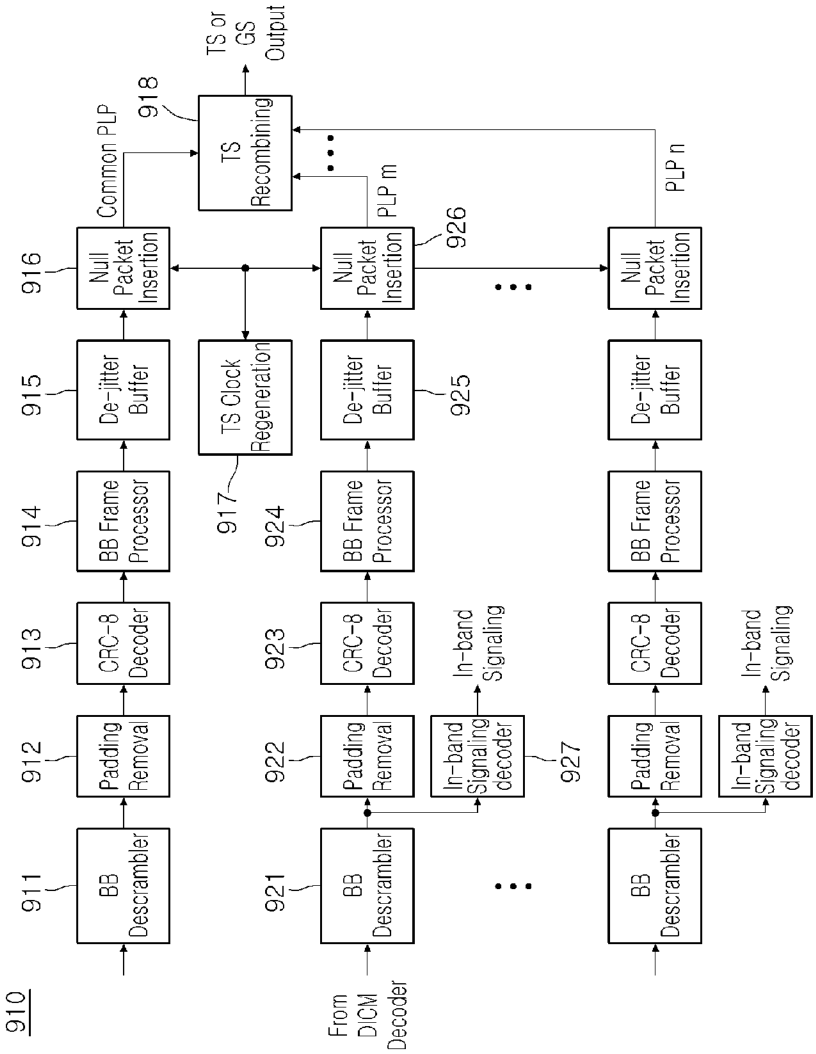


[Fig. 18]



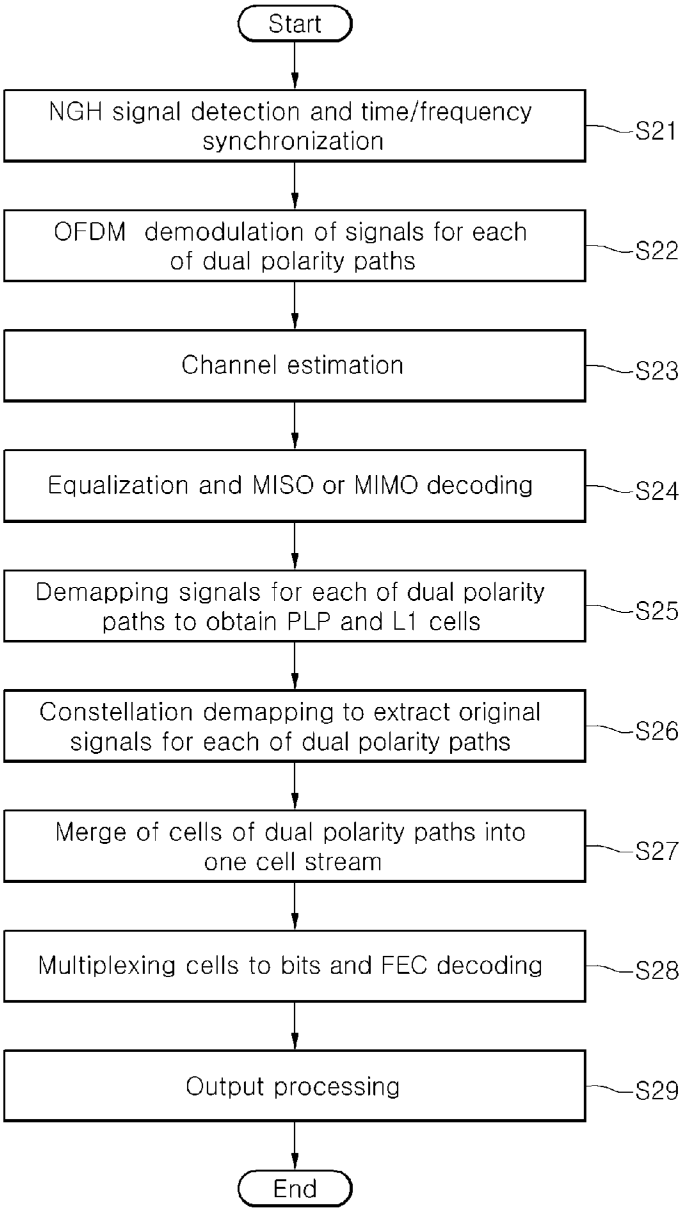
Output processor for single PLP input

[Fig. 19]



Output processor for multiple PLP inputs

[Fig. 20]


Start
NGH signal detection and time/frequency synchronization
S21
OFDM demodulation of signals for each of dual polarity paths
S22
Channel estimation
S23
Equalization and MISO or MIMO decoding
S24
Demapping signals for each of dual polarity paths to obtain PLP and L1 cells
S25
Constellation demapping to extract original signals for each of dual polarity paths
S26
Merge of cells of dual polarity paths into one cell stream
S27
Multiplexing cells to bits and FEC decoding
S28
Output processing
S29
End