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(54) **APPARATUS AND METHOD FOR TRANSMITTING AND RECEIVING A SIGNAL**

VORRICHTUNG UND VERFAHREN ZUM SENDEN UND EMPFANGEN EINES SIGNALS

APPAREIL ET PROCÉDÉ POUR LA TRANSMISSION ET LA RÉCEPTION D'UN SIGNAL

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terrestrial television broadcasting system  
(DVB-T2)", DIGITAL VIDEO BROADCASTING,  
[Online] 1 June 2008 (2008-06-01), XP002546005,  
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URL: <http://www.dvb.org/technology/dvbt2/a122.tm3980r5.DVB-T2.pdf> [retrieved on  
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**Description****BACKGROUND OF THE INVENTION****Field of the Invention**

[0001] The present invention relates to a method for transmitting and receiving a signal and an apparatus for transmitting and receiving a signal, and more particularly, to a method for transmitting and receiving a signal and an apparatus for transmitting and receiving a signal, which are capable of improving data transmission efficiency.

**Description of the Related Art**

[0002] As a digital broadcasting technology has been developed, users have received a high definition (HD) moving image. With continuous development of a compression algorithm and high performance of hardware, a better environment will be provided to the users in the future. A digital television (DTV) system can receive a digital broadcasting signal and provide a variety of supplementary services to users as well as a video signal and an audio signal.

[0003] Digital Video Broadcasting (DVB)-C2 is the third specification to join DVB's family of second generation transmission systems. Developed in 1994, today DVB-C is deployed in more than 50 million cable tuners worldwide. In line with the other DVB second generation systems, DVB-C2 uses a combination of Low-density parity-check (LDPC) and BCH codes. This powerful Forward Error correction (FEC) provides about 5dB improvement of carrier-to-noise ratio over DVB-C. Appropriate bit-interleaving schemes optimize the overall robustness of the FEC system. Extended by a header, these frames are called Physical Layer Pipes (PLP). One or more of these PLPs are multiplexed into a data slice. Two dimensional interleaving (in the time and frequency domains) is applied to each slice enabling the receiver to eliminate the impact of burst impairments and frequency selective interference such as single frequency ingress.

[0004] With the development of these digital broadcasting technologies, a requirement for a service such as a video signal and an audio signal increased and the size of data desired by users or the number of broadcasting channels gradually increased. DVB project "Frame structure channel and modulation for a second generation terrestrial television broadcasting system (DVB-T2)", Digital Video Broadcasting [online] June 2008 (2008-06-01) discloses frame structure channel coding techniques for broadcast systems.

**SUMMARY OF THE INVENTION**

[0005] Any occurrence of the term "embodiment" in the description has to be considered as an "aspect of the invention", the invention being defined in the appended independent claims. Accordingly, the present invention is directed to a method for transmitting and receiving a signal and an apparatus for transmitting and receiving a signal that substantially obviate one or more problems due to limitations and disadvantages of the related art.

[0006] An object of the present invention is to provide a method of transmitting broadcasting signal to a receiver according to claim 1.

[0007] Another aspect of the present invention provides a method of receiving broadcasting signal according to claim 9.

[0008] Yet another aspect of the present invention provides a transmitter for transmitting broadcasting signal to a receiver according to claim 5.

[0009] Yet another aspect of the present invention provides a receiver for receiving a broadcasting signal according to claim 13.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0010] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention and together with the description serve to explain the principle of the invention. In the drawings:

Fig. 1 is an example of 64- Quadrature amplitude modulation (QAM) used in European DVB-T.

Fig. 2 is a method of Binary Reflected Gray Code (BRGC).

Fig. 3 is an output close to Gaussian by modifying 64-QAM used in DVB-T.

Fig. 4 is Hamming distance between Reflected pair in BRGC.

Fig. 5 is characteristics in QAM where Reflected pair exists for each I axis and Q axis.

Fig. 6 is a method of modifying QAM using Reflected pair of BRGC.

Fig. 7 is an example of modified 64/256/1024/4096-QAM.

Figs. 8-9 are an example of modified 64-QAM using Reflected Pair of BRGC.  
 Figs. 10-11 are an example of modified 256-QAM using Reflected Pair of BRGC.  
 Figs. 12-13 are an example of modified 1024-QAM using Reflected Pair of BRGC(0~511).  
 Figs. 14-15 are an example of modified 1024-QAM using Reflected Pair of BRGC(512~1023).  
 5 Figs. 16-17 are an example of modified 4096-QAM using Reflected Pair of BRGC(0~511).  
 Figs. 18-19 are an example of modified 4096-QAM using Reflected Pair of BRGC(512~1023).  
 Figs. 20-21 are an example of modified 4096-QAM using Reflected Pair of BRGC(1024~1535).  
 Figs. 22-23 are an example of modified 4096-QAM using Reflected Pair of BRGC(1536~2047).  
 Figs. 24-25 are an example of modified 4096-QAM using Reflected Pair of BRGC(2048~2559).  
 10 Figs. 26-27 are an example of modified 4096-QAM using Reflected Pair of BRGC(2560~3071).  
 Figs. 28-29 are an example of modified 4096-QAM using Reflected Pair of BRGC(3072~3583).  
 Figs. 30-31 are an example of modified 4096-QAM using Reflected Pair of BRGC(3584~4095).  
 Fig. 32 is an example of Bit mapping of Modified-QAM where 256-QAM is modified using BRGC.  
 Fig. 33 is an example of transformation of MQAM into Non-uniform constellation.  
 15 Fig. 34 is an example of digital transmission system.  
 Fig. 35 is an example of an input processor.  
 Fig. 36 is an information that can be included in Base band (BB).  
 Fig. 37 is an example of BICM.  
 Fig. 38 is an example of shortened/punctured encoder.  
 20 Fig. 39 is an example of applying various constellations.  
 Fig. 40 is another example of cases where compatibility between conventional systems is considered.  
 Fig. 41 is a frame structure which comprises preamble for L1 signaling and data symbol for PLP data.  
 Fig. 42 is an example of frame builder.  
 Fig. 43 is an example of pilot insert (404) shown in Fig. 4.  
 25 Fig. 44 is a structure of SP.  
 Fig. 45 is a new SP structure or Pilot Pattern (PP) 5'.  
 Fig. 46 is a suggested PP5' structure.  
 Fig. 47 is a relationship between data symbol and preamble.  
 Fig. 48 is another relationship between data symbol and preamble.  
 30 Fig. 49 is an example of cable channel delay profile.  
 Fig. 50 is scattered pilot structure that uses  $z=56$  and  $z=112$ .  
 Fig. 51 is an example of modulator based on OFDM.  
 Fig. 52 is an example of preamble structure.  
 Fig. 53 is an example of Preamble decoding.  
 35 Fig. 54 is a process for designing more optimized preamble.  
 Fig. 55 is another example of preamble structure  
 Fig. 56 is another example of Preamble decoding.  
 Fig. 57 is an example of Preamble structure.  
 Fig. 58 is an example of L1 decoding.  
 40 Fig. 59 is an example of analog processor.  
 Fig. 60 is an example of digital receiver system.  
 Fig. 61 is an example of analog processor used at receiver.  
 Fig. 62 is an example of demodulator.  
 Fig. 63 is an example of frame parser.  
 45 Fig. 64 is an example of BICM demodulator.  
 Fig. 65 is an example of LDPC decoding using shortening / puncturing.  
 Fig. 66 is an example of output processor.  
 Fig. 67 is an example of L1 block repetition rate of 8 MHz.  
 Fig. 68 is an example of L1 block repetition rate of 8 MHz.  
 50 Fig. 69 is a new L1 block repetition rate of 7.61 MHz.  
 Fig. 70 is an example of L1 signaling which is transmitted in frame header.  
 Fig. 71 is preamble and L1 Structure simulation result.  
 Fig. 72 is an example of symbol interleaver.  
 Fig. 73 is an example of an L1 block transmission.  
 55 Fig. 74 is another example of L1 signaling transmitted within a frame header.  
 Fig. 75 is an example of frequency or time interleaving/deinterleaving.

**DESCRIPTION OF THE PREFERRED EMBODIMENTS**

**[0011]** Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

**[0012]** In the following description, the term "service" is indicative of either broadcast contents which can be transmitted/received by the signal transmission/reception apparatus.

**[0013]** Quadrature amplitude modulation (QAM) using Binary Reflected Gray Code (BRGC) is used as modulation in a broadcasting transmission environment where conventional Bit Interleaved Coded Modulation (BICM) is used. Fig. 1 shows an example of 64-QAM used in European DVB-T.

**[0014]** BRGC can be made using the method shown in Fig. 2. An n bit BRGC can be made by adding a reverse code of (n-1) bit BRGC (i.e., reflected code) to a back of (n-1) bit, by adding 0s to a front of original (n-1) bit BRGC, and by adding 1s to a front of reflected code. The BRGC code made by this method has a Hamming distance between adjacent codes of one (1). In addition, when BRGC is applied to QAM, the Hamming distance between a point and the four points which are most closely adjacent to the point, is one (1) and the Hamming distance between the point and another four points which are second most closely adjacent to the point, is two (2). Such characteristics of Hamming distances between a specific constellation point and other adjacent points can be dubbed as Gray mapping rule in QAM.

**[0015]** To make a system robust against Additive White Gaussian Noise (AWGN), distribution of signals transmitted from a transmitter can be made close to Gaussian distribution. To be able to do that, locations of points in constellation can be modified. Fig. 3 shows an output close to Gaussian by modifying 64-QAM used in DVB-T. Such constellation can be dubbed as Non-uniform QAM (NU-QAM).

**[0016]** To make a constellation of Non-uniform QAM, Gaussian Cumulative Distribution Function (CDF) can be used. In case of 64, 256, or 1024 QAM, i.e.,  $2^N$  AMs, QAM can be divided into two independent N-PAM. By dividing Gaussian CDF into N sections of identical probability and by allowing a signal point in each section to represent the section, a constellation having Gaussian distribution can be made. In other words, coordinate  $x_j$  of newly defined non-uniform N-PAM can be defined as follows:

$$\int_{-\infty}^{x_j} \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} dx = p_j, \quad p_j \in \left\{ \frac{1}{2N}, \frac{3}{2N}, \dots, \frac{2N-1}{2N} \right\} \quad (\text{Eq. 1})$$

**[0017]** Fig. 3 is an example of transforming 64QAM of DVB-T into NU-64QAM using the above methods. Fig. 3 represents a result of modifying coordinates of each I axis and Q axis using the above methods and mapping the previous constellation points to newly defined coordinates. In case of 32, 128, or 512 QAM, i.e., cross QAM, which is not  $2^N$  QAM, by modifying  $p_j$  appropriately, a new coordinate can be found.

**[0018]** One embodiment of the present invention can modify QAM using BRGC by using characteristics of BRGC. As shown in Fig. 4, the Hamming distance between Reflected pair in BRGC is one because it differs only in one bit which is added to the front of each code. Fig. 5 shows the characteristics in QAM where Reflected pair exists for each I axis and Q axis. In this figure, Reflected pair exists on each side of the dotted black line.

**[0019]** By using Reflected pairs existing in QAM, an average power of a QAM constellation can be lowered while keeping Gray mapping rule in QAM. In other words, in a constellation where an average power is normalized as 1, the minimum Euclidean distance in the constellation can be increased. When this modified QAM is applied to broadcasting or communication systems, it is possible to implement either a more noise-robust system using the same energy as a conventional system or a system with the same performance as a conventional system but which uses less energy.

**[0020]** Fig. 6 shows a method of modifying QAM using Reflected pair of BRGC. Fig. 6a shows a constellation and Fig. 6b shows a flowchart for modifying QAM using Reflected pair of BRGC. First, a target point which has the highest power among constellation points needs to be found. Candidate points are points where that target point can move and are the closest neighbor points of the target point's reflected pair. Then, an empty point (i.e., a point which is not yet taken by other points) having the smallest power needs to be found among the candidate points and the power of the target point and the power of a candidate point are compared. If the power of the candidate point is smaller, the target point moves to the candidate point. These processes are repeated until an average power of the points on constellation reaches a minimum while keeping Gray mapping rule.

**[0021]** Fig. 7 shows an example of modified 64/256/1024/4096-QAM. The Gray mapped values correspond to Figs. 8 ~ 31 respectively. In addition to these examples, other types of modified QAM which enables identical power optimization can be realized. This is because a target point can move to multiple candidate points. The suggested modified QAM can be applied to, not only the 64/256/1024/4096-QAM, but also cross QAM, a bigger size QAM, or modulations using

other BRGC other than QAM.

**[0022]** Fig. 32 shows an example of Bit mapping of Modified-QAM where 256-QAM is modified using BRGC. Fig. 32a and Fig. 32b show mapping of Most Significant Bits (MSB). Points designated as filled circles represent mappings of ones and points designated as blank circles represent mappings of zeros. In a same manner, each bit is mapped as shown in figures from (a) through (h) in Fig. 32, until Least Significant Bits (LSB) are mapped. As shown in Fig. 32, Modified-QAM can enable bit decision using only I or Q axes as conventional QAM, except for a bit which is next to MSB (Fig. 32c and Fig. 32d). By using these characteristics, a simple receiver can be made by partially modifying a receiver for QAM. An efficient receiver can be implemented by checking both I and Q values only when determining bit next to MSB and by calculating only I or Q for the rest of bits. This method can be applied to Approximate LLR, Exact LLR, or Hard decision.

**[0023]** By using the Modified-QAM or MQAM, which uses the characteristics of above BRGC, Non-uniform constellation or NU-MQAM can be made. In the above equation where Gaussian CDF is used,  $P_j$  can be modified to fit MQAM. Just like QAM, in MQAM, two PAMs having I axis and Q axis can be considered. However, unlike QAM where a number of points corresponding to a value of each PAM axis are identical, the number of points changes in MQAM. If a number of points that corresponds to  $j$ th value of PAM is defined as  $n_j$  in a MQAM where a total of  $M$  constellation points exist, then  $P_j$  can be defined as follows:

$$\int_{-\infty}^{x_j} \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} dx = P_j \quad P_j = \frac{\sum_{i=0}^{j-1} n_i + \frac{n_j}{2}}{M}, \quad n_0 = 0 \quad (\text{Eq. 2})$$

**[0024]** By using the newly defined  $P_j$ , MQAM can be transformed into Non-uniform constellation.  $P_j$  can be defined as follows for the example of 256-MQAM.

$$P_j \in \left\{ \frac{2.5}{256}, \frac{10}{256}, \frac{22}{256}, \frac{36}{256}, \frac{51}{256}, \frac{67}{256}, \frac{84}{256}, \frac{102}{256}, \frac{119.5}{256}, \frac{136.5}{256}, \frac{154}{256}, \frac{172}{256}, \frac{189}{256}, \frac{205}{256}, \frac{220}{256}, \frac{234}{256}, \frac{246}{256}, \frac{253.5}{256} \right\}$$

**[0025]** Fig. 33 is an example of transformation of MQAM into Non-uniform constellation. The NU-MQAM made using these methods can retain characteristics of MQAM receivers with modified coordinates of each PAM. Thus, an efficient receiver can be implemented. In addition, a more noise-robust system than the previous NU-QAM can be implemented. For a more efficient broadcasting transmission system, hybridizing MQAM and NU-MQAM is possible. In other words, a more noise-robust system can be implemented by using MQAM for an environment where an error correction code with high code rate is used and by using NU-MQAM otherwise. For such a case, a transmitter can let a receiver have information of code rate of an error correction code currently used and a kind of modulation currently used such that the receiver can demodulate according to the modulation currently used.

**[0026]** Fig. 34 shows an example of digital transmission system. Inputs can comprise a number of MPEG-TS streams or GSE (General Stream Encapsulation) streams. An input processor module 101 can add transmission parameters to input stream and perform scheduling for a BICM module 102. The BICM module 102 can add redundancy and interleave data for transmission channel error correction. A frame builder 103 can build frames by adding physical layer signaling information and pilots. A modulator 104 can perform modulation on input symbols in efficient methods. An analog processor 105 can perform various processes for converting input digital signals into output analog signals.

**[0027]** Fig. 35 shows an example of an input processor. Input MPEG-TS or GSE stream can be transformed by input preprocessor into a total of  $n$  streams which will be independently processed. Each of those streams can be either a complete TS frame which includes multiple service components or a minimum TS frame which includes service component (i.e., video or audio). In addition, each of those streams can be a GSE stream which transmits either multiple services or a single service.

**[0028]** Input interface module 202-1 can allocate a number of input bits equal to the maximum data field capacity of a Baseband (BB) frame. A padding may be inserted to complete the LDPC/BCH code block capacity. The input stream sync module 203-1 can provide a mechanism to regenerate, in the receiver, the clock of the Transport Stream (or packetized Generic Stream), in order to guarantee end-to-end constant bit rates and delay.

**[0029]** In order to allow the Transport Stream recombining without requiring additional memory in the receiver, the input Transport Streams are delayed by delay compensators 204-1~ $n$  considering interleaving parameters of the data PLPs in a group and the corresponding common PLP. Null packet deleting modules 205-1~ $n$  can increase transmission

efficiency by removing inserted null packet for a case of VBR (variable bit rate) service. Cyclic Redundancy Check (CRC) encoder modules 206-1~n can add CRC parity to increase transmission reliability of BB frame. BB header inserting modules 207-1~n can add BB frame header at a beginning portion of BB frame. Information that can be included in BB header is shown in Fig. 36.

**[0030]** A Merger/slicer module 208 can perform BB frame slicing from each PLP, merging BB frames from multiple PLPs, and scheduling each BB frame within a transmission frame. Therefore, the merger/slicer module 208 can output L1 signaling information which relates to allocation of PLP in frame. Lastly, a BB scrambler module 209 can randomize input bitstreams to minimize correlation between bits within bitstreams. The modules in shadow in Fig. 35 are modules used when transmission system uses a single PLP, the other modules in Fig. 35 are modules used when the transmission device uses multiple PLPs.

**[0031]** Fig. 37 shows an example of BICM module. Fig. 37a shows data path and Fig. 37b shows L1 path of BICM module. An outer coder module 301 and an inner coder module 303 can add redundancy to input bitstreams for error correction. An outer interleaver module 302 and an inner interleaver module 304 can interleave bits to prevent burst error. The Outer interleaver module 302 can be omitted if the BICM is specifically for DVB-C2. A bit demux module 305 can control reliability of each bit output from the inner interleaver module 304. A symbol mapper module 306 can map input bitstreams into symbol streams. At this time, it is possible to use any of a conventional QAM, an MQAM which uses the aforementioned BRGC for performance improvement, an NU-QAM which uses Non-uniform modulation, or an NU-MQAM which uses Non-uniform modulation applied BRGC for performance improvement. To construct a system which is more robust against noise, combinations of modulations using MQAM and/or NU-MQAM depending on the code rate of the error correction code and the constellation capacity can be considered. At this time, the Symbol mapper module 306 can use a proper constellation according to the code rate and constellation capacity. Fig. 39 shows an example of such combinations.

**[0032]** Case 1 shows an example of using only NU-MQAM at low code rate for simplified system implementation. Case 2 shows an example of using optimized constellation at each code rate. The transmitter can send information about the code rate of the error correction code and the constellation capacity to the receiver such that the receiver can use an appropriate constellation. Fig. 40 shows another example of cases where compatibility between conventional systems is considered. In addition to the examples, further combinations for optimizing the system are possible.

**[0033]** The ModCod Header inserting module 307 shown in Fig. 37 can take Adaptive coding and modulation (ACM)/Variable coding and modulation (VCM) feedback information and add parameter information used in coding and modulation to a FEC block as header. The Modulation type/Coderate (ModCod) header can include the following information:

- \* FEC type (1 bits) - long or short LDPC
- \* Coderate (3 bits)
- \* Modulation (3 bits) - up-to 64K QAM
- \* PLP identifier (8 bits)

**[0034]** The Symbol interleaver module 308 can perform interleaving in symbol domain to obtain additional interleaving effects. Similar processes performed on data path can be performed on L1 signaling path but with possibly different parameters (301-1 ~ 308-1). At this point, a shortened/punctured code module (303-1) can be used for inner code.

**[0035]** Fig. 38 shows an example of LDPC encoding using shortening / puncturing. Shortening process can be performed on input blocks which have less bits than a required number of bits for LDPC encoding as many zero bits required for LDPC encoding can be padded (301c). Zero Padded input bitstreams can have parity bits through LDPC encoding (302c). At this time, for bitstreams that correspond to original bitstreams, zeros can be removed (303c) and for parity bitstreams, puncturing (304c) can be performed according to code-rates. These processed information bitstreams and parity bitstreams can be multiplexed into original sequences and outputted (305c).

**[0036]** Fig. 41 shows a frame structure which comprises preamble for L1 signaling and data symbol for PLP data. It can be seen that preamble and data symbols are cyclically generated, using one frame as a unit. Data symbols comprise PLP type 0 which is transmitted using a fixed modulation/coding and PLP type 1 which is transmitted using a variable modulation/coding. For PLP type 0, information such as modulation, FEC type, and FEC code rate are transmitted in preamble (see Fig. 42 Frame header insert 401). For PLP type 1, corresponding information can be transmitted in FEC block header of a data symbol (see Fig. 37 ModCod header insert 307). By the separation of PLP types, ModCod overhead can be reduced by 3~4% from a total transmission rate, for PLP type0 which is transmitted at a fixed bit rate. At a receiver, for fixed modulation/coding PLP of PLP type 0, Frame header remover r401 shown in Fig. 63 can extract information on Modulation and FEC code rate and provide the extracted information to a BICM decoding module. For variable modulation/coding PLP of PLP type 1, ModCod extracting modules, r307 and r307-1 shown in Fig. 64 can extract and provide the parameters necessary for BICM decoding.

**[0037]** Fig. 42 shows an example of a frame builder. A frame header inserting module 401 can form a frame from input

symbol streams and can add frame header at front of each transmitted frame. The frame header can include the following information:

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5      * Number of bonded channels (4 bits)
      * Guard interval (2 bits)
      * PAPR (2 bits)
      * Pilot pattern (2 bits)
      * Digital System identification (16 bits)
      * Frame identification (16 bits)
10     * Frame length (16 bits) - number of Orthogonal Frequency Division Multiplexing (OFDM) symbols per frame
      * Superframe length (16 bits) - number of frames per superframe
      * number of PLPs (8 bits)
      * for each PLP

15         PLP identification (8 bits)
            Channel bonding id (4 bits)
            PLP start (9 bits)
            PLP type (2 bits) - common PLP or others
            PLP payload type (5 bits)
20         MC type (1 bit) - fixed/variable modulation & coding
            if MC type == fixed modulation & coding

            FEC type (1 bit) - long or short LDPC
            Coderate (3 bits)
25         Modulation (3 bits) - up-to 64K QAM

            end if;
            Number of notch channels (2 bits)
            for each notch
30                 Notch start (9 bits)
                    Notch width (9 bits)

            end for;
35         PLP width (9 bits) - max number of FEC blocks of PLP
            PLP time interleaving type (2 bits)

            end for;
            * CRC-32 (32 bits)
40

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**[0038]** Channel bonding environment is assumed for L1 information transmitted in Frame header and data that correspond to each data slice is defined as PLP. Therefore, information such as PLP identifier, channel bonding identifier, and PLP start address are required for each channel used in bonding. One embodiment of this invention suggests transmitting ModCod field in FEC frame header if PLP type supports variable modulation/coding and transmitting ModCod field in Frame header if PLP type supports fixed modulation/coding to reduce signaling overhead. In addition, if a Notch band exists for each PLP, by transmitting the start address of the Notch and its width, decoding corresponding carriers at the receiver can become unnecessary.

**[0039]** Fig. 43 shows an example of Pilot Pattern 5 (PP5) applied in a channel bonding environment. As shown, if SP positions are coincident with preamble pilot positions, irregular pilot structure can occur.

**[0040]** Fig. 43a shows an example of pilot inserting module 404 as shown in Fig. 42. As represented in Fig. 43, if a single frequency band (for example, 8 MHz) is used, the available bandwidth is 7.61 MHz, but if multiple frequency bands are bonded, guard bands can be removed, thus, frequency efficiency can increase greatly. Fig. 43b is an example of preamble inserting module 504 as shown in Fig. 51 that is transmitted at the front part of the frame and even with channel bonding, the preamble has repetition rate of 7.61 MHz, which is bandwidth of L1 block. This is a structure considering the bandwidth of a tuner which performs initial channel scanning.

**[0041]** Pilot Patterns exist for both Preamble and Data Symbols. For data symbol, scattered pilot (SP) patterns can be used. Pilot Pattern 5 (PP5) and Pilot Pattern 7 (PP7) of T2 can be good candidates for frequency-only interpolation. PP5 has  $x=12$ ,  $y=4$ ,  $z=48$  for  $GI=1/64$  and PP7 has  $x=24$ ,  $y=4$ ,  $z=96$  for  $GI=1/128$ . Additional time-interpolation is also

possible for a better channel estimation. Pilot patterns for preamble can cover all possible pilot positions for initial channel acquisition. In addition, preamble pilot positions should be coincident with SP positions and a single pilot pattern for both the preamble and the SP is desired. Preamble pilots could also be used for time-interpolation and every preamble could have an identical pilot pattern. These requirements are important for C2 detection in scanning and necessary for frequency offset estimation with scrambling sequence correlation. In a channel bonding environment, the coincidence in pilot positions should also be kept for channel bonding because irregular pilot structure may degrade interpolation performance.

**[0042]** In detail, if a distance  $z$  between scattered pilots (SPs) in an OFDM symbol is 48 and if a distance  $y$  between SPs corresponding to a specific SP carrier along the time axis is 4, an effective distance  $x$  after time interpolation becomes 12. This is when a guard interval (GI) fraction is  $1/64$ . If GI fraction is  $1/128$ ,  $x=24$ ,  $y=4$ , and  $z=96$  can be used. If channel bonding is used, SP positions can be made coincident with preamble pilot positions by generating non-continuous points in scattered pilot structure.

**[0043]** At this time, preamble pilot positions can be coincident with every SP positions of data symbol. When channel bonding is used, data slice where a service is transmitted, can be determined regardless of 8 MHz bandwidth granularity. However, for reducing overhead for data slice addressing, transmission starting from SP position and ending at SP position can be chosen.

**[0044]** When a receiver receives such SPs, if necessary, channel estimation module r501 shown in Fig. 62 can perform time interpolation to obtain pilots shown in dotted lines in Fig. 43 and perform frequency interpolation. At this time, for non-continuous points of which intervals are designated as 32 in Fig. 43, either performing interpolations on left and right separately or performing interpolations on only one side then performing interpolation on the other side by using the already interpolated pilot positions of which interval is 12 as a reference point can be implemented. At this time, data slice width can vary within 7.61 MHz, thus, a receiver can minimize power consumption by performing channel estimation and decoding only necessary subcarriers.

**[0045]** Fig. 44 shows another example of PP5 applied in channel bonding environment or a structure of SP for maintaining effective distance  $x$  as 12 to avoid irregular SP structure shown in Fig. 43 when channel bonding is used. Fig. 44a is a structure of SP for data symbol and Fig. 44b is a structure of SP for preamble symbol.

**[0046]** As shown, if SP distance is kept consistent in case of channel bonding, there will be no problem in frequency interpolation but pilot positions between data symbol and preamble may not be coincident. In other words, this structure does not require additional channel estimation for an irregular SP structure, however, SP positions used in channel bonding and preamble pilot positions become different for each channel.

**[0047]** Fig. 45 shows a new SP structure or PP5' to provide a solution to the two problems aforementioned in channel bonding environment. Specifically, a pilot distance of  $x=16$  can solve those problems. To preserve pilot density or to maintain the same overhead, a PP5' can have  $x=16$ ,  $y=3$ ,  $z=48$  for  $GI=1/64$  and a PP7' can have  $x=16$ ,  $y=6$ ,  $z=96$  for  $GI=1/128$ . Frequency-only interpolation capability can still be maintained. Pilot positions are depicted in Fig. 45 for comparison with PP5 structure.

**[0048]** Fig. 46 shows an example of a new SP Pattern or PP5' structure in channel bonding environment. As shown in figure 46, whether either single channel or channel bonding is used, an effective pilot distance  $x=16$  can be provided. In addition, because SP positions can be made coincident with preamble pilot positions, channel estimation deterioration caused by SP irregularity or non-coincident SP positions can be avoided. In other words, no irregular SP position exists for freq-interpolator and coincidence between preamble and SP positions is provided.

**[0049]** Consequently, the proposed new SP patterns can be advantageous in that single SP pattern can be used for both single and bonded channel; no irregular pilot structure can be caused, thus a good channel estimation is possible; both preamble and SP pilot positions can be kept coincident; pilot density can be kept the same as for PP5 and PP7 respectively; and Frequency-only interpolation capability can also be preserved.

**[0050]** In addition, the preamble structure can meet the requirements such as preamble pilot positions should cover all possible SP positions for initial channel acquisition; maximum number of carriers should be 3409 (7.61 MHz) for initial scanning; exactly same pilot patterns and scrambling sequence should be used for C2 detection; and no detection-specific preamble like P1 in T2 is required.

**[0051]** In terms of relation with frame structure, data slice position granularity may be modified to 16 carriers rather than 12, thus, less position addressing overhead can occur and no other problem regarding data slice condition, Null slot condition etc can be expected.

**[0052]** Therefore, at channel estimation module r501 of Fig. 62, pilots in every preamble can be used when time interpolation of SP of data symbol is performed. Therefore, channel acquisition and channel estimation at the frame boundaries can be improved.

**[0053]** Now, regarding requirements related to the preamble and the pilot structure, there is consensus in that positions of preamble pilots and SPs should coincide regardless of channel bonding; the number of total carriers in L1 block should be dividable by pilot distance to avoid irregular structure at band edge; L1 blocks should be repeated in frequency domain; and L1 blocks should always be decodable in arbitrary tuner window position. Additional requirements would

be that pilot positions and patterns should be repeated by period of 8 MHz; correct carrier frequency offset should be estimated without channel bonding knowledge; and L1 decoding (re-ordering) is impossible before the frequency offset is compensated.

**[0054]** Fig. 47 shows a relationship between data symbol and preamble when preamble structures as shown in Fig. 52 and Fig. 53 are used. L1 block can be repeated by period of 6 MHz. For L1 decoding, both frequency offset and Preamble shift pattern should be found. L1 decoding is not possible in arbitrary tuner position without channel bonding information and a receiver cannot differentiate between preamble shift value and frequency offset.

**[0055]** Thus, a receiver, specifically for Frame header remover r401 shown in Fig. 63 to perform L1 signal decoding, channel bonding structure needs to be obtained. Because preamble shift amount expected at two vertically shadowed regions in Fig. 47 is known, time/freq synchronizing module r505 in Fig. 62 can estimate carrier frequency offset. Based on the estimation, L1 signaling path (r308-1 ~ r301-1) in Fig. 64 can decode L1.

**[0056]** Fig. 48 shows a relationship between data symbol and preamble when the preamble structure as shown in Fig. 55 is used. L1 block can be repeated by period of 8 MHz. For L1 decoding, only frequency offset needs to be found and channel bonding knowledge may not be required. Frequency offset can be easily estimated by using known Pseudo Random Binary Sequence (PRBS) sequence. As shown in Fig. 48, preamble and data symbols are aligned, thus, additional sync search can become unnecessary. Therefore, for a receiver, specifically for the Frame header remover module r401 shown in Fig. 63, it is possible that only correlation peak with pilot scrambling sequence needs to be obtained to perform L1 signal decoding. The time/freq synchronizing module r505 in Fig. 62 can estimate carrier frequency offset from peak position.

**[0057]** Fig. 49 shows an example of cable channel delay profile.

**[0058]** From the point of view of pilot design, current GI already over-protects delay spread of cable channel. In the worst case, redesigning the channel model can be an option. To repeat the pattern exactly every 8 MHz, the pilot distance should be a divisor of 3584 carriers ( $z=32$  or  $56$ ). A pilot density of  $z=32$  can increase pilot overhead, thus,  $z=56$  can be chosen. Slightly less delay coverage may not be an important in cable channel. For example, it can be  $8\ \mu\text{s}$  for PP5' and  $4\ \mu\text{s}$  for PP7' compared to  $9.3\ \mu\text{s}$  (PP5) and  $4.7\ \mu\text{s}$  (PP7). Meaningful delays can be covered by both pilot patterns even in a worst case. For preamble pilot position, no more than all SP positions in data symbol are necessary.

**[0059]** If the  $-40\ \text{dB}$  delay path can be ignored, actual delay spread can become  $2.5\ \mu\text{s}$ ,  $1/64\ \text{GI} = 7\ \mu\text{s}$ , or  $1/128\ \text{GI} = 3.5\ \mu\text{s}$ . This shows that pilot distance parameter,  $z=56$  can be a good enough value. In addition,  $z=56$  can be a convenient value for structuring pilot pattern that enables preamble structure shown in Fig. 48.

**[0060]** Fig. 50 shows scattered pilot structure that uses  $z=56$  and  $z=112$  which is constructed at pilot inserting module 404 in Fig. 42. PP5' ( $x=14, y=4, z=56$ ) and PP7' ( $x=28, y=4, z=112$ ) are proposed. Edge carriers could be inserted for closing edge.

**[0061]** As shown in Fig. 50, pilots are aligned at 8 MHz from each edge of the band, every pilot position and pilot structure can be repeated every 8 MHz. Thus, this structure can support the preamble structure shown in Fig. 48. In addition, a common pilot structure between preamble and data symbols can be used. Therefore, channel estimation module r501 in Fig. 62 can perform channel estimation using interpolation on preamble and data symbols because no irregular pilot pattern can occur, regardless of window position which is decided by data slice locations. At this time, using only frequency interpolation can be enough to compensate channel distortion from delay spread. If time interpolation is performed additionally, more accurate channel estimation can be performed.

**[0062]** Consequently, in the new proposed pilot pattern, pilot position and pattern can be repeated based on a period of 8 MHz. A single pilot pattern can be used for both preamble and data symbols. L1 decoding can always be possible without channel bonding knowledge. In addition, the proposed pilot pattern may not affect commonality with T2 because the same pilot strategy of scattered pilot pattern can be used; T2 already uses 8 different pilot patterns; and no significant receiver complexity can be increased by modified pilot patterns. For a pilot scrambling sequence, the period of PRBS can be 2047 (m-sequence); PRBS generation can be reset every 8 MHz, of which the period is 3584; pilot repetition rate of 56 can be also co-prime with 2047; and no PAPR issue can be expected.

**[0063]** Fig. 51 shows an example of a modulator based on OFDM. Input symbol streams can be transformed into time domain by IFFT module 501. If necessary, peak-to-average power ratio (PAPR) can be reduced at PAPR reducing module 502. For PAPR methods, Active constellation extension (ACE) or tone reservation can be used. GI inserting module 503 can copy a last part of effective OFDM symbol to fill guard interval in a form of cyclic prefix.

**[0064]** Preamble inserting module 504 can insert preamble at the front of each transmitted frame such that a receiver can detect digital signal, frame and acquire time/freq offset acquisition. At this time, the preamble signal can perform physical layer signaling such as FFT size (3 bits) and Guard interval size (3 bits). The Preamble inserting module 504 can be omitted if the modulator is specifically for DVB-C2.

**[0065]** Fig. 52 shows an example of a preamble structure for channel bonding, generated at preamble inserting module 504 in Fig. 51. One complete L1 block should be "always decodable" in any arbitrary 7.61 MHz tuning window position and no loss of L1 signaling regardless of tuner window position should occur. As shown, L1 blocks can be repeated in frequency domain by period of 6 MHz. Data symbol can be channel bonded for every 8 MHz. If, for L1 decoding, a

receiver uses a tuner such as the tuner r603 represented in Fig. 61 which uses a bandwidth of 7.61 MHz, the Frame header remover r401 in Fig. 63 needs to rearrange the received cyclic shifted L1 block (Fig. 53) to its original form. This rearrangement is possible because L1 block is repeated for every 6MHz block. Fig. 53a can be reordered into Fig. 53b.

**[0066]** Fig. 54 shows a process for designing a more optimized preamble. The preamble structure of Fig. 52 uses only 6MHz of total tuner bandwidth 7.61 MHz for L1 decoding. In terms of spectrum efficiency, tuner bandwidth of 7.61 MHz is not fully utilized. Therefore, there can be further optimization in spectrum efficiency.

**[0067]** Fig. 55 shows another example of preamble structure or preamble symbols structure for full spectrum efficiency, generated at Frame Header Inserting module 401 in Fig. 42. Just like data symbol, L1 blocks can be repeated in frequency domain by period of 8 MHz. One complete L1 block is still "always decodable" in any arbitrary 7.61 MHz tuning window position. After tuning, the 7.61 MHz data can be regarded as a virtually punctured code. Having exactly the same bandwidth for both the preamble and data symbols and exactly the same pilot structure for both the preamble and data symbols can maximize spectrum efficiency. Other features such as cyclic shifted property and not sending L1 block in case of no data slice can be kept unchanged. In other words, the bandwidth of preamble symbols can be identical with the bandwidth of data symbols or, as shown in Fig. 57, the bandwidth of the preamble symbols can be the bandwidth of the tuner (here, it's 7.61 MHz). The tuner bandwidth can be defined as a bandwidth that corresponds to a number of total active carriers when a single channel is used. That is, the bandwidth of the preamble symbol can correspond to the number of total active carriers (here, it's 7.61 MHz).

**[0068]** Fig. 56 shows a virtually punctured code. The 7.61 MHz data among the 8 MHz L1 block can be considered as punctured coded. When a tuner r603 shown in Fig. 61 uses 7.61 MHz bandwidth for L1 decoding, Frame header remover r401 in Fig. 63 needs to rearrange received, cyclic shifted L1 block into original form as shown in Fig. 56. At this time, L1 decoding is performed using the entire bandwidth of the tuner. Once the L1 block is rearranged, a spectrum of the rearranged L1 block can have a blank region within the spectrum as shown in upper right side of Fig. 56 because an original size of L1 block is 8 MHz bandwidth.

**[0069]** Once the blank region is zero padded, either after deinterleaving in symbol domain by the freq. deinterleaver r403 in Fig. 63 or by the symbol deinterleaver r308-1 in Fig. 64 or after deinterleaving in bit domain by the symbol demapper r306-1, bit mux r305-1, and inner deinterleaver r304-1 in Fig. 64, the block can have a form which appears to be punctured as shown in lower right side of Fig. 56.

**[0070]** This L1 block can be decoded at the punctured/shortened decode module r303-1 in Fig. 64. By using these preamble structure, the entire tuner bandwidth can be utilized, thus spectrum efficiency and coding gain can be increased. In addition, an identical bandwidth and pilot structure can be used for the preamble and data symbols.

**[0071]** In addition, if the preamble bandwidth or the preamble symbols bandwidth is set as a tuner bandwidth as shown in Fig. 58, (it's 7.61 MHz in the example), a complete L1 block can be obtained after rearrangement even without puncturing. In other words, for a frame having preamble symbols, wherein the preamble symbols have at least one layer 1 (L1) block, it can be said, the L1 block has 3408 active subcarriers and the 3408 active subcarriers correspond to 7.61 MHz of 8MHz Radio Frequency (RF) band.

**[0072]** Thus, spectrum efficiency and L1 decoding performance can be maximized. In other words, at a receiver, decoding can be performed at punctured/shortened decode module r303-1 in Fig. 64, after performing only deinterleaving in the symbol domain.

**[0073]** Consequently, the proposed new preamble structure can be advantageous in that it's fully compatible with previously used preamble except that the bandwidth is different; L1 blocks are repeated by period of 8 MHz; L1 block can be always decodable regardless of tuner window position; Full tuner bandwidth can be used for L1 decoding; maximum spectrum efficiency can guarantee more coding gain; incomplete L1 block can be considered as punctured coded; simple and same pilot structure can be used for both preamble and data; and identical bandwidth can be used for both preamble and data.

**[0074]** Fig. 59 shows an example of an analog processor. A DAC module 601 can convert digital signal input into analog signal. After transmission frequency bandwidth is up-converted (602) and analog filtered (603) signal can be transmitted.

**[0075]** Fig. 60 shows an example of a digital receiver system. Received signal is converted into digital signal at an analog process module r105. A demodulator r104 can convert the signal into data in frequency domain. A frame parser r103 can remove pilots and headers and enable selection of service information that needs to be decoded. A BICM demodulator r102 can correct errors in the transmission channel. An output processor r101 can restore the originally transmitted service stream and timing information.

**[0076]** Fig. 61 shows an example of analog processor used at the receiver. A Tuner/AGC module r603 can select desired frequency bandwidth from received signal. A down converting module r602 can restore baseband. An ADC module r601 can convert analog signal into digital signal.

**[0077]** Fig. 62 shows an example of demodulator. A frame detecting module r506 can detect the preamble, check if a corresponding digital signal exists, and detect a start of a frame. A time/freq synchronizing module r505 can perform synchronization in time and frequency domains. At this time, for time domain synchronization, a guard interval correlation

can be used. For frequency domain synchronization, correlation can be used or offset can be estimated from phase information of a subcarrier that is transmitted in the frequency domain. A preamble removing module r504 can remove preamble from the front of detected frame. A GI removing module r503 can remove guard interval. A FFT module r501 can transform signal in the time domain into signal in the frequency domain. A channel estimation/equalization module r501 can compensate errors by estimating distortion in transmission channel using pilot symbol. The Preamble removing module r504 can be omitted if the demodulator is specifically for DVB-C2.

[0078] Fig. 63 shows an example of frame parser. A pilot removing module r404 can remove pilot symbol. A freq deinterleaving module r403 can perform deinterleaving in the frequency domain. An OFDM symbol merger r402 can restore data frame from symbol streams transmitted in OFDM symbols. A frame header removing module r401 can extract physical layer signaling from header of each transmitted frame and remove header. Extracted information can be used as parameters for following processes in the receiver.

[0079] Fig. 64 shows an example of a BICM demodulator. Fig. 64a shows a data path and Fig. 64b shows a L1 signaling path. A symbol deinterleaver r308 can perform deinterleaving in the symbol domain. A ModCod extract r307 can extract ModCod parameters from front of each BB frame and make the parameters available for following adaptive/variable demodulation and decoding processes. A Symbol demapper r306 can demap input symbol streams into bit Log-Likelihood Ratio (LLR) streams. The Output bit LLR streams can be calculated by using a constellation used in a Symbol mapper 306 of the transmitter as reference point. At this point, when the aforementioned MQAM or NU-MQAM is used, by calculating both I axis and Q axis when calculating bit nearest from MSB and by calculating either I axis or Q axis when calculating the rest bits, an efficient symbol demapper can be implemented. This method can be applied to, for example, Approximate LLR, Exact LLR, or Hard decision.

[0080] When an optimized constellation according to constellation capacity and code rate of error correction code at the Symbol mapper 306 of the transmitter is used, the Symbol demapper r306 of the receiver can obtain a constellation using the code rate and constellation capacity information transmitted from the transmitter. The bit mux r305 of the receiver can perform an inverse function of the bit demux 305 of the transmitter. The Inner deinterleaver r304 and outer deinterleaver r302 of the receiver can perform inverse functions of the inner interleaver 304 and outer interleaver 302 of the transmitter, respectively to get the bitstream in its original sequence. The outer deinterleaver r302 can be omitted if the BICM demodulator is specifically for DVB-C2.

[0081] The inner decoder r303 and outer decoder r301 of the receiver can perform corresponding decoding processes to the inner coder 303 and outer code 301 of the transmitter, respectively, to correct errors in the transmission channel. Similar processes performed on data path can be performed on L1 signaling path, but with different parameters (r308-1 ~ r301-1). At this point, as explained in the preamble part, a shortened/punctured code module r303-1 can be used for L1 signal decoding.

[0082] Fig. 65 shows an example of LDPC decoding using shortening / puncturing. A demux r301a can separately output information part and parity part of systematic code from input bit streams. For the information part, a zero padding (r302a) can be performed according to a number of input bit streams of LDPC decoder, for the parity part, input bit streams for (r303a) the LDPC decoder can be generated by de-puncturing punctured part. LDPC decoding (r304a) can be performed on generated bit streams, zeros in information part can be removed and output (r305a).

[0083] Fig. 66 shows an example of output processor. A BB descrambler r209 can restore scrambled (209) bit streams at the transmitter. A Splitter r208 can restore BB frames that correspond to multiple PLP that are multiplexed and transmitted from the transmitter according to PLP path. For each PLP path, a BB header remover r207-1~n can remove the header that is transmitted at the front of the BB frame. A CRC decoder r206-1~n can perform CRC decoding and make reliable BB frames available for selection. A Null packet inserting modules r205-1~n can restore null packets which were removed for higher transmission efficiency in their original location. A Delay recovering modules r204-1~n can restore a delay that exists between each PLP path.

[0084] An output clock recovering modules r203-1~n can restore the original timing of the service stream from timing information transmitted from the input stream synchronization modules 203-1~n. An output interface modules r202-1~n can restore data in TS/GS packet from input bit streams that are sliced in BB frame. An output postprocess modules r201-1~n can restore multiple TS/GS streams into a complete TS/GS stream, if necessary. The shaded blocks shown in Fig. 66 represent modules that can be used when a single PLP is processed at a time and the rest of the blocks represent modules that can be used when multiple PLPs are processed at the same time.

[0085] Preamble pilot patterns were carefully designed to avoid PAPR increase, thus, whether L1 repetition rate may increase PAPR needs to be considered. The number of L1 information bits varies dynamically according to the channel bonding, the number of PLPs, etc. In detail, it is necessary to consider things such as fixed L1 block size may introduce unnecessary overhead; L1 signaling should be protected more strongly than data symbols; and time interleaving of L1 block can improve robustness over channel impairment such as impulsive noise need.

[0086] For a L1 block repetition rate of 8 MHz, as shown in Fig. 67, full spectrum efficiency (26.8% BW increase) is exhibited with virtual puncturing but the PAPR may be increased since L1 bandwidth is the same as that of the data symbols. For the repetition rate of 8 MHz, 4K-FFT DVB-T2 frequency interleaving can be used for commonality and the

same pattern can repeat itself at a 8 MHz period after interleaving.

**[0087]** For a L1 block repetition rate of 6 MHz, as shown in Fig. 68, reduced spectrum efficiency can be exhibited with no virtual puncturing. A similar problem of PAPR as for the 8MHz case can occur since the L1 and data symbol bandwidths share LCM=24 MHz. For the repetition rate of 6 MHz, 4K-FFT DVB-T2 frequency interleaving can be used for commonality and the same pattern can repeat itself at a period of 24 MHz after interleaving.

**[0088]** Fig. 69 shows a new L1 block repetition rate of 7.61 MHz or full tuner bandwidth. A full spectrum efficiency (26.8% BW increase) can be obtained with no virtual puncturing. There can be no PAPR issue since L1 and data symbol bandwidths share LCM≈1704 MHz. For the repetition rate of 7.61 MHz, 4K-FFT DVB-T2 frequency interleaving can be used for commonality and the same pattern can repeat itself by period of about 1704 MHz after interleaving.

**[0089]** Fig. 70 is an example of L1 signaling which is transmitted in the frame header. Each information in L1 signaling can be transmitted to the receiver and can be used as a decoding parameter. Especially, the information can be used in L1 signal path shown in Fig. 64 and PLPs can be transmitted in each data slice. An increased robustness for each PLP can be obtained.

**[0090]** Fig. 72 is an example of a symbol interleaver 308-1 as shown in L1 signaling path in Fig. 37 and also can be an example of its corresponding symbol deinterleaver r308-1 as shown in L1 signaling path in Fig. 64. Blocks with tilted lines represent L1 blocks and solid blocks represent data carriers. L1 blocks can be transmitted not only within a single preamble, but also can be transmitted within multiple OFDM blocks. Depending on a size of L1 block, the size of the interleaving block can vary. In other words, num\_L1\_sym and L1 span can be different from each other. To minimize unnecessary overhead, data can be transmitted within the rest of the carriers of the OFDM symbols where the L1 block is transmitted. At this point, full spectrum efficiency can be guaranteed because the repeating cycle of L1 block is still a full tuner bandwidth. In Fig. 72, the numbers in blocks with tilted lines represent the bit order within a single LDPC block.

**[0091]** Consequently, when bits are written in an interleaving memory in the row direction according to a symbol index as shown in Fig. 72 and read in the column direction according to a carrier index, a block interleaving effect can be obtained. In other words, one LDPC block can be interleaved in the time domain and the frequency domain and then can be transmitted. Num\_L1\_sym can be a predetermined value, for example, a number between 2~4 can be set as a number of OFDM symbols. At this point, to increase the granularity of the L1 block size, a punctured/shortened LDPC code having a minimum length of the codeword can be used for L1 protection.

**[0092]** Fig. 73 is an example of an L1 block transmission. Fig. 73 illustrates Fig. 72 in frame domain. As shown on Fig. 73a, L1 blocks can be spanning in full tuner bandwidth or as shown on Fig. 73b, L1 blocks can be partially spanned and the rest of the carriers can be used for data carrier. In either case, it can be seen that the repetition rate of L1 block can be identical to a full tuner bandwidth. In addition, for OFDM symbols which uses L1 signaling including preamble, only symbol interleaving can be performed while not allowing data transmission in that OFDM symbols. Consequently, for OFDM symbol used for L1 signaling, a receiver can decode L1 by performing deinterleaving without data decoding. At this point, the L1 block can transmit L1 signaling of current frame or L1 signaling of a subsequent frame. At the receiver side, L1 parameters decoded from L1 signaling decoding path shown in Fig. 64 can be used for decoding process for data path from frame parser of subsequent frame.

**[0093]** In summary, at a transmitter, interleaving blocks of L1 region can be performed by writing blocks to a memory in a row direction and reading the written blocks from the memory in a column direction. At a receiver, deinterleaving blocks of L1 region can be performed by writing blocks to a memory in a column direction and reading the written blocks from the memory in a row direction. The reading and writing directions of transmitter and receiver can be interchanged.

**[0094]** When simulation is performed with assumptions such as CR=1/2 for L1 protection and for T2 commonality; 16-QAM symbol mapping; pilot density of 6 in the Preamble; number of short LDPC implies required amount of puncturing/shortening are made, results or conclusions such as only preamble for L1 transmission may not be sufficient; the number of OFDM symbols depends on the amount of L1 block size; shortest LDPC codeword (e.g. 192 bits information) among shortened/punctured code may be used for flexibility and fine granularity; and Padding may be added if required with negligible overhead, can be obtained. The result is summarized in Fig. 71.

**[0095]** Consequently, for a L1 block repetition rate, full tuner bandwidth with no virtual puncturing can be a good solution and still no PAPR issue can arise with full spectrum efficiency. For L1 signaling, efficient signaling structure can allow maximum configuration in an environment of 8 channels bonding, 32 notches, 256 data slices, and 256 PLPs. For L1 block structure, flexible L1 signaling can be implemented according to L1 block size. Time interleaving can be performed for better robustness for T2 commonality. Less overhead can allow data transmission in preamble.

**[0096]** Block interleaving of L1 block can be performed for better robustness. The interleaving can be performed with fixed pre-defined number of L1 symbols (num\_L1\_sym) and a number of carriers spanned by L1 as a parameter (L1\_span). The same technique is used for P2 preamble interleaving in DVB-T2.

**[0097]** L1 block of variable size can be used. Size can be adaptable to the amount of L1 signaling bits, resulting in a reduced overhead. Full spectrum efficiency can be obtained with no PAPR issue. Less than 7.61 MHz repetition can mean that more redundancy can be sent but unused. No PAPR issue can arise because of 7.61 MHz repetition rate for L1 block.

**[0098]** Fig. 74 is another example of L1 signaling transmitted within a frame header. This Fig. 74 is different from Fig. 70 in that the L1\_span field having 12 bits it is divided into two fields. In other words, the L1\_span field is divided into a L1\_column having 9 bits and a L1\_row having 3 bits. The L1\_column represents the carrier index that L1 spans. Because data slice starts and ends at every 12 carriers, which is the pilot density, the 12 bits of overhead can be reduced by 3 bits to reach 9 bits.

**[0099]** L1\_row represents the number of OFDM symbols where L1 is spanning when time interleaving is applied. Consequently, time interleaving can be performed within an area of L1\_columns multiplied by L1\_rows. Alternatively, a total size of L1 blocks can be transmitted such that L1\_span shown in Fig. 70 can be used when time interleaving is not performed. For such a case, L1 block size is 11,776 x 2 bits in the example, thus 15 bits is enough. Consequently, the L1\_span field can be made up of 15 bits.

**[0100]** Fig. 75 is an example of frequency or time interleaving/deinterleaving. The Fig. 75 shows a part of a whole transmission frame. The Fig. 75 also shows bonding of multiple 8 MHz bandwidths. A frame can consist of a preamble which transmits L1 blocks and a data symbol which transmits data. The different kinds of data symbols represent data slices for different services. As shown in Fig. 75, the preamble transmits L1 blocks for every 7.61 MHz.

**[0101]** For the preamble, frequency or time interleaving is performed within L1 blocks and not performed between L1 blocks. That is, for the preamble, it can be said that interleaving is performed at L1 block level. This allows decoding the L1 blocks by transmitting L1 blocks within a tuner window bandwidth even when the tuner window has moved to a random location within a channel bonding system.

**[0102]** For decoding data symbol at a random tuner window bandwidth, interleaving between data slices should not occur. That is, for data slices, it can be said that interleaving is performed at data slice level. Consequently, frequency interleaving and time interleaving should be performed within a data slice. Therefore, a symbol interleaver 308 in a data path of a BICM module of transmitter as shown in Fig. 37 can perform symbol interleaving for each data slice. A symbol interleaver 308-1 in an L1 signal path can perform symbol interleaving for each L1 block.

**[0103]** A frequency interleaver 403 shown in Fig. 42 needs to perform interleaving on the preamble and data symbols separately. Specifically, for the preamble, frequency interleaving can be performed for each L1 block and for data symbol, frequency interleaving can be performed for each data slice. At this point, time interleaving in data path or L1 signal path may not be performed considering low latency mode.

**[0104]** Using the suggested methods and devices, among others advantages it is possible to implement an efficient digital transmitter, receiver and structure of physical layer signaling.

**[0105]** By transmitting ModCod information in each BB frame header that is necessary for ACM/VCM and transmitting the rest of the physical layer signaling in a frame header, signaling overhead can be minimized.

**[0106]** Modified QAM for a more energy efficient transmission or a more noise-robust digital broadcasting system can be implemented. The system can include transmitter and receiver for each example disclosed and the combinations thereof.

**[0107]** An Improved Non-uniform QAM for a more energy efficient transmission or a more noise-robust digital broadcasting system can be implemented. A method of using code rate of error correction code of NU-MQAM and MQAM is also described. The system can include transmitter and receiver for each example disclosed and the combinations thereof.

**[0108]** The suggested L1 signaling method can reduce overhead by 3~4% by minimizing signaling overhead during channel bonding.

**[0109]** It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the invention.

## Claims

1. A method of transmitting a broadcasting signal to a receiver decoding the broadcasting signal, comprising:

converting an input stream into a Baseband, BB, frame of Physical Layer Pipe, PLP;  
coding data in the BB frame of PLP, by a Forward Error Correction, FEC, scheme;  
mapping preamble data into preamble data symbols and the coded data into data symbols;  
building at least one data slice based on the data symbols;  
time-interleaving the data symbols at data slice level;  
time-interleaving the preamble data symbols;  
building a signal frame based on the time-interleaved preamble data symbols and the at least one data slice  
having the time-interleaved data symbols;  
modulating the built signal frame by an Orthogonal Frequency Division Multiplexing, OFDM, method; and  
transmitting the modulated signal frame,

wherein a Layer-1, L1, block is repeated in the preamble data symbols in frequency domain by a same bandwidth, wherein the same bandwidth is 7.61 MHz, and wherein when two parts out of repeated L1 blocks within a tuning window of the receiver are reordered, the reordered parts configure a complete L1 block, wherein the L1 block includes L1 signaling information for signaling the data slice.

2. The method of claim 1, wherein the L1 signaling information comprises notch start information indicating a start position of a notch band existing in the signal frame.
3. The method of claim 1, wherein the L1 signaling information comprises notch width information indicating a width of a notch band existing in the signal frame.
4. The method of claims 1, wherein the L1 signaling information comprises notch number information indicating a number of notch channels existing in the signal frame.

5. An apparatus for transmitting a broadcasting signal to a receiver decoding the broadcasting signal, comprising:

an input processor for converting an input stream into a Baseband, BB, frame of Physical Layer Pipe, PLP;  
 a coding unit for coding data in the BB frame of PLP, by a Forward Error Correction, FEC, scheme;  
 a mapper for mapping preamble data bits into preamble data symbols and data bits into data symbols;  
 a first time-interleaver for time-interleaving the data symbols at data slice level, wherein at least one data slice is built based on the data symbols;  
 a second time-interleaver for time-interleaving the preamble data symbols;  
 a frame builder for building a signal frame based on the time-interleaved preamble data symbols and the at least one data slice having the time-interleaved data symbols;  
 a modulating unit for modulating the built signal frame by an Orthogonal Frequency Division Multiplexing, OFDM, method; and  
 a transmission unit for transmitting the modulated signal frame,

wherein a Layer-1, L1, block is repeated in the preamble data symbols in frequency domain by a same bandwidth, wherein the same bandwidth is 7.61 MHz, and wherein when two parts out of repeated L1 blocks within a tuning window of the receiver are reordered, the reordered parts configure a complete L1 block, wherein the L1 block includes L1 signaling information for signaling the data slice.

6. The apparatus of claim 5, wherein the L1 signaling information comprises notch start information indicating a start position of a notch band existing in the signal frame.
7. The apparatus of claim 5, wherein the L1 signaling information comprises notch width information indicating a width of a notch band existing in the signal frame.
8. The apparatus of claims 6, wherein the L1 signaling information comprises notch number information indicating a number of notch channels existing in the signal frame.
9. A method of receiving a broadcasting signal in a receiver decoding the broadcasting signal, comprising:

demodulating the broadcasting signal using an Orthogonal Frequency Division Multiplexing, OFDM, method;  
 obtaining a signal frame from the demodulated broadcasting signal, the signal frame comprising preamble data symbols and data symbols, wherein the data symbols are included in at least one data slice;  
 time-deinterleaving the data symbols at data slice level;  
 time-deinterleaving the preamble symbols;  
 demapping the time-deinterleaved data symbols into data bits;  
 decoding the data bits using low density parity check decoding scheme; and  
 converting the decoded data bits into a Baseband, BB, Frame of a Physical Layer Pipe, PLP,

wherein a Layer-1, L1, block is repeated in the preamble data symbols in frequency domain by a same bandwidth, wherein the same bandwidth is 7.61 MHz, and wherein when two parts out of repeated L1 blocks within a tuning window of the receiver are reordered, the reordered parts configure a complete L1 block, wherein the L1 block includes L1 signaling information for signaling the data slice.

10. The method of claim 9, wherein the L1 signaling information comprises notch start information indicating a start position of a notch band existing in the signal frame.

11. The method of claim 9, wherein the L1 signaling information comprises notch width information indicating a width of a notch band existing in the signal frame.

12. The method of claims 9, wherein the L1 signaling information comprises notch number information indicating a number of notch channels existing in the signal frame.

13. A receiver for receiving a broadcasting signal, comprising:

a demodulating unit for demodulating the broadcasting signal using an Orthogonal Frequency Division Multiplexing, OFDM, method;

an obtaining unit for obtaining a signal frame from the demodulated broadcasting signal, the signal frame comprising preamble data symbols and data symbols, wherein the data symbols are included in at least one data slice;

a first time-deinterleaver for time-deinterleaving the data symbols at data slice level;

a second time-deinterleaver for time-deinterleaving the preamble symbols;

a demapping unit for demapping the time-deinterleaved data symbols into data bits;

a decoding unit for decoding the data bits using low density parity check decoding scheme;

an output processor for converting the decoded data bits into a Baseband, BB, Frame of a Physical Layer Pipe, PLP,

wherein a Layer-1, L1, block is repeated in the preamble data symbols in frequency domain by a same bandwidth, wherein the same bandwidth is 7.61 MHz, and wherein when two parts out of repeated L1 blocks within a tuning window of the receiver are reordered, the reordered parts configure a complete L1 block, wherein the L1 block includes L1 signaling information for signaling the data slice.

14. The apparatus of claim 13, wherein the L1 signaling information comprises notch start information indicating a start position of a notch band existing in the signal frame.

15. The apparatus of claim 13, wherein the L1 signaling information comprises notch width information indicating a width of a notch band existing in the signal frame.

16. The apparatus of claims 13, wherein the L1 signaling information comprises notch number information indicating a number of notch channels existing in the signal frame.

## Patentansprüche

1. Verfahren zum Senden eines Rundfunksignals an einen Empfänger, der das Rundfunksignal dekodiert, umfassend:

Konvertieren eines Eingabestroms in einen Basisband-Rahmen, BB-Rahmen, einer Physical Layer Pipe, PLP;

Kodieren von Daten im BB-Rahmen der PLP durch ein Vorwärtsfehlerkorrektur-Schema, FEC-Schema;

Abbilden von Präambeldaten in Präambeldatensymbole und der kodierten Daten in Datensymbole;

Aufbauen zumindest einer Datenscheibe auf der Grundlage der Datensymbole;

Zeitverschachteln der Datensymbole auf Datenscheibenniveau;

Zeitverschachteln der Präambeldatensymbole;

Aufbauen eines Signalrahmens auf der Grundlage der zeitverschachtelten Präambeldatensymbole und der zumindest einen Datenscheibe mit den zeitverschachtelten Datensymbolen;

Modulieren des aufgebauten Signalrahmens durch ein Orthogonal-Frequency-Division-Multiplexing-Verfahren, OFDM-Verfahren; und

Senden des modulierten Signalrahmens,

wobei ein Layer-1-Block, L1-Block, in den Präambeldatensymbolen im Frequenzbereich durch eine gleiche Bandbreite wiederholt wird, wobei die gleiche Bandbreite 7,61 MHz beträgt und wobei, wenn zwei Teile aus wiederholten L1-Blöcken innerhalb eines Abstimmungsfensters des Empfängers umgeordnet sind, die umgeordneten Teile einen vollständigen L1-Block konfigurieren, wobei der L1-Block L1-Signalisierungsinformationen zum Signalisieren der Datenscheibe beinhaltet.

2. Verfahren nach Anspruch 1, wobei die L1-Signalisierungsinformationen Kerbstartinformationen umfassen, die eine Startposition eines im Signalrahmen existierenden Kerbbands anzeigen.

3. Verfahren nach Anspruch 1, wobei die L1-Signalisierungsinformationen Kerbbreiteninformationen umfassen, die eine Breite eines im Signalrahmen existierenden Kerbbands anzeigen.

4. Verfahren nach Anspruch 1, wobei die L1-Signalisierungsinformationen Kerbanzahlinformationen umfassen, die eine Anzahl von im Signalrahmen existierenden Kerbkanälen anzeigen.

5. Vorrichtung zum Senden eines Rundfunksignals an einen Empfänger, der das Rundfunksignal dekodiert, umfassend:

einen Eingabeprozessor zum Konvertieren eines Eingabestroms in einen Baseband-Rahmen, BB-Rahmen, einer Physical Layer Pipe, PLP;  
eine Kodierungseinheit zum Kodieren von Daten im BB-Rahmen der PLP durch ein Vorwärtsfehlerkorrektur-Schema, FEC-Schema;  
eine Abbildungseinrichtung zum Abbilden von Präambeldatenbits in Präambeldatensymbole und von Datenbits in Datensymbole;  
eine erste Zeitverschachtelungseinrichtung zum Zeitverschachteln der Datensymbole auf Datenscheibenniveau, wobei zumindest eine Datenscheibe auf der Grundlage der Datensymbole aufgebaut wird;  
eine zweite Zeitverschachtelungseinrichtung zum Zeitverschachteln der Präambeldatensymbole;  
eine Rahmenaufbaueinrichtung zum Aufbauen eines Signalrahmens auf der Grundlage der zeitverschachtelten Präambeldatensymbole und der zumindest einen Datenscheibe mit den zeitverschachtelten Datensymbolen;  
eine Modulationseinheit zum Modulieren des aufgebauten Signalrahmens durch ein Orthogonal-Frequency-Division-Multiplexing-Verfahren, OFDM-Verfahren; und  
eine Sendeeinheit zum Senden des modulierten Signalrahmens,

wobei ein Layer-1-Block, L1-Block, in den Präambeldatensymbolen im Frequenzbereich durch eine gleiche Bandbreite wiederholt wird, wobei die gleiche Bandbreite 7,61 MHz beträgt, und wobei, wenn zwei Teile aus wiederholten L1-Blöcken innerhalb eines Abstimmungsfensters des Empfängers umgeordnet sind, die umgeordneten Teile einen vollständigen L1-Block konfigurieren, wobei der L1-Block L1-Signalisierungsinformationen zum Signalisieren der Datenscheibe beinhaltet.

6. Vorrichtung nach Anspruch 5, wobei die L1-Signalisierungsinformationen Kerbstartinformationen umfassen, die eine Startposition eines im Signalrahmen existierenden Kerbbands anzeigen.

7. Vorrichtung nach Anspruch 5, wobei die L1-Signalisierungsinformationen Kerbbreiteninformationen umfassen, die eine Breite eines im Signalrahmen existierenden Kerbbands anzeigen.

8. Vorrichtung nach Anspruch 6, wobei die L1-Signalisierungsinformationen Kerbanzahlinformationen umfassen, die eine Anzahl von im Signalrahmen existierenden Kerbkanälen anzeigen.

9. Verfahren zum Empfangen eines Rundfunksignals in einem Empfänger, der das Rundfunksignal dekodiert, umfassend:

Demodulieren des Rundfunksignals anhand eines Orthogonal-Frequency-Division-Multiplexing-Verfahrens, OFDM-Verfahrens;  
Erlangen eines Signalrahmens aus dem demodulierten Rundfunksignal, wobei der Signalrahmen Präambeldatensymbole und Datensymbole umfasst, wobei die Datensymbole in zumindest einer Datenscheibe enthalten sind;  
Zeitentschachteln der Datensymbole auf Datenscheibenniveau;  
Zeitentschachteln der Präambelsymbole;  
Rückabbilden der zeitentschachtelten Datensymbole in Datenbits;  
Dekodieren der Datenbits anhand eines Low-Density-Parity-Check-Dekodierungsschemas und  
Konvertieren der dekodierten Datenbits in einen Basisband-Rahmen, BB-Rahmen, einer Physical Layer Pipe, PLP,

wobei ein Layer-1-Block, L1-Block, in den Präambeldatensymbolen im Frequenzbereich durch eine gleiche Bandbreite wiederholt wird, wobei die gleiche Bandbreite 7,61 MHz beträgt, und wobei, wenn zwei Teile aus wiederholten

L1-Blöcken innerhalb eines Abstimmungsfensters des Empfängers umgeordnet sind, die umgeordneten Teile einen vollständigen L1-Block konfigurieren, wobei der L1-Block L1-Signalisierungsinformationen zum Signalisieren der Datenscheibe beinhaltet.

- 5 10. Verfahren nach Anspruch 9, wobei die L1-Signalisierungsinformationen Kerbstartinformationen umfassen, die eine Startposition eines im Signalrahmen existierenden Kerbbands anzeigen.
11. Verfahren nach Anspruch 9, wobei die L1-Signalisierungsinformationen Kerbbreiteninformationen umfassen, die eine Breite eines im Signalrahmen existierenden Kerbbands anzeigen.
- 10 12. Verfahren nach Anspruch 9, wobei die L1-Signalisierungsinformationen Kerbanzahlinformationen umfassen, die eine Anzahl von im Signalrahmen existierenden Kerbkanälen anzeigen.
13. Empfänger zum Empfangen eines Rundfunksignals, umfassend:  
15 eine Demodulationseinheit zum Demodulieren des Rundfunksignals anhand eines Orthogonal-Frequency-Division-Multiplexing-Verfahrens, OFDM-Verfahrens;  
eine Erlangungseinheit zum Erlangen eines Signalrahmens aus dem demodulierten Rundfunksignal, wobei der Signalrahmen Präambeladatensymbole und Datensymbole umfasst, wobei die Datensymbole in zumindest einer  
20 Datenscheibe enthalten sind;  
eine erste Zeitentschachtelungseinheit zum Zeitentschachteln der Datensymbole auf Datenscheibenniveau;  
eine zweite Zeitentschachtelungseinheit zum Zeitentschachteln der Präambelsymbole;  
eine Rückabbildungseinheit zum Rückabbilden der zeitentschachtelten Datensymbole in Datenbits;  
eine Dekodierungseinheit zum Dekodieren der Datenbits anhand eines Low-Density-Parity-Check-Dekodierungsschemas;  
25 einen Ausgabeprozessor zum Konvertieren der dekodierten Datenbits in einen Baseband-Rahmen, BB-Rahmen, einer Physical Layer Pipe, PLP,  
wobei ein Layer-1-Block, L1-Block, in den Präambeladatensymbolen im Frequenzbereich durch eine gleiche Bandbreite wiederholt wird, wobei die gleiche Bandbreite 7,61 MHz beträgt, und wobei, wenn zwei Teile aus  
30 wiederholten L1-Blöcken innerhalb eines Abstimmungsfensters des Empfängers umgeordnet sind, die umgeordneten Teile einen vollständigen L1-Block konfigurieren, wobei der L1-Block L1-Signalisierungsinformationen zum Signalisieren der Datenscheibe beinhaltet.
14. Vorrichtung nach Anspruch 13, wobei die L1-Signalisierungsinformationen Kerbstartinformationen umfassen, die eine Startposition eines im Signalrahmen existierenden Kerbbands anzeigen.
- 35 15. Vorrichtung nach Anspruch 13, wobei die L1-Signalisierungsinformationen Kerbbreiteninformationen umfassen, die eine Breite eines im Signalrahmen existierenden Kerbbands anzeigen.
16. Vorrichtung nach Anspruch 13, wobei die L1-Signalisierungsinformationen Kerbanzahlinformationen umfassen, die eine Anzahl von im Signalrahmen existierenden Kerbkanälen anzeigen.
- 40

## Revendications

- 45 1. Procédé de transmission d'un signal de radiodiffusion à un récepteur décodant le signal de radiodiffusion, comprenant :  
la conversion d'un flux d'entrée en une trame de bande de base, BB, de pipeline de couche physique, PLP ;  
50 le codage de données dans la couche BB de PLP, par un schéma de correction d'erreurs sans voie de retour, FEC ;  
le mappage de bits de données de préambule dans des symboles de données de préambule et de bits de données dans des symboles de données ;  
la construction d'au moins une tranche de données sur la base des symboles de données ;  
55 l'entrelacement temporel des symboles de données à un niveau de tranche de données ;  
l'entrelacement temporel des symboles de données de préambule ;  
la construction d'une trame de signal sur la base des symboles de données de préambule entrelacés temporellement et de l'au moins une tranche de données ayant les symboles de données entrelacés temporellement ;

## EP 2 323 330 B1

la modulation de la trame de signal construite par un procédé de multiplexage par répartition en fréquence orthogonale, OFDM ; et  
la transmission de la trame de signal modulée,

dans lequel un bloc de couche 1, L1, est répété dans les symboles de données de préambule dans le domaine fréquentiel par une même bande passante, dans lequel la même bande passante est 7,61 MHz, et dans lequel, quand deux parties parmi des blocs de L1 répétés à l'intérieur d'une fenêtre de syntonisation du récepteur sont réordonnées, les parties réordonnées configurent un bloc de L1 complet, dans lequel le bloc de L1 inclut des informations de signalisation de L1 pour la signalisation de la tranche de données.

2. Procédé selon la revendication 1, dans lequel les informations de signalisation de L1 comprennent des informations de début de coupure indiquant une position de début d'une bande de coupure existant dans la trame de signal.

3. Procédé selon la revendication 1, dans lequel les informations de signalisation de L1 comprennent des informations de largeur de coupure indiquant une largeur d'une bande de coupure existant dans la trame de signal.

4. Procédé selon la revendication 1, dans lequel les informations de signalisation de L1 comprennent des informations de nombre de canaux coupe-bande existant dans la trame de signal.

5. Appareil pour transmettre un signal de radiodiffusion à un récepteur décodant le signal de radiodiffusion, comprenant :

un processeur d'entrée pour la conversion d'un flux d'entrée en une trame de bande de base, BB, de pipeline de couche physique, PLP ;

une unité de codage pour le codage de données dans la couche BB de PLP, par un schéma de correction d'erreurs sans voie de retour, FEC ;

un dispositif de mappage pour le mappage de bits de données de préambule dans des symboles de données de préambule et de bits de données dans des symboles de données ;

un premier dispositif d'entrelacement temporel pour l'entrelacement temporel de symboles de données à un niveau de tranche de données, dans lequel au moins une tranche de données est construite sur la base des symboles de données ;

un deuxième dispositif d'entrelacement temporel pour l'entrelacement temporel de symboles de données de préambule ;

un dispositif de construction de trame pour la construction d'une trame de signal sur la base des symboles de données de préambule entrelacés temporellement et de l'au moins une tranche de données ayant les symboles de données entrelacés temporellement ;

une unité de modulation pour la modulation de la trame de signal construite par un procédé de multiplexage par répartition en fréquence orthogonale, OFDM ; et

une unité de transmission pour la transmission de la trame de signal modulée,

dans lequel un bloc de couche 1, L1, est répété dans les symboles de données de préambule dans le domaine fréquentiel par une même bande passante, dans lequel la même bande passante est 7,61 MHz, et dans lequel, quand deux parties parmi des blocs de L1 répétés à l'intérieur d'une fenêtre de syntonisation du récepteur sont réordonnées, les parties réordonnées configurent un bloc de L1 complet, dans lequel le bloc de L1 inclut des informations de signalisation de L1 pour la signalisation de la tranche de données.

6. Appareil selon la revendication 5, dans lequel les informations de signalisation de L1 comprennent des informations de début de coupure indiquant une position de début d'une bande de coupure existant dans la trame de signal.

7. Appareil selon la revendication 5, dans lequel les informations de signalisation de L1 comprennent des informations de largeur de coupure indiquant une largeur d'une bande de coupure existant dans la trame de signal.

8. Appareil selon la revendication 6, dans lequel les informations de signalisation de L1 comprennent des informations de nombre de canaux coupe-bande existant dans la trame de signal.

9. Procédé de réception d'un signal de radiodiffusion dans un récepteur décodant le signal de radiodiffusion, comprenant :

la démodulation du signal de radiodiffusion en utilisant un procédé de multiplexage par répartition en fréquence orthogonale, OFDM ;  
 l'obtention d'une trame de signal à partir du signal de radiodiffusion démodulé, la trame de signal comprenant des symboles de données de préambule et des symboles de données, dans lequel les symboles de données sont inclus dans au moins une tranche de données ;  
 le désentrelacement temporel des symboles de données à un niveau de tranche de données ;  
 le désentrelacement temporel des symboles de préambule ;  
 le démappage des symboles de données désentrelacés temporellement en bits de données ;  
 le décodage des bits de données en utilisant un schéma de décodage à contrôle de parité à faible densité ; et  
 la conversion des bits de données décodés en une trame de bande de base, BB, de pipeline de couche physique, PLP,

dans lequel un bloc de couche 1, L1, est répété dans les symboles de données de préambule dans le domaine fréquentiel par une même bande passante, dans lequel la même bande passante est 7,61 MHz, et dans lequel, quand deux parties parmi des blocs de L1 répétés à l'intérieur d'une fenêtre de syntonisation du récepteur sont réordonnées, les parties réordonnées configurent un bloc de L1 complet, dans lequel le bloc de L1 inclut des informations de signalisation de L1 pour la signalisation de la tranche de données.

**10.** Procédé selon la revendication 9, dans lequel les informations de signalisation de L1 comprennent des informations de début de coupure indiquant une position de début d'une bande de coupure existant dans la trame de signal.

**11.** Procédé selon la revendication 9, dans lequel les informations de signalisation de L1 comprennent des informations de largeur de coupure indiquant une largeur d'une bande de coupure existant dans la trame de signal.

**12.** Procédé selon la revendication 9, dans lequel les informations de signalisation de L1 comprennent des informations de nombre de canaux coupe-bande existant dans la trame de signal.

**13.** Récepteur pour recevoir un signal de radiodiffusion, comprenant :

une unité de démodulation pour la démodulation du signal de radiodiffusion en utilisant un procédé de multiplexage par répartition en fréquence orthogonale, OFDM ;  
 une unité d'obtention pour l'obtention d'une trame de signal à partir du signal de radiodiffusion démodulé, la trame de signal comprenant des symboles de données de préambule et des symboles de données, dans lequel les symboles de données sont inclus dans au moins une tranche de données ;  
 un premier dispositif de désentrelacement temporel pour le désentrelacement temporel des symboles de données à un niveau de tranche de données ;  
 un deuxième dispositif de désentrelacement temporel pour le désentrelacement temporel des symboles de préambule ;  
 une unité de démappage pour le démappage des symboles de données désentrelacés temporellement en bits de données ;  
 une unité de décodage pour le décodage des bits de données en utilisant un schéma de décodage à contrôle de parité à faible densité ;  
 un processeur de sortie pour la conversion des bits de données décodés en une trame de bande de base, BB, de pipeline de couche physique, PLP,  
 dans lequel un bloc de couche 1, L1, est répété dans les symboles de données de préambule dans le domaine fréquentiel par une même bande passante, dans lequel la même bande passante est 7,61 MHz, et dans lequel, quand deux parties parmi des blocs de L1 répétés à l'intérieur d'une fenêtre de syntonisation du récepteur sont réordonnées, les parties réordonnées configurent un bloc de L1 complet, dans lequel le bloc de L1 inclut des informations de signalisation de L1 pour la signalisation de la tranche de données.

**14.** Appareil selon la revendication 13, dans lequel les informations de signalisation de L1 comprennent des informations de début de coupure indiquant une position de début d'une bande de coupure existant dans la trame de signal.

**15.** Appareil selon la revendication 13, dans lequel les informations de signalisation de L1 comprennent des informations de largeur de coupure indiquant une largeur d'une bande de coupure existant dans la trame de signal.

**16.** Appareil selon la revendication 13, dans lequel les informations de signalisation de L1 comprennent des informations de nombre de canaux coupe-bande existant dans la trame de signal.

Fig. 1

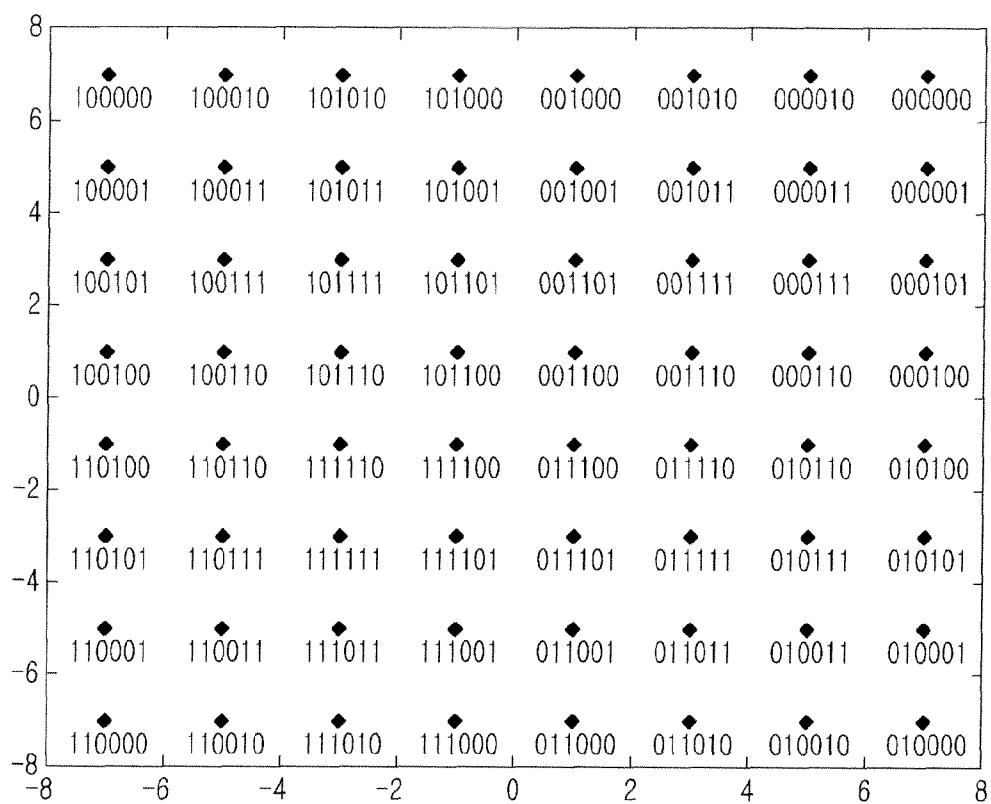


Fig. 2

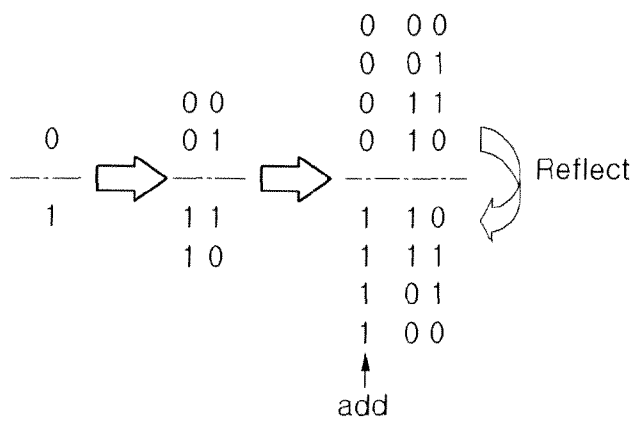


Fig. 3

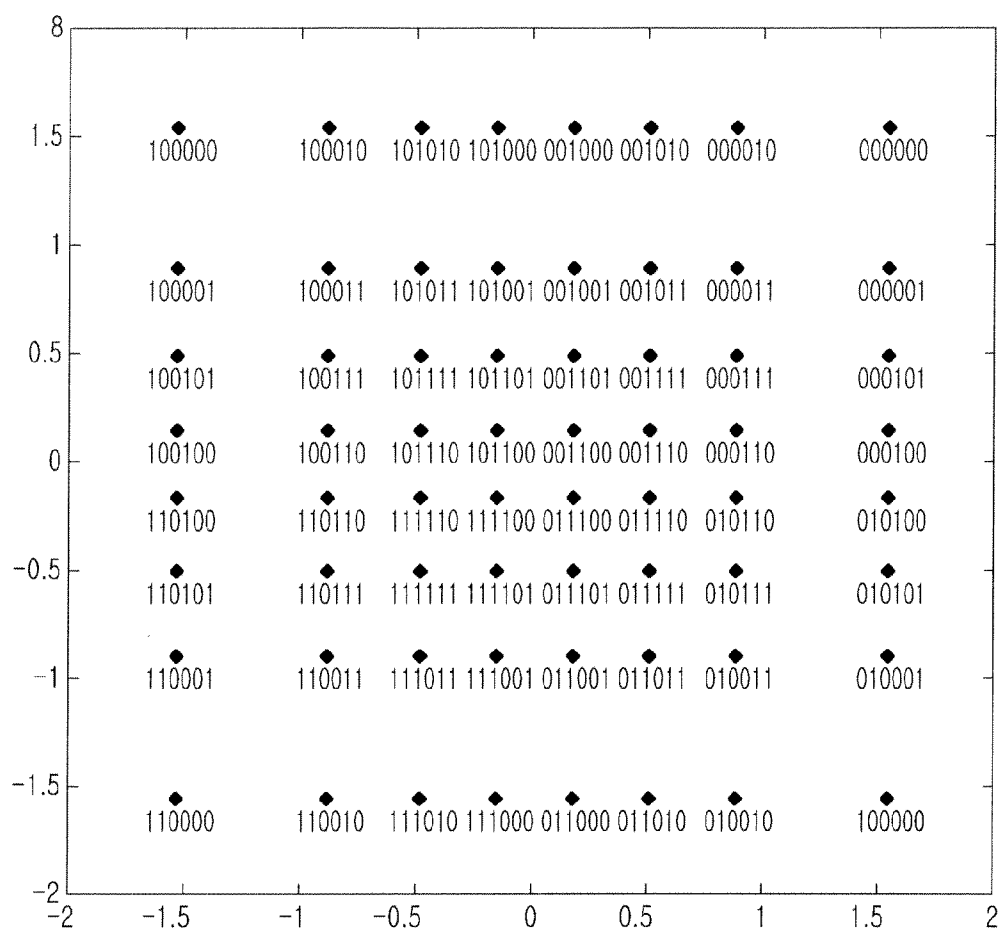


Fig. 4

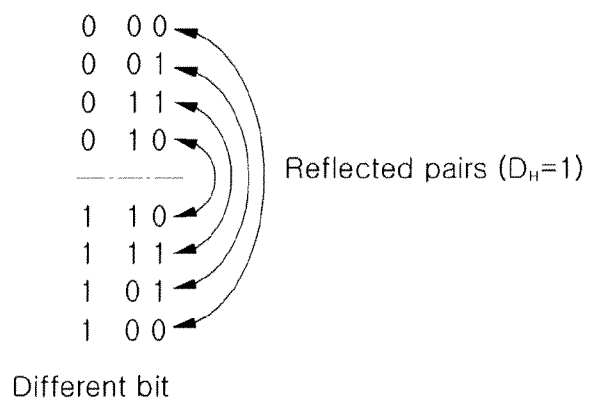


**Fig. 5**

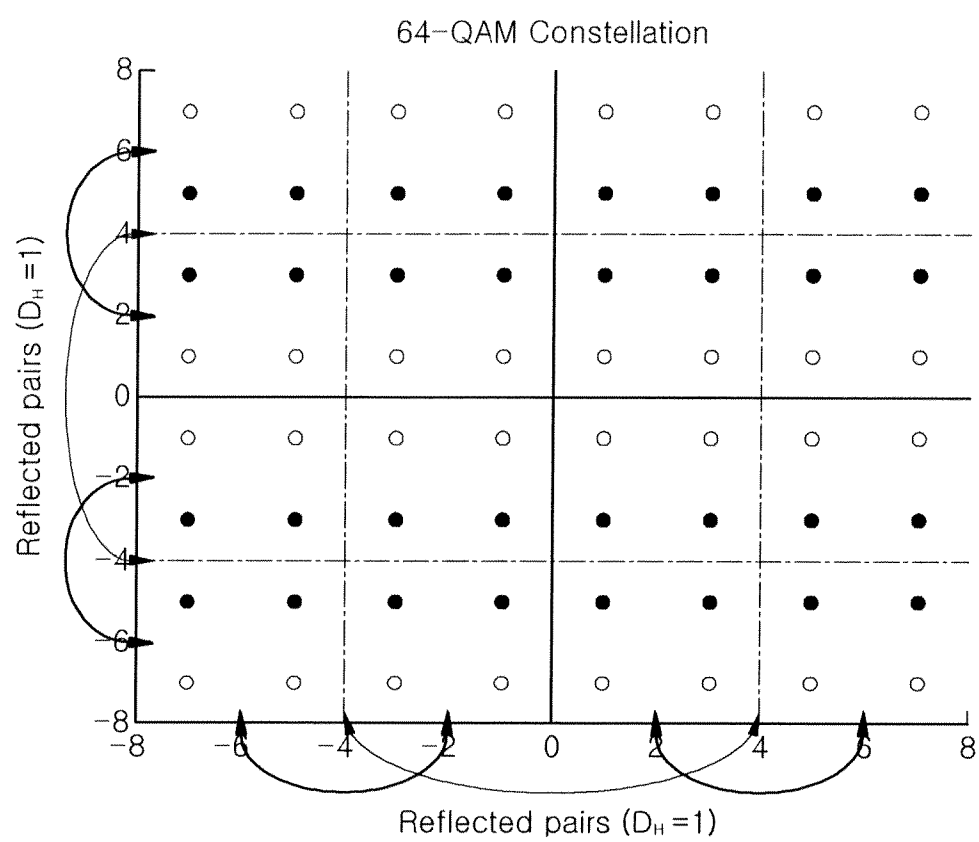
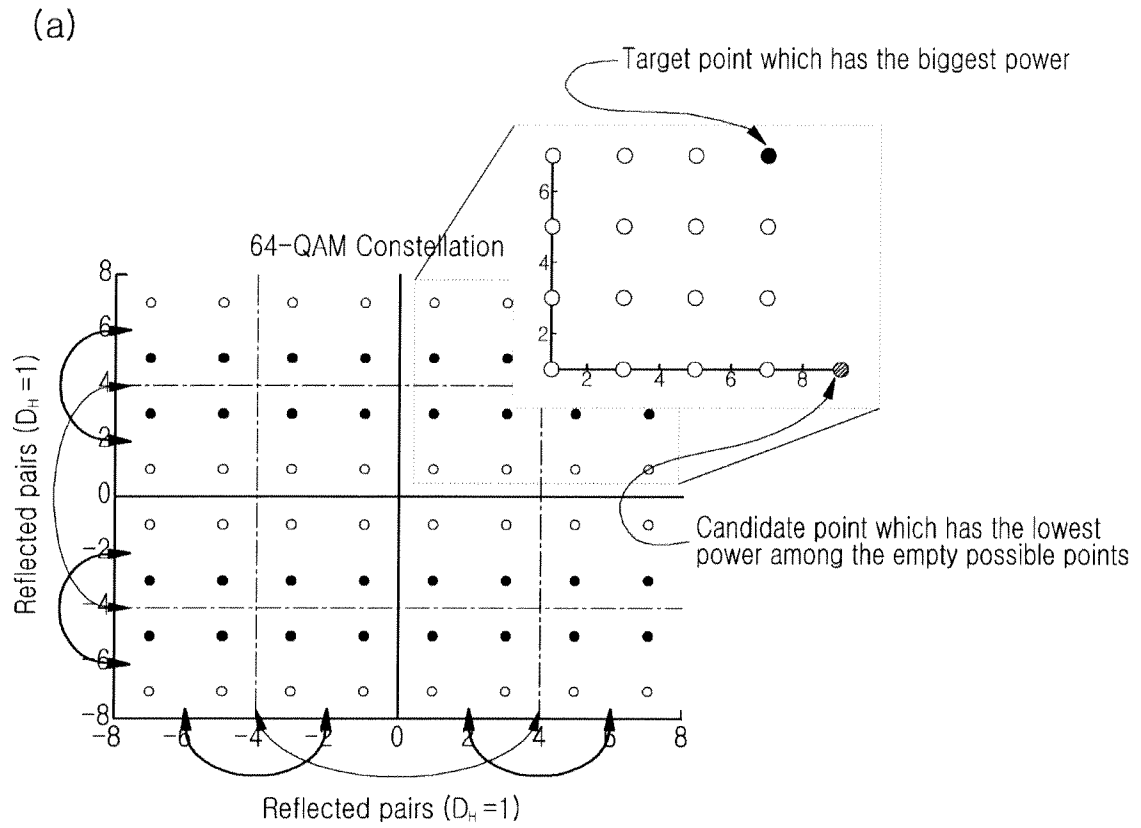


Fig. 6



(b)

\*Candidate point is the closest neighbor point of target point's reflected pair

Pt : Power of target point  
 Pc : Power of candidate point  
 Ps : Powers of each scatter points

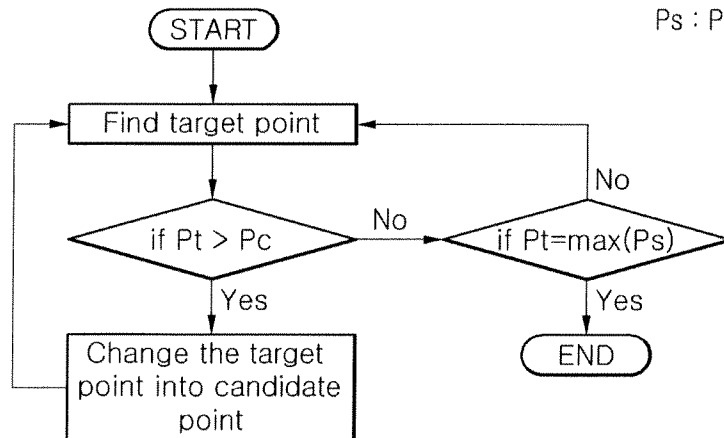


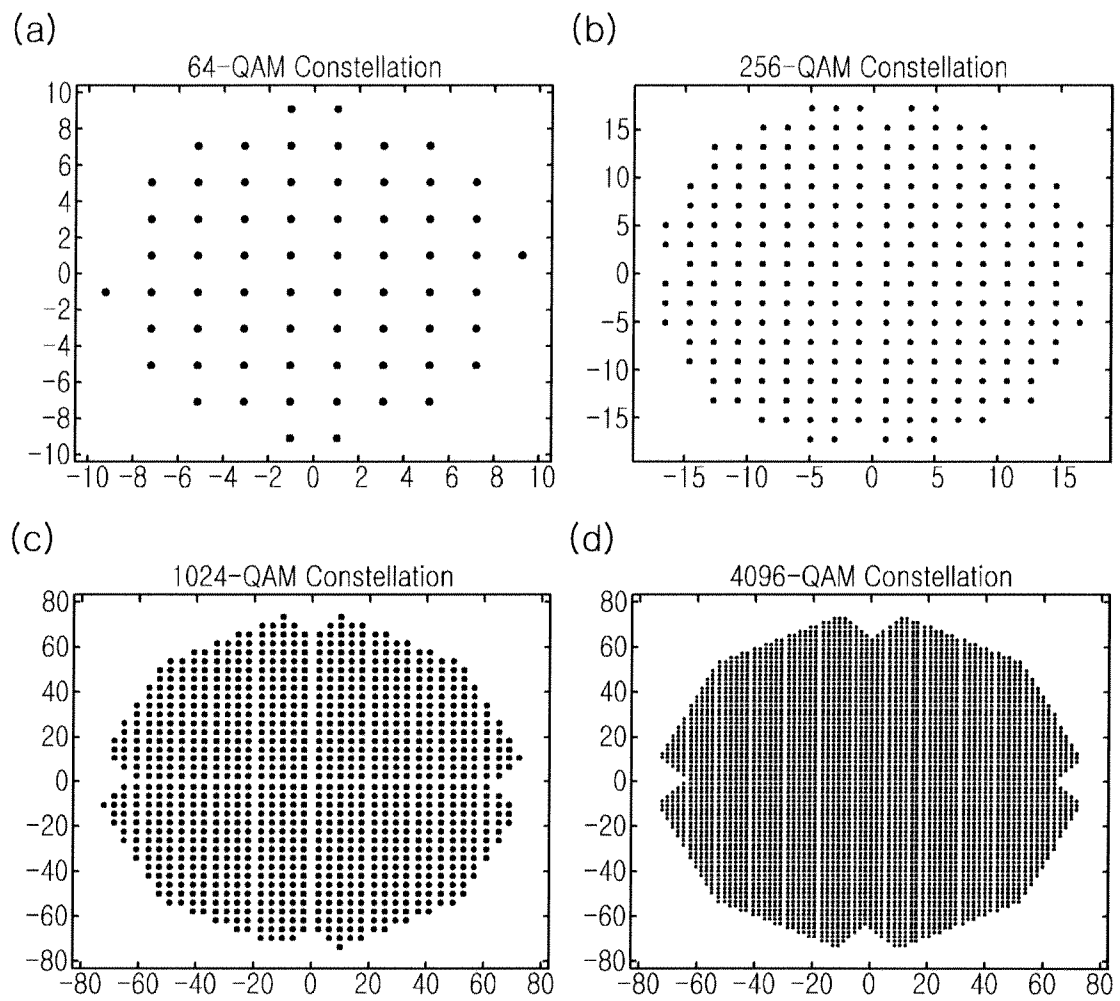
**Fig. 7**

Fig. 8

| Value | Scatter |
|-------|---------|
| 0     | 9 + 1i  |
| 1     | 7 + 5i  |
| 2     | 5 + 7i  |
| 3     | 5 + 5i  |
| 4     | 7 + 1i  |
| 5     | 7 + 3i  |
| 6     | 5 + 1i  |
| 7     | 5 + 3i  |
| 8     | 1 + 7i  |
| 9     | 1 + 5i  |
| 10    | 3 + 7i  |
| 11    | 3 + 5i  |
| 12    | 1 + 1i  |
| 13    | 1 + 3i  |
| 14    | 3 + 1i  |
| 15    | 3 + 3i  |
| 16    | 1 - 9i  |
| 17    | 7 - 5i  |
| 18    | 5 - 7i  |
| 19    | 5 - 5i  |
| 20    | 7 - 1i  |
| 21    | 7 - 3i  |
| 22    | 5 - 1i  |
| 23    | 5 - 3i  |
| 24    | 1 - 7i  |
| 25    | 1 - 5i  |
| 26    | 3 - 7i  |
| 27    | 3 - 5i  |
| 28    | 1 - 1i  |
| 29    | 1 - 3i  |
| 30    | 3 - 1i  |

Fig. 9

| Value | Scatter |
|-------|---------|
| 31    | 3 - 3i  |
| 32    | -1 + 9i |
| 33    | -7 + 5i |
| 34    | -5 + 7i |
| 35    | -5 + 5i |
| 36    | -7 + 1i |
| 37    | -7 + 3i |
| 38    | -5 + 1i |
| 39    | -5 + 3i |
| 40    | -1 + 7i |
| 41    | -1 + 5i |
| 42    | -3 + 7i |
| 43    | -3 + 5i |
| 44    | -1 + 1i |
| 45    | -1 + 3i |
| 46    | -3 + 1i |
| 47    | -3 + 3i |
| 48    | -9 - 1i |
| 49    | -7 - 5i |
| 50    | -5 - 7i |
| 51    | -5 - 5i |
| 52    | -7 - 1i |
| 53    | -7 - 3i |
| 54    | -5 - 1i |
| 55    | -5 - 3i |
| 56    | -1 - 7i |
| 57    | -1 - 5i |
| 58    | -3 - 7i |
| 59    | -3 - 5i |
| 60    | -1 - 1i |
| 61    | -1 - 3i |
| 62    | -3 - 1i |
| 63    | -3 - 3i |

Fig. 10

| Value | Scatter  | Value | Scatter  | Value | Scatter   | Value | Scatter   |
|-------|----------|-------|----------|-------|-----------|-------|-----------|
| 0     | 17 + 1i  | 64    | 1 - 17i  | 128   | -1 + 17i  | 192   | -17 - 1i  |
| 1     | 17 + 3i  | 65    | 17 - 3i  | 129   | -17 + 3i  | 193   | -17 - 3i  |
| 2     | 3 + 17i  | 66    | 3 - 17i  | 130   | -3 + 17i  | 194   | -3 - 17i  |
| 3     | 13 + 13i | 67    | 13 - 13i | 131   | -13 + 13i | 195   | -13 - 13i |
| 4     | 15 + 9i  | 68    | 15 - 9i  | 132   | -15 + 9i  | 196   | -15 - 9i  |
| 5     | 17 + 5i  | 69    | 17 - 5i  | 133   | -17 + 5i  | 197   | -17 - 5i  |
| 6     | 13 + 9i  | 70    | 13 - 9i  | 134   | -13 + 9i  | 198   | -13 - 9i  |
| 7     | 13 + 11i | 71    | 13 - 11i | 135   | -13 + 11i | 199   | -13 - 11i |
| 8     | 9 + 15i  | 72    | 9 - 15i  | 136   | -9 + 15i  | 200   | -9 - 15i  |
| 9     | 9 + 13i  | 73    | 9 - 13i  | 137   | -9 + 13i  | 201   | -9 - 13i  |
| 10    | 5 + 17i  | 74    | 5 - 17i  | 138   | -5 + 17i  | 202   | -5 - 17i  |
| 11    | 11 + 13i | 75    | 11 - 13i | 139   | -11 + 13i | 203   | -11 - 13i |
| 12    | 9 + 9i   | 76    | 9 - 9i   | 140   | -9 + 9i   | 204   | -9 - 9i   |
| 13    | 9 + 11i  | 77    | 9 - 11i  | 141   | -9 + 11i  | 205   | -9 - 11i  |
| 14    | 11 + 9i  | 78    | 11 - 9i  | 142   | -11 + 9i  | 206   | -11 - 9i  |
| 15    | 11 + 11i | 79    | 11 - 11i | 143   | -11 + 11i | 207   | -11 - 11i |
| 16    | 15 + 1i  | 80    | 15 - 1i  | 144   | -15 + 1i  | 208   | -15 - 1i  |
| 17    | 15 + 3i  | 81    | 15 - 3i  | 145   | -15 + 3i  | 209   | -15 - 3i  |
| 18    | 13 + 1i  | 82    | 13 - 1i  | 146   | -13 + 1i  | 210   | -13 - 1i  |
| 19    | 13 + 3i  | 83    | 13 - 3i  | 147   | -13 + 3i  | 211   | -13 - 3i  |
| 20    | 15 + 7i  | 84    | 15 - 7i  | 148   | -15 + 7i  | 212   | -15 - 7i  |
| 21    | 15 + 5i  | 85    | 15 - 5i  | 149   | -15 + 5i  | 213   | -15 - 5i  |
| 22    | 13 + 7i  | 86    | 13 - 7i  | 150   | -13 + 7i  | 214   | -13 - 7i  |
| 23    | 13 + 5i  | 87    | 13 - 5i  | 151   | -13 + 5i  | 215   | -13 - 5i  |
| 24    | 9 + 1i   | 88    | 9 - 1i   | 152   | -9 + 1i   | 216   | -9 - 1i   |
| 25    | 9 + 3i   | 89    | 9 - 3i   | 153   | -9 + 3i   | 217   | -9 - 3i   |
| 26    | 11 + 1i  | 90    | 11 - 1i  | 154   | -11 + 1i  | 218   | -11 - 1i  |
| 27    | 11 + 3i  | 91    | 11 - 3i  | 155   | -11 + 3i  | 219   | -11 - 3i  |
| 28    | 9 + 7i   | 92    | 9 - 7i   | 156   | -9 + 7i   | 220   | -9 - 7i   |
| 29    | 9 + 5i   | 93    | 9 - 5i   | 157   | -9 + 5i   | 221   | -9 - 5i   |
| 30    | 11 + 7i  | 94    | 11 - 7i  | 158   | -11 + 7i  | 222   | -11 - 7i  |

Fig. 11

|    |         |     |         |     |          |     |          |
|----|---------|-----|---------|-----|----------|-----|----------|
| 31 | 11 + 5i | 95  | 11 - 5i | 159 | -11 + 5i | 223 | -11 - 5i |
| 32 | 1 + 15i | 96  | 1 - 15i | 160 | -1 + 15i | 224 | -1 - 15i |
| 33 | 1 + 13i | 97  | 1 - 13i | 161 | -1 + 13i | 225 | -1 - 13i |
| 34 | 3 + 15i | 98  | 3 - 15i | 162 | -3 + 15i | 226 | -3 - 15i |
| 35 | 3 + 13i | 99  | 3 - 13i | 163 | -3 + 13i | 227 | -3 - 13i |
| 36 | 1 + 9i  | 100 | 1 - 9i  | 164 | -1 + 9i  | 228 | -1 - 9i  |
| 37 | 1 + 11i | 101 | 1 - 11i | 165 | -1 + 11i | 229 | -1 - 11i |
| 38 | 3 + 9i  | 102 | 3 - 9i  | 166 | -3 + 9i  | 230 | -3 - 9i  |
| 39 | 3 + 11i | 103 | 3 - 11i | 167 | -3 + 11i | 231 | -3 - 11i |
| 40 | 7 + 15i | 104 | 7 - 15i | 168 | -7 + 15i | 232 | -7 - 15i |
| 41 | 7 + 13i | 105 | 7 - 13i | 169 | -7 + 13i | 233 | -7 - 13i |
| 42 | 5 + 15i | 106 | 5 - 15i | 170 | -5 + 15i | 234 | -5 - 15i |
| 43 | 5 + 13i | 107 | 5 - 13i | 171 | -5 + 13i | 235 | -5 - 13i |
| 44 | 7 + 9i  | 108 | 7 - 9i  | 172 | -7 + 9i  | 236 | -7 - 9i  |
| 45 | 7 + 11i | 109 | 7 - 11i | 173 | -7 + 11i | 237 | -7 - 11i |
| 46 | 5 + 9i  | 110 | 5 - 9i  | 174 | -5 + 9i  | 238 | -5 - 9i  |
| 47 | 5 + 11i | 111 | 5 - 11i | 175 | -5 + 11i | 239 | -5 - 11i |
| 48 | 1 + 1i  | 112 | 1 - 1i  | 176 | -1 + 1i  | 240 | -1 - 1i  |
| 49 | 1 + 3i  | 113 | 1 - 3i  | 177 | -1 + 3i  | 241 | -1 - 3i  |
| 50 | 3 + 1i  | 114 | 3 - 1i  | 178 | -3 + 1i  | 242 | -3 - 1i  |
| 51 | 3 + 3i  | 115 | 3 - 3i  | 179 | -3 + 3i  | 243 | -3 - 3i  |
| 52 | 1 + 7i  | 116 | 1 - 7i  | 180 | -1 + 7i  | 244 | -1 - 7i  |
| 53 | 1 + 5i  | 117 | 1 - 5i  | 181 | -1 + 5i  | 245 | -1 - 5i  |
| 54 | 3 + 7i  | 118 | 3 - 7i  | 182 | -3 + 7i  | 246 | -3 - 7i  |
| 55 | 3 + 5i  | 119 | 3 - 5i  | 183 | -3 + 5i  | 247 | -3 - 5i  |
| 56 | 7 + 1i  | 120 | 7 - 1i  | 184 | -7 + 1i  | 248 | -7 - 1i  |
| 57 | 7 + 3i  | 121 | 7 - 3i  | 185 | -7 + 3i  | 249 | -7 - 3i  |
| 58 | 5 + 1i  | 122 | 5 - 1i  | 186 | -5 + 1i  | 250 | -5 - 1i  |
| 59 | 5 + 3i  | 123 | 5 - 3i  | 187 | -5 + 3i  | 251 | -5 - 3i  |
| 60 | 7 + 7i  | 124 | 7 - 7i  | 188 | -7 + 7i  | 252 | -7 - 7i  |
| 61 | 7 + 5i  | 125 | 7 - 5i  | 189 | -7 + 5i  | 253 | -7 - 5i  |
| 62 | 5 + 7i  | 126 | 5 - 7i  | 190 | -5 + 7i  | 254 | -5 - 7i  |
| 63 | 5 + 5i  | 127 | 5 - 5i  | 191 | -5 + 5i  | 255 | -5 - 5i  |



Fig. 13

|    |          |     |          |     |          |     |          |     |          |     |          |     |          |     |          |
|----|----------|-----|----------|-----|----------|-----|----------|-----|----------|-----|----------|-----|----------|-----|----------|
| 31 | 27 + 21i | 95  | 27 + 11i | 159 | 5 + 21i  | 223 | 5 + 11i  | 287 | 27 - 21i | 351 | 27 - 11i | 415 | 5 - 21i  | 479 | 5 - 11i  |
| 32 | 17 + 31i | 96  | 17 + 1i  | 160 | 15 + 31i | 224 | 15 + 1i  | 288 | 17 - 31i | 352 | 17 - 1i  | 416 | 15 - 31i | 480 | 15 - 1i  |
| 33 | 17 + 29i | 97  | 17 + 3i  | 161 | 15 + 29i | 225 | 15 + 3i  | 289 | 17 - 29i | 353 | 17 - 3i  | 417 | 15 - 29i | 481 | 15 - 3i  |
| 34 | 13 + 33i | 98  | 19 + 1i  | 162 | 13 + 31i | 226 | 13 + 1i  | 290 | 13 - 33i | 354 | 19 - 1i  | 418 | 13 - 31i | 482 | 13 - 1i  |
| 35 | 19 + 29i | 99  | 19 + 3i  | 163 | 13 + 29i | 227 | 13 + 3i  | 291 | 19 - 29i | 355 | 19 - 3i  | 419 | 13 - 29i | 483 | 13 - 3i  |
| 36 | 17 + 25i | 100 | 17 + 7i  | 164 | 15 + 25i | 228 | 15 + 7i  | 292 | 17 - 25i | 356 | 17 - 7i  | 420 | 15 - 25i | 484 | 15 - 7i  |
| 37 | 17 + 27i | 101 | 17 + 5i  | 165 | 15 + 27i | 229 | 15 + 5i  | 293 | 17 - 27i | 357 | 17 - 5i  | 421 | 15 - 27i | 485 | 15 - 5i  |
| 38 | 19 + 25i | 102 | 19 + 7i  | 166 | 13 + 25i | 230 | 13 + 7i  | 294 | 19 - 25i | 358 | 19 - 7i  | 422 | 13 - 25i | 486 | 13 - 7i  |
| 39 | 19 + 27i | 103 | 19 + 5i  | 167 | 13 + 27i | 231 | 13 + 5i  | 295 | 19 - 27i | 359 | 19 - 5i  | 423 | 13 - 27i | 487 | 13 - 5i  |
| 40 | 9 + 33i  | 104 | 23 + 1i  | 168 | 9 + 31i  | 232 | 9 + 1i   | 296 | 9 - 33i  | 360 | 23 - 1i  | 424 | 9 - 31i  | 488 | 9 - 1i   |
| 41 | 9 + 35i  | 105 | 23 + 3i  | 169 | 9 + 29i  | 233 | 9 + 3i   | 297 | 9 - 35i  | 361 | 23 - 3i  | 425 | 9 - 29i  | 489 | 9 - 3i   |
| 42 | 11 + 33i | 106 | 21 + 1i  | 170 | 11 + 31i | 234 | 11 + 1i  | 298 | 11 - 33i | 362 | 21 - 1i  | 426 | 11 - 31i | 490 | 11 - 1i  |
| 43 | 21 + 29i | 107 | 21 + 3i  | 171 | 11 + 29i | 235 | 11 + 3i  | 299 | 21 - 29i | 363 | 21 - 3i  | 427 | 11 - 29i | 491 | 11 - 3i  |
| 44 | 23 + 25i | 108 | 23 + 7i  | 172 | 9 + 25i  | 236 | 9 + 7i   | 300 | 23 - 25i | 364 | 23 - 7i  | 428 | 9 - 25i  | 492 | 9 - 7i   |
| 45 | 23 + 27i | 109 | 23 + 5i  | 173 | 9 + 27i  | 237 | 9 + 5i   | 301 | 23 - 27i | 365 | 23 - 5i  | 429 | 9 - 27i  | 493 | 9 - 5i   |
| 46 | 21 + 25i | 110 | 21 + 7i  | 174 | 11 + 25i | 238 | 11 + 7i  | 302 | 21 - 25i | 366 | 21 - 7i  | 430 | 11 - 25i | 494 | 11 - 7i  |
| 47 | 21 + 27i | 111 | 21 + 5i  | 175 | 11 + 27i | 239 | 11 + 5i  | 303 | 21 - 27i | 367 | 21 - 5i  | 431 | 11 - 27i | 495 | 11 - 5i  |
| 48 | 17 + 17i | 112 | 17 + 15i | 176 | 15 + 17i | 240 | 15 + 15i | 304 | 17 - 17i | 368 | 17 - 15i | 432 | 15 - 17i | 496 | 15 - 15i |
| 49 | 17 + 19i | 113 | 17 + 13i | 177 | 15 + 19i | 241 | 15 + 13i | 305 | 17 - 19i | 369 | 17 - 13i | 433 | 15 - 19i | 497 | 15 - 13i |
| 50 | 19 + 17i | 114 | 19 + 15i | 178 | 13 + 17i | 242 | 13 + 15i | 306 | 19 - 17i | 370 | 19 - 15i | 434 | 13 - 17i | 498 | 13 - 15i |
| 51 | 19 + 19i | 115 | 19 + 13i | 179 | 13 + 19i | 243 | 13 + 13i | 307 | 19 - 19i | 371 | 19 - 13i | 435 | 13 - 19i | 499 | 13 - 13i |
| 52 | 17 + 23i | 116 | 17 + 9i  | 180 | 15 + 23i | 244 | 15 + 9i  | 308 | 17 - 23i | 372 | 17 - 9i  | 436 | 15 - 23i | 500 | 15 - 9i  |
| 53 | 17 + 21i | 117 | 17 + 11i | 181 | 15 + 21i | 245 | 15 + 11i | 309 | 17 - 21i | 373 | 17 - 11i | 437 | 15 - 21i | 501 | 15 - 11i |
| 54 | 19 + 23i | 118 | 19 + 9i  | 182 | 13 + 23i | 246 | 13 + 9i  | 310 | 19 - 23i | 374 | 19 - 9i  | 438 | 13 - 23i | 502 | 13 - 9i  |
| 55 | 19 + 21i | 119 | 19 + 11i | 183 | 13 + 21i | 247 | 13 + 11i | 311 | 19 - 21i | 375 | 19 - 11i | 439 | 13 - 21i | 503 | 13 - 11i |
| 56 | 23 + 17i | 120 | 23 + 15i | 184 | 9 + 17i  | 248 | 9 + 15i  | 312 | 23 - 17i | 376 | 23 - 15i | 440 | 9 - 17i  | 504 | 9 - 15i  |
| 57 | 23 + 19i | 121 | 23 + 13i | 185 | 9 + 19i  | 249 | 9 + 13i  | 313 | 23 - 19i | 377 | 23 - 13i | 441 | 9 - 19i  | 505 | 9 - 13i  |
| 58 | 21 + 17i | 122 | 21 + 15i | 186 | 11 + 17i | 250 | 11 + 15i | 314 | 21 - 17i | 378 | 21 - 15i | 442 | 11 - 17i | 506 | 11 - 15i |
| 59 | 21 + 19i | 123 | 21 + 13i | 187 | 11 + 19i | 251 | 11 + 13i | 315 | 21 - 19i | 379 | 21 - 13i | 443 | 11 - 19i | 507 | 11 - 13i |
| 60 | 23 + 23i | 124 | 23 + 9i  | 188 | 9 + 23i  | 252 | 9 + 9i   | 316 | 23 - 23i | 380 | 23 - 9i  | 444 | 9 - 23i  | 508 | 9 - 9i   |
| 61 | 23 + 21i | 125 | 23 + 11i | 189 | 9 + 21i  | 253 | 9 + 11i  | 317 | 23 - 21i | 381 | 23 - 11i | 445 | 9 - 21i  | 509 | 9 - 11i  |
| 62 | 21 + 23i | 126 | 21 + 9i  | 190 | 11 + 23i | 254 | 11 + 9i  | 318 | 21 - 23i | 382 | 21 - 9i  | 446 | 11 - 23i | 510 | 11 - 9i  |
| 63 | 21 + 21i | 127 | 21 + 11i | 191 | 11 + 21i | 255 | 11 + 11i | 319 | 21 - 21i | 383 | 21 - 11i | 447 | 11 - 21i | 511 | 11 - 11i |

29

30

Fig. 16

|    |          |     |          |     |          |     |          |     |          |     |          |     |          |     |          |
|----|----------|-----|----------|-----|----------|-----|----------|-----|----------|-----|----------|-----|----------|-----|----------|
| 31 | 69 + 11i | 95  | 69 + 21i | 159 | 37 + 53i | 223 | 37 + 43i | 287 | 59 + 11i | 351 | 59 + 21i | 415 | 37 + 11i | 479 | 37 + 21i |
| 32 | 15 + 65i | 96  | 49 + 33i | 160 | 17 + 65i | 224 | 47 + 33i | 288 | 49 + 11i | 352 | 49 + 31i | 416 | 47 + 11i | 480 | 47 + 31i |
| 33 | 15 + 67i | 97  | 49 + 35i | 161 | 17 + 67i | 225 | 47 + 35i | 289 | 49 + 3i  | 353 | 49 + 29i | 417 | 47 + 3i  | 481 | 47 + 29i |
| 34 | 13 + 65i | 98  | 51 + 33i | 162 | 19 + 65i | 226 | 45 + 33i | 290 | 51 + 11i | 354 | 51 + 31i | 418 | 45 + 11i | 482 | 45 + 31i |
| 35 | 13 + 67i | 99  | 51 + 35i | 163 | 19 + 67i | 227 | 45 + 35i | 291 | 51 + 3i  | 355 | 51 + 29i | 419 | 45 + 3i  | 483 | 45 + 29i |
| 36 | 15 + 71i | 100 | 49 + 39i | 164 | 17 + 71i | 228 | 47 + 39i | 292 | 49 + 7i  | 356 | 49 + 25i | 420 | 47 + 7i  | 484 | 47 + 25i |
| 37 | 15 + 69i | 101 | 49 + 37i | 165 | 17 + 69i | 229 | 47 + 37i | 293 | 49 + 5i  | 357 | 49 + 27i | 421 | 47 + 5i  | 485 | 47 + 27i |
| 38 | 13 + 71i | 102 | 51 + 39i | 166 | 45 + 57i | 230 | 45 + 39i | 294 | 51 + 7i  | 358 | 51 + 25i | 422 | 45 + 7i  | 486 | 45 + 25i |
| 39 | 13 + 69i | 103 | 51 + 37i | 167 | 19 + 69i | 231 | 45 + 37i | 295 | 51 + 5i  | 359 | 51 + 27i | 423 | 45 + 5i  | 487 | 45 + 27i |
| 40 | 9 + 65i  | 104 | 55 + 33i | 168 | 23 + 65i | 232 | 41 + 33i | 296 | 55 + 11i | 360 | 55 + 31i | 424 | 41 + 11i | 488 | 41 + 31i |
| 41 | 9 + 67i  | 105 | 55 + 35i | 169 | 23 + 67i | 233 | 41 + 35i | 297 | 55 + 3i  | 361 | 55 + 29i | 425 | 41 + 3i  | 489 | 41 + 29i |
| 42 | 11 + 65i | 106 | 53 + 33i | 170 | 21 + 65i | 234 | 43 + 33i | 298 | 53 + 11i | 362 | 53 + 31i | 426 | 43 + 11i | 490 | 43 + 31i |
| 43 | 11 + 67i | 107 | 53 + 35i | 171 | 21 + 67i | 235 | 43 + 35i | 299 | 53 + 3i  | 363 | 53 + 29i | 427 | 43 + 3i  | 491 | 43 + 29i |
| 44 | 9 + 71i  | 108 | 55 + 39i | 172 | 41 + 57i | 236 | 41 + 39i | 300 | 55 + 7i  | 364 | 55 + 25i | 428 | 41 + 7i  | 492 | 41 + 25i |
| 45 | 9 + 69i  | 109 | 55 + 37i | 173 | 41 + 59i | 237 | 41 + 37i | 301 | 55 + 5i  | 365 | 55 + 27i | 429 | 41 + 5i  | 493 | 41 + 27i |
| 46 | 11 + 71i | 110 | 53 + 39i | 174 | 43 + 57i | 238 | 43 + 39i | 302 | 53 + 7i  | 366 | 53 + 25i | 430 | 43 + 7i  | 494 | 43 + 25i |
| 47 | 11 + 69i | 111 | 53 + 37i | 175 | 21 + 69i | 239 | 43 + 37i | 303 | 53 + 5i  | 367 | 53 + 27i | 431 | 43 + 5i  | 495 | 43 + 27i |
| 48 | 49 + 49i | 112 | 49 + 47i | 176 | 47 + 49i | 240 | 47 + 47i | 304 | 49 + 15i | 368 | 49 + 17i | 432 | 47 + 15i | 496 | 47 + 17i |
| 49 | 49 + 51i | 113 | 49 + 45i | 177 | 47 + 51i | 241 | 47 + 45i | 305 | 49 + 13i | 369 | 49 + 19i | 433 | 47 + 13i | 497 | 47 + 19i |
| 50 | 51 + 49i | 114 | 51 + 47i | 178 | 45 + 49i | 242 | 45 + 47i | 306 | 51 + 15i | 370 | 51 + 17i | 434 | 45 + 15i | 498 | 45 + 17i |
| 51 | 51 + 51i | 115 | 51 + 45i | 179 | 45 + 51i | 243 | 45 + 45i | 307 | 51 + 13i | 371 | 51 + 19i | 435 | 45 + 13i | 499 | 45 + 19i |
| 52 | 49 + 55i | 116 | 49 + 41i | 180 | 47 + 55i | 244 | 47 + 41i | 308 | 49 + 9i  | 372 | 49 + 23i | 436 | 47 + 9i  | 500 | 47 + 23i |
| 53 | 49 + 53i | 117 | 49 + 43i | 181 | 47 + 53i | 245 | 47 + 43i | 309 | 49 + 11i | 373 | 49 + 21i | 437 | 47 + 11i | 501 | 47 + 21i |
| 54 | 13 + 73i | 118 | 51 + 41i | 182 | 45 + 55i | 246 | 45 + 41i | 310 | 51 + 9i  | 374 | 51 + 23i | 438 | 45 + 9i  | 502 | 45 + 23i |
| 55 | 51 + 53i | 119 | 51 + 43i | 183 | 45 + 53i | 247 | 45 + 43i | 311 | 51 + 11i | 375 | 51 + 21i | 439 | 45 + 11i | 503 | 45 + 21i |
| 56 | 55 + 49i | 120 | 55 + 47i | 184 | 41 + 49i | 248 | 41 + 47i | 312 | 55 + 15i | 376 | 55 + 17i | 440 | 41 + 15i | 504 | 41 + 17i |
| 57 | 73 + 13i | 121 | 55 + 45i | 185 | 41 + 51i | 249 | 41 + 45i | 313 | 55 + 13i | 377 | 55 + 19i | 441 | 41 + 13i | 505 | 41 + 19i |
| 58 | 53 + 49i | 122 | 53 + 47i | 186 | 43 + 49i | 250 | 43 + 47i | 314 | 53 + 15i | 378 | 53 + 17i | 442 | 43 + 15i | 506 | 43 + 17i |
| 59 | 53 + 51i | 123 | 53 + 45i | 187 | 43 + 51i | 251 | 43 + 45i | 315 | 53 + 13i | 379 | 53 + 19i | 443 | 43 + 13i | 507 | 43 + 19i |
| 60 | 73 + 9i  | 124 | 55 + 41i | 188 | 41 + 55i | 252 | 41 + 41i | 316 | 55 + 9i  | 380 | 55 + 23i | 444 | 41 + 9i  | 508 | 41 + 23i |
| 61 | 73 + 11i | 125 | 55 + 43i | 189 | 41 + 53i | 253 | 41 + 43i | 317 | 55 + 11i | 381 | 55 + 21i | 445 | 41 + 11i | 509 | 41 + 21i |
| 62 | 11 + 73i | 126 | 53 + 41i | 190 | 43 + 55i | 254 | 43 + 41i | 318 | 53 + 9i  | 382 | 53 + 23i | 446 | 43 + 9i  | 510 | 43 + 23i |
| 63 | 53 + 53i | 127 | 53 + 43i | 191 | 43 + 53i | 255 | 43 + 43i | 319 | 53 + 11i | 383 | 53 + 21i | 447 | 43 + 11i | 511 | 43 + 21i |

Fig. 17

|    |          |     |          |     |          |     |          |     |          |     |          |     |          |     |          |
|----|----------|-----|----------|-----|----------|-----|----------|-----|----------|-----|----------|-----|----------|-----|----------|
| 31 | 69 + 11i | 95  | 69 + 21i | 159 | 37 + 53i | 223 | 37 + 43i | 287 | 59 + 11i | 351 | 59 + 21i | 415 | 37 + 11i | 479 | 37 + 21i |
| 32 | 15 + 65i | 96  | 49 + 33i | 160 | 17 + 65i | 224 | 47 + 33i | 288 | 49 + 11i | 352 | 49 + 31i | 416 | 47 + 11i | 480 | 47 + 31i |
| 33 | 15 + 67i | 97  | 49 + 35i | 161 | 17 + 67i | 225 | 47 + 35i | 289 | 49 + 3i  | 353 | 49 + 29i | 417 | 47 + 3i  | 481 | 47 + 29i |
| 34 | 13 + 65i | 98  | 51 + 33i | 162 | 19 + 65i | 226 | 45 + 33i | 290 | 51 + 11i | 354 | 51 + 31i | 418 | 45 + 11i | 482 | 45 + 31i |
| 35 | 13 + 67i | 99  | 51 + 35i | 163 | 19 + 67i | 227 | 45 + 35i | 291 | 51 + 3i  | 355 | 51 + 29i | 419 | 45 + 3i  | 483 | 45 + 29i |
| 36 | 15 + 71i | 100 | 49 + 39i | 164 | 17 + 71i | 228 | 47 + 39i | 292 | 49 + 7i  | 356 | 49 + 25i | 420 | 47 + 7i  | 484 | 47 + 25i |
| 37 | 15 + 69i | 101 | 49 + 37i | 165 | 17 + 69i | 229 | 47 + 37i | 293 | 49 + 5i  | 357 | 49 + 27i | 421 | 47 + 5i  | 485 | 47 + 27i |
| 38 | 13 + 71i | 102 | 51 + 39i | 166 | 45 + 57i | 230 | 45 + 39i | 294 | 51 + 7i  | 358 | 51 + 25i | 422 | 45 + 7i  | 486 | 45 + 25i |
| 39 | 13 + 69i | 103 | 51 + 37i | 167 | 19 + 69i | 231 | 45 + 37i | 295 | 51 + 5i  | 359 | 51 + 27i | 423 | 45 + 5i  | 487 | 45 + 27i |
| 40 | 9 + 65i  | 104 | 55 + 33i | 168 | 23 + 65i | 232 | 41 + 33i | 296 | 55 + 11i | 360 | 55 + 31i | 424 | 41 + 11i | 488 | 41 + 31i |
| 41 | 9 + 67i  | 105 | 55 + 35i | 169 | 23 + 67i | 233 | 41 + 35i | 297 | 55 + 3i  | 361 | 55 + 29i | 425 | 41 + 3i  | 489 | 41 + 29i |
| 42 | 11 + 65i | 106 | 53 + 33i | 170 | 21 + 65i | 234 | 43 + 33i | 298 | 53 + 11i | 362 | 53 + 31i | 426 | 43 + 11i | 490 | 43 + 31i |
| 43 | 11 + 67i | 107 | 53 + 35i | 171 | 21 + 67i | 235 | 43 + 35i | 299 | 53 + 3i  | 363 | 53 + 29i | 427 | 43 + 3i  | 491 | 43 + 29i |
| 44 | 9 + 71i  | 108 | 55 + 39i | 172 | 41 + 57i | 236 | 41 + 39i | 300 | 55 + 7i  | 364 | 55 + 25i | 428 | 41 + 7i  | 492 | 41 + 25i |
| 45 | 9 + 69i  | 109 | 55 + 37i | 173 | 41 + 59i | 237 | 41 + 37i | 301 | 55 + 5i  | 365 | 55 + 27i | 429 | 41 + 5i  | 493 | 41 + 27i |
| 46 | 11 + 71i | 110 | 53 + 39i | 174 | 43 + 57i | 238 | 43 + 39i | 302 | 53 + 7i  | 366 | 53 + 25i | 430 | 43 + 7i  | 494 | 43 + 25i |
| 47 | 11 + 69i | 111 | 53 + 37i | 175 | 21 + 69i | 239 | 43 + 37i | 303 | 53 + 5i  | 367 | 53 + 27i | 431 | 43 + 5i  | 495 | 43 + 27i |
| 48 | 49 + 49i | 112 | 49 + 47i | 176 | 47 + 49i | 240 | 47 + 47i | 304 | 49 + 15i | 368 | 49 + 17i | 432 | 47 + 15i | 496 | 47 + 17i |
| 49 | 49 + 51i | 113 | 49 + 45i | 177 | 47 + 51i | 241 | 47 + 45i | 305 | 49 + 13i | 369 | 49 + 19i | 433 | 47 + 13i | 497 | 47 + 19i |
| 50 | 51 + 49i | 114 | 51 + 47i | 178 | 45 + 49i | 242 | 45 + 47i | 306 | 51 + 15i | 370 | 51 + 17i | 434 | 45 + 15i | 498 | 45 + 17i |
| 51 | 51 + 51i | 115 | 51 + 45i | 179 | 45 + 51i | 243 | 45 + 45i | 307 | 51 + 13i | 371 | 51 + 19i | 435 | 45 + 13i | 499 | 45 + 19i |
| 52 | 49 + 55i | 116 | 49 + 41i | 180 | 47 + 55i | 244 | 47 + 41i | 308 | 49 + 9i  | 372 | 49 + 23i | 436 | 47 + 9i  | 500 | 47 + 23i |
| 53 | 49 + 53i | 117 | 49 + 43i | 181 | 47 + 53i | 245 | 47 + 43i | 309 | 49 + 11i | 373 | 49 + 21i | 437 | 47 + 11i | 501 | 47 + 21i |
| 54 | 13 + 73i | 118 | 51 + 41i | 182 | 45 + 55i | 246 | 45 + 41i | 310 | 51 + 9i  | 374 | 51 + 23i | 438 | 45 + 9i  | 502 | 45 + 23i |
| 55 | 51 + 53i | 119 | 51 + 43i | 183 | 45 + 53i | 247 | 45 + 43i | 311 | 51 + 11i | 375 | 51 + 21i | 439 | 45 + 11i | 503 | 45 + 21i |
| 56 | 55 + 49i | 120 | 55 + 47i | 184 | 41 + 49i | 248 | 41 + 47i | 312 | 55 + 15i | 376 | 55 + 17i | 440 | 41 + 15i | 504 | 41 + 17i |
| 57 | 73 + 13i | 121 | 55 + 45i | 185 | 41 + 51i | 249 | 41 + 45i | 313 | 55 + 13i | 377 | 55 + 19i | 441 | 41 + 13i | 505 | 41 + 19i |
| 58 | 53 + 49i | 122 | 53 + 47i | 186 | 43 + 49i | 250 | 43 + 47i | 314 | 53 + 15i | 378 | 53 + 17i | 442 | 43 + 15i | 506 | 43 + 17i |
| 59 | 53 + 51i | 123 | 53 + 45i | 187 | 43 + 51i | 251 | 43 + 45i | 315 | 53 + 13i | 379 | 53 + 19i | 443 | 43 + 13i | 507 | 43 + 19i |
| 60 | 73 + 9i  | 124 | 55 + 41i | 188 | 41 + 55i | 252 | 41 + 41i | 316 | 55 + 9i  | 380 | 55 + 23i | 444 | 41 + 9i  | 508 | 41 + 23i |
| 61 | 73 + 11i | 125 | 55 + 43i | 189 | 41 + 53i | 253 | 41 + 43i | 317 | 55 + 11i | 381 | 55 + 21i | 445 | 41 + 11i | 509 | 41 + 21i |
| 62 | 11 + 73i | 126 | 53 + 41i | 190 | 43 + 55i | 254 | 43 + 41i | 318 | 53 + 9i  | 382 | 53 + 23i | 446 | 43 + 9i  | 510 | 43 + 23i |
| 63 | 53 + 53i | 127 | 53 + 43i | 191 | 43 + 53i | 255 | 43 + 43i | 319 | 53 + 11i | 383 | 53 + 21i | 447 | 43 + 11i | 511 | 43 + 21i |

| Value | Scatter | Value | Scatter | Value | Scatter  | Value | Scatter  | Value | Scatter | Value | Scatter | Value | Scatter  | Value | Scatter  | Value | Scatter  |
|-------|---------|-------|---------|-------|----------|-------|----------|-------|---------|-------|---------|-------|----------|-------|----------|-------|----------|
| 512   | 1 + 63i | 576   | 1 + 33i | 640   | 31 + 63i | 704   | 31 + 33i | 768   | 1 + 1i  | 832   | 1 + 31i | 896   | 31 + 1i  | 960   | 31 + 31i | 960   | 31 + 31i |
| 513   | 1 + 61i | 577   | 1 + 35i | 641   | 31 + 61i | 705   | 31 + 35i | 769   | 1 + 3i  | 833   | 1 + 29i | 897   | 31 + 3i  | 961   | 31 + 29i | 961   | 31 + 29i |
| 514   | 3 + 63i | 578   | 3 + 33i | 642   | 29 + 63i | 706   | 29 + 33i | 770   | 3 + 1i  | 834   | 3 + 31i | 898   | 29 + 1i  | 962   | 29 + 31i | 962   | 29 + 31i |
| 515   | 3 + 61i | 579   | 3 + 35i | 643   | 29 + 61i | 707   | 29 + 35i | 771   | 3 + 3i  | 835   | 3 + 29i | 899   | 29 + 3i  | 963   | 29 + 29i | 963   | 29 + 29i |
| 516   | 1 + 57i | 580   | 1 + 39i | 644   | 31 + 57i | 708   | 31 + 39i | 772   | 1 + 7i  | 836   | 1 + 25i | 900   | 31 + 7i  | 964   | 31 + 25i | 964   | 31 + 25i |
| 517   | 1 + 59i | 581   | 1 + 37i | 645   | 31 + 59i | 709   | 31 + 37i | 773   | 1 + 5i  | 837   | 1 + 27i | 901   | 31 + 5i  | 965   | 31 + 27i | 965   | 31 + 27i |
| 518   | 3 + 57i | 582   | 3 + 39i | 646   | 29 + 57i | 710   | 29 + 39i | 774   | 3 + 7i  | 838   | 3 + 25i | 902   | 29 + 7i  | 966   | 29 + 25i | 966   | 29 + 25i |
| 519   | 3 + 59i | 583   | 3 + 37i | 647   | 29 + 59i | 711   | 29 + 37i | 775   | 3 + 5i  | 839   | 3 + 27i | 903   | 29 + 5i  | 967   | 29 + 27i | 967   | 29 + 27i |
| 520   | 7 + 63i | 584   | 7 + 33i | 648   | 25 + 63i | 712   | 25 + 33i | 776   | 7 + 1i  | 840   | 7 + 31i | 904   | 25 + 1i  | 968   | 25 + 31i | 968   | 25 + 31i |
| 521   | 7 + 61i | 585   | 7 + 35i | 649   | 25 + 61i | 713   | 25 + 35i | 777   | 7 + 3i  | 841   | 7 + 29i | 905   | 25 + 3i  | 969   | 25 + 29i | 969   | 25 + 29i |
| 522   | 5 + 63i | 586   | 5 + 33i | 650   | 27 + 63i | 714   | 27 + 33i | 778   | 5 + 1i  | 842   | 5 + 31i | 906   | 27 + 1i  | 970   | 27 + 31i | 970   | 27 + 31i |
| 523   | 5 + 61i | 587   | 5 + 35i | 651   | 27 + 61i | 715   | 27 + 35i | 779   | 5 + 3i  | 843   | 5 + 29i | 907   | 27 + 3i  | 971   | 27 + 29i | 971   | 27 + 29i |
| 524   | 7 + 57i | 588   | 7 + 39i | 652   | 25 + 57i | 716   | 25 + 39i | 780   | 7 + 7i  | 844   | 7 + 25i | 908   | 25 + 7i  | 972   | 25 + 25i | 972   | 25 + 25i |
| 525   | 7 + 59i | 589   | 7 + 37i | 653   | 25 + 59i | 717   | 25 + 37i | 781   | 7 + 5i  | 845   | 7 + 27i | 909   | 25 + 5i  | 973   | 25 + 27i | 973   | 25 + 27i |
| 526   | 5 + 57i | 590   | 5 + 39i | 654   | 27 + 57i | 718   | 27 + 39i | 782   | 5 + 7i  | 846   | 5 + 25i | 910   | 27 + 7i  | 974   | 27 + 25i | 974   | 27 + 25i |
| 527   | 5 + 59i | 591   | 5 + 37i | 655   | 27 + 59i | 719   | 27 + 37i | 783   | 5 + 5i  | 847   | 5 + 27i | 911   | 27 + 5i  | 975   | 27 + 27i | 975   | 27 + 27i |
| 528   | 1 + 49i | 592   | 1 + 47i | 656   | 31 + 49i | 720   | 31 + 47i | 784   | 1 + 15i | 848   | 1 + 17i | 912   | 31 + 15i | 976   | 31 + 17i | 976   | 31 + 17i |
| 529   | 1 + 51i | 593   | 1 + 45i | 657   | 31 + 51i | 721   | 31 + 45i | 785   | 1 + 13i | 849   | 1 + 19i | 913   | 31 + 13i | 977   | 31 + 19i | 977   | 31 + 19i |
| 530   | 3 + 49i | 594   | 3 + 47i | 658   | 29 + 49i | 722   | 29 + 47i | 786   | 3 + 15i | 850   | 3 + 17i | 914   | 29 + 15i | 978   | 29 + 17i | 978   | 29 + 17i |
| 531   | 3 + 51i | 595   | 3 + 45i | 659   | 29 + 51i | 723   | 29 + 45i | 787   | 3 + 13i | 851   | 3 + 19i | 915   | 29 + 13i | 979   | 29 + 19i | 979   | 29 + 19i |
| 532   | 1 + 55i | 596   | 1 + 41i | 660   | 31 + 55i | 724   | 31 + 41i | 788   | 1 + 9i  | 852   | 1 + 23i | 916   | 31 + 9i  | 980   | 31 + 23i | 980   | 31 + 23i |
| 533   | 1 + 53i | 597   | 1 + 43i | 661   | 31 + 53i | 725   | 31 + 43i | 789   | 1 + 11i | 853   | 1 + 21i | 917   | 31 + 11i | 981   | 31 + 21i | 981   | 31 + 21i |
| 534   | 3 + 55i | 598   | 3 + 41i | 662   | 29 + 55i | 726   | 29 + 41i | 790   | 3 + 9i  | 854   | 3 + 23i | 918   | 29 + 9i  | 982   | 29 + 23i | 982   | 29 + 23i |
| 535   | 3 + 53i | 599   | 3 + 43i | 663   | 29 + 53i | 727   | 29 + 43i | 791   | 3 + 11i | 855   | 3 + 21i | 919   | 29 + 11i | 983   | 29 + 21i | 983   | 29 + 21i |
| 536   | 7 + 49i | 600   | 7 + 47i | 664   | 25 + 49i | 728   | 25 + 47i | 792   | 7 + 15i | 856   | 7 + 17i | 920   | 25 + 15i | 984   | 25 + 17i | 984   | 25 + 17i |
| 537   | 7 + 51i | 601   | 7 + 45i | 665   | 25 + 51i | 729   | 25 + 45i | 793   | 7 + 13i | 857   | 7 + 19i | 921   | 25 + 13i | 985   | 25 + 19i | 985   | 25 + 19i |
| 538   | 5 + 49i | 602   | 5 + 47i | 666   | 27 + 49i | 730   | 27 + 47i | 794   | 5 + 15i | 858   | 5 + 17i | 922   | 27 + 15i | 986   | 27 + 17i | 986   | 27 + 17i |
| 539   | 5 + 51i | 603   | 5 + 45i | 667   | 27 + 51i | 731   | 27 + 45i | 795   | 5 + 13i | 859   | 5 + 19i | 923   | 27 + 13i | 987   | 27 + 19i | 987   | 27 + 19i |
| 540   | 7 + 55i | 604   | 7 + 41i | 668   | 25 + 55i | 732   | 25 + 41i | 796   | 7 + 9i  | 860   | 7 + 23i | 924   | 25 + 9i  | 988   | 25 + 23i | 988   | 25 + 23i |

Fig. 19

|     |          |     |          |     |          |     |          |     |          |     |          |     |          |      |          |
|-----|----------|-----|----------|-----|----------|-----|----------|-----|----------|-----|----------|-----|----------|------|----------|
| 541 | 7 + 53i  | 605 | 7 + 43i  | 669 | 25 + 53i | 733 | 25 + 43i | 797 | 7 + 11i  | 861 | 7 + 21i  | 925 | 25 + 11i | 989  | 25 + 21i |
| 542 | 5 + 55i  | 606 | 5 + 41i  | 670 | 27 + 55i | 734 | 27 + 41i | 798 | 5 + 9i   | 862 | 5 + 23i  | 926 | 27 + 9i  | 990  | 27 + 23i |
| 543 | 5 + 53i  | 607 | 5 + 43i  | 671 | 27 + 53i | 735 | 27 + 43i | 799 | 5 + 11i  | 863 | 5 + 21i  | 927 | 27 + 11i | 991  | 27 + 21i |
| 544 | 15 + 63i | 608 | 15 + 33i | 672 | 17 + 63i | 736 | 17 + 33i | 800 | 15 + 1i  | 864 | 15 + 31i | 928 | 17 + 1i  | 992  | 17 + 31i |
| 545 | 15 + 61i | 609 | 15 + 35i | 673 | 17 + 61i | 737 | 17 + 35i | 801 | 15 + 3i  | 865 | 15 + 29i | 929 | 17 + 3i  | 993  | 17 + 29i |
| 546 | 13 + 63i | 610 | 13 + 33i | 674 | 19 + 63i | 738 | 19 + 33i | 802 | 13 + 1i  | 866 | 13 + 31i | 930 | 19 + 1i  | 994  | 19 + 31i |
| 547 | 13 + 61i | 611 | 13 + 35i | 675 | 19 + 61i | 739 | 19 + 35i | 803 | 13 + 3i  | 867 | 13 + 29i | 931 | 19 + 3i  | 995  | 19 + 29i |
| 548 | 15 + 57i | 612 | 15 + 39i | 676 | 17 + 57i | 740 | 17 + 39i | 804 | 15 + 7i  | 868 | 15 + 25i | 932 | 17 + 7i  | 996  | 17 + 25i |
| 549 | 15 + 59i | 613 | 15 + 37i | 677 | 17 + 59i | 741 | 17 + 37i | 805 | 15 + 5i  | 869 | 15 + 27i | 933 | 17 + 5i  | 997  | 17 + 27i |
| 550 | 13 + 57i | 614 | 13 + 39i | 678 | 19 + 57i | 742 | 19 + 39i | 806 | 13 + 7i  | 870 | 13 + 25i | 934 | 19 + 7i  | 998  | 19 + 25i |
| 551 | 13 + 59i | 615 | 13 + 37i | 679 | 19 + 59i | 743 | 19 + 37i | 807 | 13 + 5i  | 871 | 13 + 27i | 935 | 19 + 5i  | 999  | 19 + 27i |
| 552 | 9 + 63i  | 616 | 9 + 33i  | 680 | 23 + 63i | 744 | 23 + 33i | 808 | 9 + 1i   | 872 | 9 + 31i  | 936 | 23 + 1i  | 1000 | 23 + 31i |
| 553 | 9 + 61i  | 617 | 9 + 35i  | 681 | 23 + 61i | 745 | 23 + 35i | 809 | 9 + 3i   | 873 | 9 + 29i  | 937 | 23 + 3i  | 1001 | 23 + 29i |
| 554 | 11 + 63i | 618 | 11 + 33i | 682 | 21 + 63i | 746 | 21 + 33i | 810 | 11 + 1i  | 874 | 11 + 31i | 938 | 21 + 1i  | 1002 | 21 + 31i |
| 555 | 11 + 61i | 619 | 11 + 35i | 683 | 21 + 61i | 747 | 21 + 35i | 811 | 11 + 3i  | 875 | 11 + 29i | 939 | 21 + 3i  | 1003 | 21 + 29i |
| 556 | 9 + 57i  | 620 | 9 + 39i  | 684 | 23 + 57i | 748 | 23 + 39i | 812 | 9 + 7i   | 876 | 9 + 25i  | 940 | 23 + 7i  | 1004 | 23 + 25i |
| 557 | 9 + 59i  | 621 | 9 + 37i  | 685 | 23 + 59i | 749 | 23 + 37i | 813 | 9 + 5i   | 877 | 9 + 27i  | 941 | 23 + 5i  | 1005 | 23 + 27i |
| 558 | 11 + 57i | 622 | 11 + 39i | 686 | 21 + 57i | 750 | 21 + 39i | 814 | 11 + 7i  | 878 | 11 + 25i | 942 | 21 + 7i  | 1006 | 21 + 25i |
| 559 | 11 + 59i | 623 | 11 + 37i | 687 | 21 + 59i | 751 | 21 + 37i | 815 | 11 + 5i  | 879 | 11 + 27i | 943 | 21 + 5i  | 1007 | 21 + 27i |
| 560 | 15 + 49i | 624 | 15 + 47i | 688 | 17 + 49i | 752 | 17 + 47i | 816 | 15 + 15i | 880 | 15 + 17i | 944 | 17 + 15i | 1008 | 17 + 17i |
| 561 | 15 + 51i | 625 | 15 + 45i | 689 | 17 + 51i | 753 | 17 + 45i | 817 | 15 + 13i | 881 | 15 + 19i | 945 | 17 + 13i | 1009 | 17 + 19i |
| 562 | 13 + 49i | 626 | 13 + 47i | 690 | 19 + 49i | 754 | 19 + 47i | 818 | 13 + 15i | 882 | 13 + 17i | 946 | 19 + 15i | 1010 | 19 + 17i |
| 563 | 13 + 51i | 627 | 13 + 45i | 691 | 19 + 51i | 755 | 19 + 45i | 819 | 13 + 13i | 883 | 13 + 19i | 947 | 19 + 13i | 1011 | 19 + 19i |
| 564 | 15 + 55i | 628 | 15 + 41i | 692 | 17 + 55i | 756 | 17 + 41i | 820 | 15 + 9i  | 884 | 15 + 23i | 948 | 17 + 9i  | 1012 | 17 + 23i |
| 565 | 15 + 53i | 629 | 15 + 43i | 693 | 17 + 53i | 757 | 17 + 43i | 821 | 15 + 11i | 885 | 15 + 21i | 949 | 17 + 11i | 1013 | 17 + 21i |
| 566 | 13 + 55i | 630 | 13 + 41i | 694 | 19 + 55i | 758 | 19 + 41i | 822 | 13 + 9i  | 886 | 13 + 23i | 950 | 19 + 9i  | 1014 | 19 + 23i |
| 567 | 13 + 53i | 631 | 13 + 43i | 695 | 19 + 53i | 759 | 19 + 43i | 823 | 13 + 11i | 887 | 13 + 21i | 951 | 19 + 11i | 1015 | 19 + 21i |
| 568 | 9 + 49i  | 632 | 9 + 47i  | 696 | 23 + 49i | 760 | 23 + 47i | 824 | 9 + 15i  | 888 | 9 + 17i  | 952 | 23 + 15i | 1016 | 23 + 17i |
| 569 | 9 + 51i  | 633 | 9 + 45i  | 697 | 23 + 51i | 761 | 23 + 45i | 825 | 9 + 13i  | 889 | 9 + 19i  | 953 | 23 + 13i | 1017 | 23 + 19i |
| 570 | 11 + 49i | 634 | 11 + 47i | 698 | 21 + 49i | 762 | 21 + 47i | 826 | 11 + 15i | 890 | 11 + 17i | 954 | 21 + 15i | 1018 | 21 + 17i |
| 571 | 11 + 51i | 635 | 11 + 45i | 699 | 21 + 51i | 763 | 21 + 45i | 827 | 11 + 13i | 891 | 11 + 19i | 955 | 21 + 13i | 1019 | 21 + 19i |
| 572 | 9 + 55i  | 636 | 9 + 41i  | 700 | 23 + 55i | 764 | 23 + 41i | 828 | 9 + 9i   | 892 | 9 + 23i  | 956 | 23 + 9i  | 1020 | 23 + 23i |
| 573 | 9 + 53i  | 637 | 9 + 43i  | 701 | 23 + 53i | 765 | 23 + 43i | 829 | 9 + 11i  | 893 | 9 + 21i  | 957 | 23 + 11i | 1021 | 23 + 21i |
| 574 | 11 + 55i | 638 | 11 + 41i | 702 | 21 + 55i | 766 | 21 + 41i | 830 | 11 + 9i  | 894 | 11 + 23i | 958 | 21 + 9i  | 1022 | 21 + 23i |
| 575 | 11 + 53i | 639 | 11 + 43i | 703 | 21 + 53i | 767 | 21 + 43i | 831 | 11 + 11i | 895 | 11 + 21i | 959 | 21 + 11i | 1023 | 21 + 21i |



Fig. 21

|      |          |      |          |      |          |      |          |      |          |      |          |      |          |      |          |
|------|----------|------|----------|------|----------|------|----------|------|----------|------|----------|------|----------|------|----------|
| 1056 | 15 - 65i | 1120 | 49 - 33i | 1184 | 17 - 65i | 1248 | 47 - 33i | 1312 | 49 - 1i  | 1376 | 49 - 31i | 1440 | 47 - 1i  | 1504 | 47 - 31i |
| 1057 | 15 - 67i | 1121 | 49 - 35i | 1185 | 17 - 67i | 1249 | 47 - 35i | 1313 | 49 - 3i  | 1377 | 49 - 29i | 1441 | 47 - 3i  | 1505 | 47 - 29i |
| 1058 | 13 - 65i | 1122 | 51 - 33i | 1186 | 19 - 65i | 1250 | 45 - 33i | 1314 | 51 - 1i  | 1378 | 51 - 31i | 1442 | 45 - 1i  | 1506 | 45 - 31i |
| 1059 | 13 - 67i | 1123 | 51 - 35i | 1187 | 19 - 67i | 1251 | 45 - 35i | 1315 | 51 - 3i  | 1379 | 51 - 29i | 1443 | 45 - 3i  | 1507 | 45 - 29i |
| 1060 | 15 - 71i | 1124 | 49 - 39i | 1188 | 17 - 71i | 1252 | 47 - 39i | 1316 | 49 - 7i  | 1380 | 49 - 25i | 1444 | 47 - 7i  | 1508 | 47 - 25i |
| 1061 | 15 - 69i | 1125 | 49 - 37i | 1189 | 17 - 69i | 1253 | 47 - 37i | 1317 | 49 - 5i  | 1381 | 49 - 27i | 1445 | 47 - 5i  | 1509 | 47 - 27i |
| 1062 | 13 - 71i | 1126 | 51 - 39i | 1190 | 45 - 57i | 1254 | 45 - 39i | 1318 | 51 - 7i  | 1382 | 51 - 25i | 1446 | 45 - 7i  | 1510 | 45 - 25i |
| 1063 | 13 - 69i | 1127 | 51 - 37i | 1191 | 19 - 69i | 1255 | 45 - 37i | 1319 | 51 - 5i  | 1383 | 51 - 27i | 1447 | 45 - 5i  | 1511 | 45 - 27i |
| 1064 | 9 - 65i  | 1128 | 55 - 33i | 1192 | 23 - 65i | 1256 | 41 - 33i | 1320 | 55 - 1i  | 1384 | 55 - 31i | 1448 | 41 - 1i  | 1512 | 41 - 31i |
| 1065 | 9 - 67i  | 1129 | 55 - 35i | 1193 | 23 - 67i | 1257 | 41 - 35i | 1321 | 55 - 3i  | 1385 | 55 - 29i | 1449 | 41 - 3i  | 1513 | 41 - 29i |
| 1066 | 11 - 65i | 1130 | 53 - 33i | 1194 | 21 - 65i | 1258 | 43 - 33i | 1322 | 53 - 1i  | 1386 | 53 - 31i | 1450 | 43 - 1i  | 1514 | 43 - 31i |
| 1067 | 11 - 67i | 1131 | 53 - 35i | 1195 | 21 - 67i | 1259 | 43 - 35i | 1323 | 53 - 3i  | 1387 | 53 - 29i | 1451 | 43 - 3i  | 1515 | 43 - 29i |
| 1068 | 9 - 71i  | 1132 | 55 - 39i | 1196 | 41 - 57i | 1260 | 41 - 39i | 1324 | 55 - 7i  | 1388 | 55 - 25i | 1452 | 41 - 7i  | 1516 | 41 - 25i |
| 1069 | 9 - 69i  | 1133 | 55 - 37i | 1197 | 41 - 59i | 1261 | 41 - 37i | 1325 | 55 - 5i  | 1389 | 55 - 27i | 1453 | 41 - 5i  | 1517 | 41 - 27i |
| 1070 | 11 - 71i | 1134 | 53 - 39i | 1198 | 43 - 57i | 1262 | 43 - 39i | 1326 | 53 - 7i  | 1390 | 53 - 25i | 1454 | 43 - 7i  | 1518 | 43 - 25i |
| 1071 | 11 - 69i | 1135 | 53 - 37i | 1199 | 21 - 69i | 1263 | 43 - 37i | 1327 | 53 - 5i  | 1391 | 53 - 27i | 1455 | 43 - 5i  | 1519 | 43 - 27i |
| 1072 | 49 - 49i | 1136 | 49 - 47i | 1200 | 47 - 49i | 1264 | 47 - 47i | 1328 | 49 - 15i | 1392 | 49 - 17i | 1456 | 47 - 15i | 1520 | 47 - 17i |
| 1073 | 49 - 51i | 1137 | 49 - 45i | 1201 | 47 - 51i | 1265 | 47 - 45i | 1329 | 49 - 13i | 1393 | 49 - 19i | 1457 | 47 - 13i | 1521 | 47 - 19i |
| 1074 | 51 - 49i | 1138 | 51 - 47i | 1202 | 45 - 49i | 1266 | 45 - 47i | 1330 | 51 - 15i | 1394 | 51 - 17i | 1458 | 45 - 15i | 1522 | 45 - 17i |
| 1075 | 51 - 51i | 1139 | 51 - 45i | 1203 | 45 - 51i | 1267 | 45 - 45i | 1331 | 51 - 13i | 1395 | 51 - 19i | 1459 | 45 - 13i | 1523 | 45 - 19i |
| 1076 | 49 - 55i | 1140 | 49 - 41i | 1204 | 47 - 55i | 1268 | 47 - 41i | 1332 | 49 - 9i  | 1396 | 49 - 23i | 1460 | 47 - 9i  | 1524 | 47 - 23i |
| 1077 | 49 - 53i | 1141 | 49 - 43i | 1205 | 47 - 53i | 1269 | 47 - 43i | 1333 | 49 - 11i | 1397 | 49 - 21i | 1461 | 47 - 11i | 1525 | 47 - 21i |
| 1078 | 13 - 73i | 1142 | 51 - 41i | 1206 | 45 - 55i | 1270 | 45 - 41i | 1334 | 51 - 9i  | 1398 | 51 - 23i | 1462 | 45 - 9i  | 1526 | 45 - 23i |
| 1079 | 51 - 53i | 1143 | 51 - 43i | 1207 | 45 - 53i | 1271 | 45 - 43i | 1335 | 51 - 11i | 1399 | 51 - 21i | 1463 | 45 - 11i | 1527 | 45 - 21i |
| 1080 | 55 - 49i | 1144 | 55 - 47i | 1208 | 41 - 49i | 1272 | 41 - 47i | 1336 | 55 - 15i | 1400 | 55 - 17i | 1464 | 41 - 15i | 1528 | 41 - 17i |
| 1081 | 73 - 13i | 1145 | 55 - 45i | 1209 | 41 - 51i | 1273 | 41 - 45i | 1337 | 55 - 13i | 1401 | 55 - 19i | 1465 | 41 - 13i | 1529 | 41 - 19i |
| 1082 | 53 - 49i | 1146 | 53 - 47i | 1210 | 43 - 49i | 1274 | 43 - 47i | 1338 | 53 - 15i | 1402 | 53 - 17i | 1466 | 43 - 15i | 1530 | 43 - 17i |
| 1083 | 53 - 51i | 1147 | 53 - 45i | 1211 | 43 - 51i | 1275 | 43 - 45i | 1339 | 53 - 13i | 1403 | 53 - 19i | 1467 | 43 - 13i | 1531 | 43 - 19i |
| 1084 | 9 - 73i  | 1148 | 55 - 41i | 1212 | 41 - 55i | 1276 | 41 - 41i | 1340 | 55 - 9i  | 1404 | 55 - 23i | 1468 | 41 - 9i  | 1532 | 41 - 23i |
| 1085 | 73 - 11i | 1149 | 55 - 43i | 1213 | 41 - 53i | 1277 | 41 - 43i | 1341 | 55 - 11i | 1405 | 55 - 21i | 1469 | 41 - 11i | 1533 | 41 - 21i |
| 1086 | 11 - 73i | 1150 | 53 - 41i | 1214 | 43 - 55i | 1278 | 43 - 41i | 1342 | 53 - 9i  | 1406 | 53 - 23i | 1470 | 43 - 9i  | 1534 | 43 - 23i |
| 1087 | 53 - 53i | 1151 | 53 - 43i | 1215 | 43 - 53i | 1279 | 43 - 43i | 1343 | 53 - 11i | 1407 | 53 - 21i | 1471 | 43 - 11i | 1535 | 43 - 21i |



Fig. 23

|      |          |      |          |      |          |      |          |      |          |      |          |      |          |      |          |
|------|----------|------|----------|------|----------|------|----------|------|----------|------|----------|------|----------|------|----------|
| 1571 | 13 - 61i | 1635 | 13 - 35i | 1699 | 19 - 61i | 1763 | 19 - 35i | 1827 | 13 - 3i  | 1891 | 13 - 29i | 1955 | 19 - 3i  | 2019 | 19 - 29i |
| 1572 | 15 - 57i | 1636 | 15 - 39i | 1700 | 17 - 57i | 1764 | 17 - 39i | 1828 | 15 - 7i  | 1892 | 15 - 25i | 1956 | 17 - 7i  | 2020 | 17 - 25i |
| 1573 | 15 - 59i | 1637 | 15 - 37i | 1701 | 17 - 59i | 1765 | 17 - 37i | 1829 | 15 - 5i  | 1893 | 15 - 27i | 1957 | 17 - 5i  | 2021 | 17 - 27i |
| 1574 | 13 - 57i | 1638 | 13 - 39i | 1702 | 19 - 57i | 1766 | 19 - 39i | 1830 | 13 - 7i  | 1894 | 13 - 25i | 1958 | 19 - 7i  | 2022 | 19 - 25i |
| 1575 | 13 - 59i | 1639 | 13 - 37i | 1703 | 19 - 59i | 1767 | 19 - 37i | 1831 | 13 - 5i  | 1895 | 13 - 27i | 1959 | 19 - 5i  | 2023 | 19 - 27i |
| 1576 | 9 - 63i  | 1640 | 9 - 33i  | 1704 | 23 - 63i | 1768 | 23 - 33i | 1832 | 9 - 1i   | 1896 | 9 - 31i  | 1960 | 23 - 1i  | 2024 | 23 - 31i |
| 1577 | 9 - 61i  | 1641 | 9 - 35i  | 1705 | 23 - 61i | 1769 | 23 - 35i | 1833 | 9 - 3i   | 1897 | 9 - 29i  | 1961 | 23 - 3i  | 2025 | 23 - 29i |
| 1578 | 11 - 63i | 1642 | 11 - 33i | 1706 | 21 - 63i | 1770 | 21 - 33i | 1834 | 11 - 1i  | 1898 | 11 - 31i | 1962 | 21 - 1i  | 2026 | 21 - 31i |
| 1579 | 11 - 61i | 1643 | 11 - 35i | 1707 | 21 - 61i | 1771 | 21 - 35i | 1835 | 11 - 3i  | 1899 | 11 - 29i | 1963 | 21 - 3i  | 2027 | 21 - 29i |
| 1580 | 9 - 57i  | 1644 | 9 - 39i  | 1708 | 23 - 57i | 1772 | 23 - 39i | 1836 | 9 - 7i   | 1900 | 9 - 25i  | 1964 | 23 - 7i  | 2028 | 23 - 25i |
| 1581 | 9 - 59i  | 1645 | 9 - 37i  | 1709 | 23 - 59i | 1773 | 23 - 37i | 1837 | 9 - 5i   | 1901 | 9 - 27i  | 1965 | 23 - 5i  | 2029 | 23 - 27i |
| 1582 | 11 - 57i | 1646 | 11 - 39i | 1710 | 21 - 57i | 1774 | 21 - 39i | 1838 | 11 - 7i  | 1902 | 11 - 25i | 1966 | 21 - 7i  | 2030 | 21 - 25i |
| 1583 | 11 - 59i | 1647 | 11 - 37i | 1711 | 21 - 59i | 1775 | 21 - 37i | 1839 | 11 - 5i  | 1903 | 11 - 27i | 1967 | 21 - 5i  | 2031 | 21 - 27i |
| 1584 | 15 - 49i | 1648 | 15 - 47i | 1712 | 17 - 49i | 1776 | 17 - 47i | 1840 | 15 - 15i | 1904 | 15 - 17i | 1968 | 17 - 15i | 2032 | 17 - 17i |
| 1585 | 15 - 51i | 1649 | 15 - 45i | 1713 | 17 - 51i | 1777 | 17 - 45i | 1841 | 15 - 13i | 1905 | 15 - 19i | 1969 | 17 - 13i | 2033 | 17 - 19i |
| 1586 | 13 - 49i | 1650 | 13 - 47i | 1714 | 19 - 49i | 1778 | 19 - 47i | 1842 | 13 - 15i | 1906 | 13 - 17i | 1970 | 19 - 15i | 2034 | 19 - 17i |
| 1587 | 13 - 51i | 1651 | 13 - 45i | 1715 | 19 - 51i | 1779 | 19 - 45i | 1843 | 13 - 13i | 1907 | 13 - 19i | 1971 | 19 - 13i | 2035 | 19 - 19i |
| 1588 | 15 - 55i | 1652 | 15 - 41i | 1716 | 17 - 55i | 1780 | 17 - 41i | 1844 | 15 - 9i  | 1908 | 15 - 23i | 1972 | 17 - 9i  | 2036 | 17 - 23i |
| 1589 | 15 - 53i | 1653 | 15 - 43i | 1717 | 17 - 53i | 1781 | 17 - 43i | 1845 | 15 - 11i | 1909 | 15 - 21i | 1973 | 17 - 11i | 2037 | 17 - 21i |
| 1590 | 13 - 55i | 1654 | 13 - 41i | 1718 | 19 - 55i | 1782 | 19 - 41i | 1846 | 13 - 9i  | 1910 | 13 - 23i | 1974 | 19 - 9i  | 2038 | 19 - 23i |
| 1591 | 13 - 53i | 1655 | 13 - 43i | 1719 | 19 - 53i | 1783 | 19 - 43i | 1847 | 13 - 11i | 1911 | 13 - 21i | 1975 | 19 - 11i | 2039 | 19 - 21i |
| 1592 | 9 - 49i  | 1656 | 9 - 47i  | 1720 | 23 - 49i | 1784 | 23 - 47i | 1848 | 9 - 15i  | 1912 | 9 - 17i  | 1976 | 23 - 15i | 2040 | 23 - 17i |
| 1593 | 9 - 51i  | 1657 | 9 - 45i  | 1721 | 23 - 51i | 1785 | 23 - 45i | 1849 | 9 - 13i  | 1913 | 9 - 19i  | 1977 | 23 - 13i | 2041 | 23 - 19i |
| 1594 | 11 - 49i | 1658 | 11 - 47i | 1722 | 21 - 49i | 1786 | 21 - 47i | 1850 | 11 - 15i | 1914 | 11 - 17i | 1978 | 21 - 15i | 2042 | 21 - 17i |
| 1595 | 11 - 51i | 1659 | 11 - 45i | 1723 | 21 - 51i | 1787 | 21 - 45i | 1851 | 11 - 13i | 1915 | 11 - 19i | 1979 | 21 - 13i | 2043 | 21 - 19i |
| 1596 | 9 - 55i  | 1660 | 9 - 41i  | 1724 | 23 - 55i | 1788 | 23 - 41i | 1852 | 9 - 9i   | 1916 | 9 - 23i  | 1980 | 23 - 9i  | 2044 | 23 - 23i |
| 1597 | 9 - 53i  | 1661 | 9 - 43i  | 1725 | 23 - 53i | 1789 | 23 - 43i | 1853 | 9 - 11i  | 1917 | 9 - 21i  | 1981 | 23 - 11i | 2045 | 23 - 21i |
| 1598 | 11 - 55i | 1662 | 11 - 41i | 1726 | 21 - 55i | 1790 | 21 - 41i | 1854 | 11 - 9i  | 1918 | 11 - 23i | 1982 | 21 - 9i  | 2046 | 21 - 23i |
| 1599 | 11 - 53i | 1663 | 11 - 43i | 1727 | 21 - 53i | 1791 | 21 - 43i | 1855 | 11 - 11i | 1919 | 11 - 21i | 1983 | 21 - 11i | 2047 | 21 - 21i |

39

Fig. 25

|      |          |      |          |      |          |      |          |      |          |      |          |      |          |      |          |
|------|----------|------|----------|------|----------|------|----------|------|----------|------|----------|------|----------|------|----------|
| 2081 | -15 + 67 | 2145 | -49 + 35 | 2209 | -17 + 67 | 2273 | -47 + 35 | 2337 | -49 + 31 | 2401 | -49 + 29 | 2465 | -47 + 31 | 2529 | -47 + 29 |
| 2082 | -13 + 65 | 2146 | -51 + 33 | 2210 | -19 + 65 | 2274 | -45 + 33 | 2338 | -51 + 31 | 2402 | -51 + 31 | 2466 | -45 + 31 | 2530 | -45 + 31 |
| 2083 | -13 + 67 | 2147 | -51 + 35 | 2211 | -19 + 67 | 2275 | -45 + 35 | 2339 | -51 + 33 | 2403 | -51 + 29 | 2467 | -45 + 33 | 2531 | -45 + 29 |
| 2084 | -15 + 71 | 2148 | -49 + 39 | 2212 | -17 + 71 | 2276 | -47 + 39 | 2340 | -49 + 71 | 2404 | -49 + 25 | 2468 | -47 + 71 | 2532 | -47 + 25 |
| 2085 | -15 + 69 | 2149 | -49 + 37 | 2213 | -17 + 69 | 2277 | -47 + 37 | 2341 | -49 + 51 | 2405 | -49 + 27 | 2469 | -47 + 51 | 2533 | -47 + 27 |
| 2086 | -13 + 71 | 2150 | -51 + 39 | 2214 | -45 + 57 | 2278 | -45 + 39 | 2342 | -51 + 71 | 2406 | -51 + 25 | 2470 | -45 + 71 | 2534 | -45 + 25 |
| 2087 | -13 + 69 | 2151 | -51 + 37 | 2215 | -19 + 69 | 2279 | -45 + 37 | 2343 | -51 + 51 | 2407 | -51 + 27 | 2471 | -45 + 51 | 2535 | -45 + 27 |
| 2088 | -9 + 65  | 2152 | -55 + 33 | 2216 | -23 + 65 | 2280 | -41 + 33 | 2344 | -55 + 11 | 2408 | -55 + 31 | 2472 | -41 + 11 | 2536 | -41 + 31 |
| 2089 | -9 + 67  | 2153 | -55 + 35 | 2217 | -23 + 67 | 2281 | -41 + 35 | 2345 | -55 + 31 | 2409 | -55 + 29 | 2473 | -41 + 31 | 2537 | -41 + 29 |
| 2090 | -11 + 65 | 2154 | -53 + 33 | 2218 | -21 + 65 | 2282 | -43 + 33 | 2346 | -53 + 11 | 2410 | -53 + 31 | 2474 | -43 + 11 | 2538 | -43 + 31 |
| 2091 | -11 + 67 | 2155 | -53 + 35 | 2219 | -21 + 67 | 2283 | -43 + 35 | 2347 | -53 + 31 | 2411 | -53 + 29 | 2475 | -43 + 31 | 2539 | -43 + 29 |
| 2092 | -9 + 71  | 2156 | -55 + 39 | 2220 | -41 + 57 | 2284 | -41 + 39 | 2348 | -55 + 71 | 2412 | -55 + 25 | 2476 | -41 + 71 | 2540 | -41 + 25 |
| 2093 | -9 + 69  | 2157 | -55 + 37 | 2221 | -41 + 59 | 2285 | -41 + 37 | 2349 | -55 + 51 | 2413 | -55 + 27 | 2477 | -41 + 51 | 2541 | -41 + 27 |
| 2094 | -11 + 71 | 2158 | -53 + 39 | 2222 | -43 + 57 | 2286 | -43 + 39 | 2350 | -53 + 71 | 2414 | -53 + 25 | 2478 | -43 + 71 | 2542 | -43 + 25 |
| 2095 | -11 + 69 | 2159 | -53 + 37 | 2223 | -21 + 69 | 2287 | -43 + 37 | 2351 | -53 + 51 | 2415 | -53 + 27 | 2479 | -43 + 51 | 2543 | -43 + 27 |
| 2096 | -49 + 49 | 2160 | -49 + 47 | 2224 | -47 + 49 | 2288 | -47 + 47 | 2352 | -49 + 15 | 2416 | -49 + 17 | 2480 | -47 + 15 | 2544 | -47 + 17 |
| 2097 | -49 + 51 | 2161 | -49 + 45 | 2225 | -47 + 51 | 2289 | -47 + 45 | 2353 | -49 + 13 | 2417 | -49 + 19 | 2481 | -47 + 13 | 2545 | -47 + 19 |
| 2098 | -51 + 49 | 2162 | -51 + 47 | 2226 | -45 + 49 | 2290 | -45 + 47 | 2354 | -51 + 15 | 2418 | -51 + 17 | 2482 | -45 + 15 | 2546 | -45 + 17 |
| 2099 | -51 + 51 | 2163 | -51 + 45 | 2227 | -45 + 51 | 2291 | -45 + 45 | 2355 | -51 + 13 | 2419 | -51 + 19 | 2483 | -45 + 13 | 2547 | -45 + 19 |
| 2100 | -49 + 55 | 2164 | -49 + 41 | 2228 | -47 + 55 | 2292 | -47 + 41 | 2356 | -49 + 91 | 2420 | -49 + 23 | 2484 | -47 + 91 | 2548 | -47 + 23 |
| 2101 | -49 + 53 | 2165 | -49 + 43 | 2229 | -47 + 53 | 2293 | -47 + 43 | 2357 | -49 + 11 | 2421 | -49 + 21 | 2485 | -47 + 11 | 2549 | -47 + 21 |
| 2102 | -13 + 73 | 2166 | -51 + 41 | 2230 | -45 + 55 | 2294 | -45 + 41 | 2358 | -51 + 91 | 2422 | -51 + 23 | 2486 | -45 + 91 | 2550 | -45 + 23 |
| 2103 | -51 + 53 | 2167 | -51 + 43 | 2231 | -45 + 53 | 2295 | -45 + 43 | 2359 | -51 + 11 | 2423 | -51 + 21 | 2487 | -45 + 11 | 2551 | -45 + 21 |
| 2104 | -55 + 49 | 2168 | -55 + 47 | 2232 | -41 + 49 | 2296 | -41 + 47 | 2360 | -55 + 15 | 2424 | -55 + 17 | 2488 | -41 + 15 | 2552 | -41 + 17 |
| 2105 | -73 + 13 | 2169 | -55 + 45 | 2233 | -41 + 51 | 2297 | -41 + 45 | 2361 | -55 + 13 | 2425 | -55 + 19 | 2489 | -41 + 13 | 2553 | -41 + 19 |
| 2106 | -53 + 49 | 2170 | -53 + 47 | 2234 | -43 + 49 | 2298 | -43 + 47 | 2362 | -53 + 15 | 2426 | -53 + 17 | 2490 | -43 + 15 | 2554 | -43 + 17 |
| 2107 | -53 + 51 | 2171 | -53 + 45 | 2235 | -43 + 51 | 2299 | -43 + 45 | 2363 | -53 + 13 | 2427 | -53 + 19 | 2491 | -43 + 13 | 2555 | -43 + 19 |
| 2108 | -9 + 73  | 2172 | -55 + 41 | 2236 | -41 + 55 | 2300 | -41 + 41 | 2364 | -55 + 91 | 2428 | -55 + 23 | 2492 | -41 + 91 | 2556 | -41 + 23 |
| 2109 | -73 + 11 | 2173 | -55 + 43 | 2237 | -41 + 53 | 2301 | -41 + 43 | 2365 | -55 + 11 | 2429 | -55 + 21 | 2493 | -41 + 11 | 2557 | -41 + 21 |
| 2110 | -11 + 73 | 2174 | -53 + 41 | 2238 | -43 + 55 | 2302 | -43 + 41 | 2366 | -53 + 91 | 2430 | -53 + 23 | 2494 | -43 + 91 | 2558 | -43 + 23 |
| 2111 | -53 + 53 | 2175 | -53 + 43 | 2239 | -43 + 53 | 2303 | -43 + 43 | 2367 | -53 + 11 | 2431 | -53 + 21 | 2495 | -43 + 11 | 2559 | -43 + 21 |



Fig. 27

|      |           |      |           |      |           |      |           |      |           |      |           |      |           |      |           |
|------|-----------|------|-----------|------|-----------|------|-----------|------|-----------|------|-----------|------|-----------|------|-----------|
| 2591 | -5 + 53i  | 2655 | -5 + 43i  | 2719 | -27 + 53i | 2783 | -27 + 43i | 2847 | -5 + 11i  | 2911 | -5 + 21i  | 2975 | -27 + 11i | 3039 | -27 + 21i |
| 2592 | -15 + 63i | 2656 | -15 + 33i | 2720 | -17 + 63i | 2784 | -17 + 33i | 2848 | -15 + 1i  | 2912 | -15 + 31i | 2976 | -17 + 1i  | 3040 | -17 + 31i |
| 2593 | -15 + 61i | 2657 | -15 + 35i | 2721 | -17 + 61i | 2785 | -17 + 35i | 2849 | -15 + 3i  | 2913 | -15 + 29i | 2977 | -17 + 3i  | 3041 | -17 + 29i |
| 2594 | -13 + 63i | 2658 | -13 + 33i | 2722 | -19 + 63i | 2786 | -19 + 33i | 2850 | -13 + 1i  | 2914 | -13 + 31i | 2978 | -19 + 1i  | 3042 | -19 + 31i |
| 2595 | -13 + 61i | 2659 | -13 + 35i | 2723 | -19 + 61i | 2787 | -19 + 35i | 2851 | -13 + 3i  | 2915 | -13 + 29i | 2979 | -19 + 3i  | 3043 | -19 + 29i |
| 2596 | -15 + 57i | 2660 | -15 + 39i | 2724 | -17 + 57i | 2788 | -17 + 39i | 2852 | -15 + 7i  | 2916 | -15 + 25i | 2980 | -17 + 7i  | 3044 | -17 + 25i |
| 2597 | -15 + 59i | 2661 | -15 + 37i | 2725 | -17 + 59i | 2789 | -17 + 37i | 2853 | -15 + 5i  | 2917 | -15 + 27i | 2981 | -17 + 5i  | 3045 | -17 + 27i |
| 2598 | -13 + 57i | 2662 | -13 + 39i | 2726 | -19 + 57i | 2790 | -19 + 39i | 2854 | -13 + 7i  | 2918 | -13 + 25i | 2982 | -19 + 7i  | 3046 | -19 + 25i |
| 2599 | -13 + 59i | 2663 | -13 + 37i | 2727 | -19 + 59i | 2791 | -19 + 37i | 2855 | -13 + 5i  | 2919 | -13 + 27i | 2983 | -19 + 5i  | 3047 | -19 + 27i |
| 2600 | -9 + 63i  | 2664 | -9 + 33i  | 2728 | -23 + 63i | 2792 | -23 + 33i | 2856 | -9 + 1i   | 2920 | -9 + 31i  | 2984 | -23 + 1i  | 3048 | -23 + 31i |
| 2601 | -9 + 61i  | 2665 | -9 + 35i  | 2729 | -23 + 61i | 2793 | -23 + 35i | 2857 | -9 + 3i   | 2921 | -9 + 29i  | 2985 | -23 + 3i  | 3049 | -23 + 29i |
| 2602 | -11 + 63i | 2666 | -11 + 33i | 2730 | -21 + 63i | 2794 | -21 + 33i | 2858 | -11 + 1i  | 2922 | -11 + 31i | 2986 | -21 + 1i  | 3050 | -21 + 31i |
| 2603 | -11 + 61i | 2667 | -11 + 35i | 2731 | -21 + 61i | 2795 | -21 + 35i | 2859 | -11 + 3i  | 2923 | -11 + 29i | 2987 | -21 + 3i  | 3051 | -21 + 29i |
| 2604 | -9 + 57i  | 2668 | -9 + 39i  | 2732 | -23 + 57i | 2796 | -23 + 39i | 2860 | -9 + 7i   | 2924 | -9 + 25i  | 2988 | -23 + 7i  | 3052 | -23 + 25i |
| 2605 | -9 + 59i  | 2669 | -9 + 37i  | 2733 | -23 + 59i | 2797 | -23 + 37i | 2861 | -9 + 5i   | 2925 | -9 + 27i  | 2989 | -23 + 5i  | 3053 | -23 + 27i |
| 2606 | -11 + 57i | 2670 | -11 + 39i | 2734 | -21 + 57i | 2798 | -21 + 39i | 2862 | -11 + 7i  | 2926 | -11 + 25i | 2990 | -21 + 7i  | 3054 | -21 + 25i |
| 2607 | -11 + 59i | 2671 | -11 + 37i | 2735 | -21 + 59i | 2799 | -21 + 37i | 2863 | -11 + 5i  | 2927 | -11 + 27i | 2991 | -21 + 5i  | 3055 | -21 + 27i |
| 2608 | -15 + 49i | 2672 | -15 + 47i | 2736 | -17 + 49i | 2800 | -17 + 47i | 2864 | -15 + 15i | 2928 | -15 + 17i | 2992 | -17 + 15i | 3056 | -17 + 17i |
| 2609 | -15 + 51i | 2673 | -15 + 45i | 2737 | -17 + 51i | 2801 | -17 + 45i | 2865 | -15 + 13i | 2929 | -15 + 19i | 2993 | -17 + 13i | 3057 | -17 + 19i |
| 2610 | -13 + 49i | 2674 | -13 + 47i | 2738 | -19 + 49i | 2802 | -19 + 47i | 2866 | -13 + 15i | 2930 | -13 + 17i | 2994 | -19 + 15i | 3058 | -19 + 17i |
| 2611 | -13 + 51i | 2675 | -13 + 45i | 2739 | -19 + 51i | 2803 | -19 + 45i | 2867 | -13 + 13i | 2931 | -13 + 19i | 2995 | -19 + 13i | 3059 | -19 + 19i |
| 2612 | -15 + 55i | 2676 | -15 + 41i | 2740 | -17 + 55i | 2804 | -17 + 41i | 2868 | -15 + 9i  | 2932 | -15 + 23i | 2996 | -17 + 9i  | 3060 | -17 + 23i |
| 2613 | -15 + 53i | 2677 | -15 + 43i | 2741 | -17 + 53i | 2805 | -17 + 43i | 2869 | -15 + 11i | 2933 | -15 + 21i | 2997 | -17 + 11i | 3061 | -17 + 21i |
| 2614 | -13 + 55i | 2678 | -13 + 41i | 2742 | -19 + 55i | 2806 | -19 + 41i | 2870 | -13 + 9i  | 2934 | -13 + 23i | 2998 | -19 + 9i  | 3062 | -19 + 23i |
| 2615 | -13 + 53i | 2679 | -13 + 43i | 2743 | -19 + 53i | 2807 | -19 + 43i | 2871 | -13 + 11i | 2935 | -13 + 21i | 2999 | -19 + 11i | 3063 | -19 + 21i |
| 2616 | -9 + 49i  | 2680 | -9 + 47i  | 2744 | -23 + 49i | 2808 | -23 + 47i | 2872 | -9 + 15i  | 2936 | -9 + 17i  | 3000 | -23 + 15i | 3064 | -23 + 17i |
| 2617 | -9 + 51i  | 2681 | -9 + 45i  | 2745 | -23 + 51i | 2809 | -23 + 45i | 2873 | -9 + 13i  | 2937 | -9 + 19i  | 3001 | -23 + 13i | 3065 | -23 + 19i |
| 2618 | -11 + 49i | 2682 | -11 + 47i | 2746 | -21 + 49i | 2810 | -21 + 47i | 2874 | -11 + 15i | 2938 | -11 + 17i | 3002 | -21 + 15i | 3066 | -21 + 17i |
| 2619 | -11 + 51i | 2683 | -11 + 45i | 2747 | -21 + 51i | 2811 | -21 + 45i | 2875 | -11 + 13i | 2939 | -11 + 19i | 3003 | -21 + 13i | 3067 | -21 + 19i |
| 2620 | -9 + 55i  | 2684 | -9 + 41i  | 2748 | -23 + 55i | 2812 | -23 + 41i | 2876 | -9 + 9i   | 2940 | -9 + 23i  | 3004 | -23 + 9i  | 3068 | -23 + 23i |
| 2621 | -9 + 53i  | 2685 | -9 + 43i  | 2749 | -23 + 53i | 2813 | -23 + 43i | 2877 | -9 + 11i  | 2941 | -9 + 21i  | 3005 | -23 + 11i | 3069 | -23 + 21i |
| 2622 | -11 + 55i | 2686 | -11 + 41i | 2750 | -21 + 55i | 2814 | -21 + 41i | 2878 | -11 + 9i  | 2942 | -11 + 23i | 3006 | -21 + 9i  | 3070 | -21 + 23i |
| 2623 | -11 + 53i | 2687 | -11 + 43i | 2751 | -21 + 53i | 2815 | -21 + 43i | 2879 | -11 + 11i | 2943 | -11 + 21i | 3007 | -21 + 11i | 3071 | -21 + 21i |

43

Fig. 29

|      |          |      |          |      |          |      |          |      |          |      |          |      |          |      |          |
|------|----------|------|----------|------|----------|------|----------|------|----------|------|----------|------|----------|------|----------|
| 3101 | -71 - 11 | 3165 | -57 - 43 | 3229 | -39 - 53 | 3293 | -39 - 43 | 3357 | -57 - 11 | 3421 | -57 - 21 | 3485 | -39 - 11 | 3549 | -39 - 21 |
| 3102 | -69 - 9  | 3166 | -59 - 41 | 3230 | -37 - 55 | 3294 | -37 - 41 | 3358 | -59 - 9  | 3422 | -59 - 23 | 3486 | -37 - 9  | 3550 | -37 - 23 |
| 3103 | -69 - 11 | 3167 | -69 - 21 | 3231 | -37 - 53 | 3295 | -37 - 43 | 3359 | -59 - 11 | 3423 | -59 - 21 | 3487 | -37 - 11 | 3551 | -37 - 21 |
| 3104 | -15 - 65 | 3168 | -49 - 33 | 3232 | -17 - 65 | 3296 | -47 - 33 | 3360 | -49 - 1  | 3424 | -49 - 31 | 3488 | -47 - 1  | 3552 | -47 - 31 |
| 3105 | -15 - 67 | 3169 | -49 - 35 | 3233 | -17 - 67 | 3297 | -47 - 35 | 3361 | -49 - 3  | 3425 | -49 - 29 | 3489 | -47 - 3  | 3553 | -47 - 29 |
| 3106 | -13 - 65 | 3170 | -51 - 33 | 3234 | -19 - 65 | 3298 | -45 - 33 | 3362 | -51 - 1  | 3426 | -51 - 31 | 3490 | -45 - 1  | 3554 | -45 - 31 |
| 3107 | -13 - 67 | 3171 | -51 - 35 | 3235 | -19 - 67 | 3299 | -45 - 35 | 3363 | -51 - 3  | 3427 | -51 - 29 | 3491 | -45 - 3  | 3555 | -45 - 29 |
| 3108 | -15 - 71 | 3172 | -49 - 39 | 3236 | -17 - 71 | 3300 | -47 - 39 | 3364 | -49 - 7  | 3428 | -49 - 25 | 3492 | -47 - 7  | 3556 | -47 - 25 |
| 3109 | -15 - 69 | 3173 | -49 - 37 | 3237 | -17 - 69 | 3301 | -47 - 37 | 3365 | -49 - 5  | 3429 | -49 - 27 | 3493 | -47 - 5  | 3557 | -47 - 27 |
| 3110 | -13 - 71 | 3174 | -51 - 39 | 3238 | -45 - 57 | 3302 | -45 - 39 | 3366 | -51 - 7  | 3430 | -51 - 25 | 3494 | -45 - 7  | 3558 | -45 - 25 |
| 3111 | -13 - 69 | 3175 | -51 - 37 | 3239 | -19 - 69 | 3303 | -45 - 37 | 3367 | -51 - 5  | 3431 | -51 - 27 | 3495 | -45 - 5  | 3559 | -45 - 27 |
| 3112 | -9 - 65  | 3176 | -55 - 33 | 3240 | -23 - 65 | 3304 | -41 - 33 | 3368 | -55 - 1  | 3432 | -55 - 31 | 3496 | -41 - 1  | 3560 | -41 - 31 |
| 3113 | -9 - 67  | 3177 | -55 - 35 | 3241 | -23 - 67 | 3305 | -41 - 35 | 3369 | -55 - 3  | 3433 | -55 - 29 | 3497 | -41 - 3  | 3561 | -41 - 29 |
| 3114 | -11 - 65 | 3178 | -53 - 33 | 3242 | -21 - 65 | 3306 | -43 - 33 | 3370 | -53 - 1  | 3434 | -53 - 31 | 3498 | -43 - 1  | 3562 | -43 - 31 |
| 3115 | -11 - 67 | 3179 | -53 - 35 | 3243 | -21 - 67 | 3307 | -43 - 35 | 3371 | -53 - 3  | 3435 | -53 - 29 | 3499 | -43 - 3  | 3563 | -43 - 29 |
| 3116 | -9 - 71  | 3180 | -55 - 39 | 3244 | -41 - 57 | 3308 | -41 - 39 | 3372 | -55 - 7  | 3436 | -55 - 25 | 3500 | -41 - 7  | 3564 | -41 - 25 |
| 3117 | -9 - 69  | 3181 | -55 - 37 | 3245 | -41 - 59 | 3309 | -41 - 37 | 3373 | -55 - 5  | 3437 | -55 - 27 | 3501 | -41 - 5  | 3565 | -41 - 27 |
| 3118 | -11 - 71 | 3182 | -53 - 39 | 3246 | -43 - 57 | 3310 | -43 - 39 | 3374 | -53 - 7  | 3438 | -53 - 25 | 3502 | -43 - 7  | 3566 | -43 - 25 |
| 3119 | -11 - 69 | 3183 | -53 - 37 | 3247 | -21 - 69 | 3311 | -43 - 37 | 3375 | -53 - 5  | 3439 | -53 - 27 | 3503 | -43 - 5  | 3567 | -43 - 27 |
| 3120 | -49 - 49 | 3184 | -49 - 47 | 3248 | -47 - 49 | 3312 | -47 - 47 | 3376 | -49 - 15 | 3440 | -49 - 17 | 3504 | -47 - 15 | 3568 | -47 - 17 |
| 3121 | -49 - 51 | 3185 | -49 - 45 | 3249 | -47 - 51 | 3313 | -47 - 45 | 3377 | -49 - 13 | 3441 | -49 - 19 | 3505 | -47 - 13 | 3569 | -47 - 19 |
| 3122 | -51 - 49 | 3186 | -51 - 47 | 3250 | -45 - 49 | 3314 | -45 - 47 | 3378 | -51 - 15 | 3442 | -51 - 17 | 3506 | -45 - 15 | 3570 | -45 - 17 |
| 3123 | -51 - 51 | 3187 | -51 - 45 | 3251 | -45 - 51 | 3315 | -45 - 45 | 3379 | -51 - 13 | 3443 | -51 - 19 | 3507 | -45 - 13 | 3571 | -45 - 19 |
| 3124 | -49 - 55 | 3188 | -49 - 41 | 3252 | -47 - 55 | 3316 | -47 - 41 | 3380 | -49 - 9  | 3444 | -49 - 23 | 3508 | -47 - 9  | 3572 | -47 - 23 |
| 3125 | -49 - 53 | 3189 | -49 - 43 | 3253 | -47 - 53 | 3317 | -47 - 43 | 3381 | -49 - 11 | 3445 | -49 - 21 | 3509 | -47 - 11 | 3573 | -47 - 21 |
| 3126 | -13 - 73 | 3190 | -51 - 41 | 3254 | -45 - 55 | 3318 | -45 - 41 | 3382 | -51 - 9  | 3446 | -51 - 23 | 3510 | -45 - 9  | 3574 | -45 - 23 |
| 3127 | -51 - 53 | 3191 | -51 - 43 | 3255 | -45 - 53 | 3319 | -45 - 43 | 3383 | -51 - 11 | 3447 | -51 - 21 | 3511 | -45 - 11 | 3575 | -45 - 21 |
| 3128 | -55 - 49 | 3192 | -55 - 47 | 3256 | -41 - 49 | 3320 | -41 - 47 | 3384 | -55 - 15 | 3448 | -55 - 17 | 3512 | -41 - 15 | 3576 | -41 - 17 |
| 3129 | -73 - 13 | 3193 | -55 - 45 | 3257 | -41 - 51 | 3321 | -41 - 45 | 3385 | -55 - 13 | 3449 | -55 - 19 | 3513 | -41 - 13 | 3577 | -41 - 19 |
| 3130 | -53 - 49 | 3194 | -53 - 47 | 3258 | -43 - 49 | 3322 | -43 - 47 | 3386 | -53 - 15 | 3450 | -53 - 17 | 3514 | -43 - 15 | 3578 | -43 - 17 |
| 3131 | -53 - 51 | 3195 | -53 - 45 | 3259 | -43 - 51 | 3323 | -43 - 45 | 3387 | -53 - 13 | 3451 | -53 - 19 | 3515 | -43 - 13 | 3579 | -43 - 19 |
| 3132 | -73 - 9  | 3196 | -55 - 41 | 3260 | -41 - 55 | 3324 | -41 - 41 | 3388 | -55 - 9  | 3452 | -55 - 23 | 3516 | -41 - 9  | 3580 | -41 - 23 |
| 3133 | -73 - 11 | 3197 | -55 - 43 | 3261 | -41 - 53 | 3325 | -41 - 43 | 3389 | -55 - 11 | 3453 | -55 - 21 | 3517 | -41 - 11 | 3581 | -41 - 21 |
| 3134 | -11 - 73 | 3198 | -53 - 41 | 3262 | -43 - 55 | 3326 | -43 - 41 | 3390 | -53 - 9  | 3454 | -53 - 23 | 3518 | -43 - 9  | 3582 | -43 - 23 |
| 3135 | -53 - 53 | 3199 | -53 - 43 | 3263 | -43 - 53 | 3327 | -43 - 43 | 3391 | -53 - 11 | 3455 | -53 - 21 | 3519 | -43 - 11 | 3583 | -43 - 21 |

Fig. 30

| Value | Scatter  | Value | Scatter  | Value | Scatter   | Value | Scatter   | Value | Scatter  | Value | Scatter  | Value | Scatter   | Value | Scatter   |
|-------|----------|-------|----------|-------|-----------|-------|-----------|-------|----------|-------|----------|-------|-----------|-------|-----------|
| 3584  | -1 - 63i | 3648  | -1 - 33i | 3712  | -31 - 63i | 3776  | -31 - 33i | 3840  | -1 - 1i  | 3904  | -1 - 31i | 3968  | -31 - 1i  | 4032  | -31 - 31i |
| 3585  | -1 - 61i | 3649  | -1 - 35i | 3713  | -31 - 61i | 3777  | -31 - 35i | 3841  | -1 - 3i  | 3905  | -1 - 29i | 3969  | -31 - 3i  | 4033  | -31 - 29i |
| 3586  | -3 - 63i | 3650  | -3 - 33i | 3714  | -29 - 63i | 3778  | -29 - 33i | 3842  | -3 - 1i  | 3906  | -3 - 31i | 3970  | -29 - 1i  | 4034  | -29 - 31i |
| 3587  | -3 - 61i | 3651  | -3 - 35i | 3715  | -29 - 61i | 3779  | -29 - 35i | 3843  | -3 - 3i  | 3907  | -3 - 29i | 3971  | -29 - 3i  | 4035  | -29 - 29i |
| 3588  | -1 - 57i | 3652  | -1 - 39i | 3716  | -31 - 57i | 3780  | -31 - 39i | 3844  | -1 - 7i  | 3908  | -1 - 25i | 3972  | -31 - 7i  | 4036  | -31 - 25i |
| 3589  | -1 - 59i | 3653  | -1 - 37i | 3717  | -31 - 59i | 3781  | -31 - 37i | 3845  | -1 - 5i  | 3909  | -1 - 27i | 3973  | -31 - 5i  | 4037  | -31 - 27i |
| 3590  | -3 - 57i | 3654  | -3 - 39i | 3718  | -29 - 57i | 3782  | -29 - 39i | 3846  | -3 - 7i  | 3910  | -3 - 25i | 3974  | -29 - 7i  | 4038  | -29 - 25i |
| 3591  | -3 - 59i | 3655  | -3 - 37i | 3719  | -29 - 59i | 3783  | -29 - 37i | 3847  | -3 - 5i  | 3911  | -3 - 27i | 3975  | -29 - 5i  | 4039  | -29 - 27i |
| 3592  | -7 - 63i | 3656  | -7 - 33i | 3720  | -25 - 63i | 3784  | -25 - 33i | 3848  | -7 - 1i  | 3912  | -7 - 31i | 3976  | -25 - 1i  | 4040  | -25 - 31i |
| 3593  | -7 - 61i | 3657  | -7 - 35i | 3721  | -25 - 61i | 3785  | -25 - 35i | 3849  | -7 - 3i  | 3913  | -7 - 29i | 3977  | -25 - 3i  | 4041  | -25 - 29i |
| 3594  | -5 - 63i | 3658  | -5 - 33i | 3722  | -27 - 63i | 3786  | -27 - 33i | 3850  | -5 - 1i  | 3914  | -5 - 31i | 3978  | -27 - 1i  | 4042  | -27 - 31i |
| 3595  | -5 - 61i | 3659  | -5 - 35i | 3723  | -27 - 61i | 3787  | -27 - 35i | 3851  | -5 - 3i  | 3915  | -5 - 29i | 3979  | -27 - 3i  | 4043  | -27 - 29i |
| 3596  | -7 - 57i | 3660  | -7 - 39i | 3724  | -25 - 57i | 3788  | -25 - 39i | 3852  | -7 - 7i  | 3916  | -7 - 25i | 3980  | -25 - 7i  | 4044  | -25 - 25i |
| 3597  | -7 - 59i | 3661  | -7 - 37i | 3725  | -25 - 59i | 3789  | -25 - 37i | 3853  | -7 - 5i  | 3917  | -7 - 27i | 3981  | -25 - 5i  | 4045  | -25 - 27i |
| 3598  | -5 - 57i | 3662  | -5 - 39i | 3726  | -27 - 57i | 3790  | -27 - 39i | 3854  | -5 - 7i  | 3918  | -5 - 25i | 3982  | -27 - 7i  | 4046  | -27 - 25i |
| 3599  | -5 - 59i | 3663  | -5 - 37i | 3727  | -27 - 59i | 3791  | -27 - 37i | 3855  | -5 - 5i  | 3919  | -5 - 27i | 3983  | -27 - 5i  | 4047  | -27 - 27i |
| 3600  | -1 - 49i | 3664  | -1 - 47i | 3728  | -31 - 49i | 3792  | -31 - 47i | 3856  | -1 - 15i | 3920  | -1 - 17i | 3984  | -31 - 15i | 4048  | -31 - 17i |
| 3601  | -1 - 51i | 3665  | -1 - 45i | 3729  | -31 - 51i | 3793  | -31 - 45i | 3857  | -1 - 13i | 3921  | -1 - 19i | 3985  | -31 - 13i | 4049  | -31 - 19i |
| 3602  | -3 - 49i | 3666  | -3 - 47i | 3730  | -29 - 49i | 3794  | -29 - 47i | 3858  | -3 - 15i | 3922  | -3 - 17i | 3986  | -29 - 15i | 4050  | -29 - 17i |
| 3603  | -3 - 51i | 3667  | -3 - 45i | 3731  | -29 - 51i | 3795  | -29 - 45i | 3859  | -3 - 13i | 3923  | -3 - 19i | 3987  | -29 - 13i | 4051  | -29 - 19i |
| 3604  | -1 - 55i | 3668  | -1 - 41i | 3732  | -31 - 55i | 3796  | -31 - 41i | 3860  | -1 - 9i  | 3924  | -1 - 23i | 3988  | -31 - 9i  | 4052  | -31 - 23i |
| 3605  | -1 - 53i | 3669  | -1 - 43i | 3733  | -31 - 53i | 3797  | -31 - 43i | 3861  | -1 - 11i | 3925  | -1 - 21i | 3989  | -31 - 11i | 4053  | -31 - 21i |
| 3606  | -3 - 55i | 3670  | -3 - 41i | 3734  | -29 - 55i | 3798  | -29 - 41i | 3862  | -3 - 9i  | 3926  | -3 - 23i | 3990  | -29 - 9i  | 4054  | -29 - 23i |
| 3607  | -3 - 53i | 3671  | -3 - 43i | 3735  | -29 - 53i | 3799  | -29 - 43i | 3863  | -3 - 11i | 3927  | -3 - 21i | 3991  | -29 - 11i | 4055  | -29 - 21i |
| 3608  | -7 - 49i | 3672  | -7 - 47i | 3736  | -25 - 49i | 3800  | -25 - 47i | 3864  | -7 - 15i | 3928  | -7 - 17i | 3992  | -25 - 15i | 4056  | -25 - 17i |
| 3609  | -7 - 51i | 3673  | -7 - 45i | 3737  | -25 - 51i | 3801  | -25 - 45i | 3865  | -7 - 13i | 3929  | -7 - 19i | 3993  | -25 - 13i | 4057  | -25 - 19i |
| 3610  | -5 - 49i | 3674  | -5 - 47i | 3738  | -27 - 49i | 3802  | -27 - 47i | 3866  | -5 - 15i | 3930  | -5 - 17i | 3994  | -27 - 15i | 4058  | -27 - 17i |
| 3611  | -5 - 51i | 3675  | -5 - 45i | 3739  | -27 - 51i | 3803  | -27 - 45i | 3867  | -5 - 13i | 3931  | -5 - 19i | 3995  | -27 - 13i | 4059  | -27 - 19i |
| 3612  | -7 - 55i | 3676  | -7 - 41i | 3740  | -25 - 55i | 3804  | -25 - 41i | 3868  | -7 - 9i  | 3932  | -7 - 23i | 3996  | -25 - 9i  | 4060  | -25 - 23i |
| 3613  | -7 - 53i | 3677  | -7 - 43i | 3741  | -25 - 53i | 3805  | -25 - 43i | 3869  | -7 - 11i | 3933  | -7 - 21i | 3997  | -25 - 11i | 4061  | -25 - 21i |
| 3614  | -5 - 55i | 3678  | -5 - 41i | 3742  | -27 - 55i | 3806  | -27 - 41i | 3870  | -5 - 9i  | 3934  | -5 - 23i | 3998  | -27 - 9i  | 4062  | -27 - 23i |
| 3615  | -5 - 53i | 3679  | -5 - 43i | 3743  | -27 - 53i | 3807  | -27 - 43i | 3871  | -5 - 11i | 3935  | -5 - 21i | 3999  | -27 - 11i | 4063  | -27 - 21i |

Fig. 31

|      |           |      |           |      |           |      |           |      |           |      |           |      |           |      |           |
|------|-----------|------|-----------|------|-----------|------|-----------|------|-----------|------|-----------|------|-----------|------|-----------|
| 3616 | -15 - 63i | 3680 | -15 - 33i | 3744 | -17 - 63i | 3808 | -17 - 33i | 3872 | -15 - 1i  | 3936 | -15 - 31i | 4000 | -17 - 1i  | 4064 | -17 - 31i |
| 3617 | -15 - 61i | 3681 | -15 - 35i | 3745 | -17 - 61i | 3809 | -17 - 35i | 3873 | -15 - 3i  | 3937 | -15 - 29i | 4001 | -17 - 3i  | 4065 | -17 - 29i |
| 3618 | -13 - 63i | 3682 | -13 - 33i | 3746 | -19 - 63i | 3810 | -19 - 33i | 3874 | -13 - 1i  | 3938 | -13 - 31i | 4002 | -19 - 1i  | 4066 | -19 - 31i |
| 3619 | -13 - 61i | 3683 | -13 - 35i | 3747 | -19 - 61i | 3811 | -19 - 35i | 3875 | -13 - 3i  | 3939 | -13 - 29i | 4003 | -19 - 3i  | 4067 | -19 - 29i |
| 3620 | -15 - 57i | 3684 | -15 - 39i | 3748 | -17 - 57i | 3812 | -17 - 39i | 3876 | -15 - 7i  | 3940 | -15 - 25i | 4004 | -17 - 7i  | 4068 | -17 - 25i |
| 3621 | -15 - 59i | 3685 | -15 - 37i | 3749 | -17 - 59i | 3813 | -17 - 37i | 3877 | -15 - 5i  | 3941 | -15 - 27i | 4005 | -17 - 5i  | 4069 | -17 - 27i |
| 3622 | -13 - 57i | 3686 | -13 - 39i | 3750 | -19 - 57i | 3814 | -19 - 39i | 3878 | -13 - 7i  | 3942 | -13 - 25i | 4006 | -19 - 7i  | 4070 | -19 - 25i |
| 3623 | -13 - 59i | 3687 | -13 - 37i | 3751 | -19 - 59i | 3815 | -19 - 37i | 3879 | -13 - 5i  | 3943 | -13 - 27i | 4007 | -19 - 5i  | 4071 | -19 - 27i |
| 3624 | -9 - 63i  | 3688 | -9 - 33i  | 3752 | -23 - 63i | 3816 | -23 - 33i | 3880 | -9 - 1i   | 3944 | -9 - 31i  | 4008 | -23 - 1i  | 4072 | -23 - 31i |
| 3625 | -9 - 61i  | 3689 | -9 - 35i  | 3753 | -23 - 61i | 3817 | -23 - 35i | 3881 | -9 - 3i   | 3945 | -9 - 29i  | 4009 | -23 - 3i  | 4073 | -23 - 29i |
| 3626 | -11 - 63i | 3690 | -11 - 33i | 3754 | -21 - 63i | 3818 | -21 - 33i | 3882 | -11 - 1i  | 3946 | -11 - 31i | 4010 | -21 - 1i  | 4074 | -21 - 31i |
| 3627 | -11 - 61i | 3691 | -11 - 35i | 3755 | -21 - 61i | 3819 | -21 - 35i | 3883 | -11 - 3i  | 3947 | -11 - 29i | 4011 | -21 - 3i  | 4075 | -21 - 29i |
| 3628 | -9 - 57i  | 3692 | -9 - 39i  | 3756 | -23 - 57i | 3820 | -23 - 39i | 3884 | -9 - 7i   | 3948 | -9 - 25i  | 4012 | -23 - 7i  | 4076 | -23 - 25i |
| 3629 | -9 - 59i  | 3693 | -9 - 37i  | 3757 | -23 - 59i | 3821 | -23 - 37i | 3885 | -9 - 5i   | 3949 | -9 - 27i  | 4013 | -23 - 5i  | 4077 | -23 - 27i |
| 3630 | -11 - 57i | 3694 | -11 - 39i | 3758 | -21 - 57i | 3822 | -21 - 39i | 3886 | -11 - 7i  | 3950 | -11 - 25i | 4014 | -21 - 7i  | 4078 | -21 - 25i |
| 3631 | -11 - 59i | 3695 | -11 - 37i | 3759 | -21 - 59i | 3823 | -21 - 37i | 3887 | -11 - 5i  | 3951 | -11 - 27i | 4015 | -21 - 5i  | 4079 | -21 - 27i |
| 3632 | -15 - 49i | 3696 | -15 - 47i | 3760 | -17 - 49i | 3824 | -17 - 47i | 3888 | -15 - 15i | 3952 | -15 - 17i | 4016 | -17 - 15i | 4080 | -17 - 17i |
| 3633 | -15 - 51i | 3697 | -15 - 45i | 3761 | -17 - 51i | 3825 | -17 - 45i | 3889 | -15 - 13i | 3953 | -15 - 19i | 4017 | -17 - 13i | 4081 | -17 - 19i |
| 3634 | -13 - 49i | 3698 | -13 - 47i | 3762 | -19 - 49i | 3826 | -19 - 47i | 3890 | -13 - 15i | 3954 | -13 - 17i | 4018 | -19 - 15i | 4082 | -19 - 17i |
| 3635 | -13 - 51i | 3699 | -13 - 45i | 3763 | -19 - 51i | 3827 | -19 - 45i | 3891 | -13 - 13i | 3955 | -13 - 19i | 4019 | -19 - 13i | 4083 | -19 - 19i |
| 3636 | -15 - 55i | 3700 | -15 - 41i | 3764 | -17 - 55i | 3828 | -17 - 41i | 3892 | -15 - 9i  | 3956 | -15 - 23i | 4020 | -17 - 9i  | 4084 | -17 - 23i |
| 3637 | -15 - 53i | 3701 | -15 - 43i | 3765 | -17 - 53i | 3829 | -17 - 43i | 3893 | -15 - 11i | 3957 | -15 - 21i | 4021 | -17 - 11i | 4085 | -17 - 21i |
| 3638 | -13 - 55i | 3702 | -13 - 41i | 3766 | -19 - 55i | 3830 | -19 - 41i | 3894 | -13 - 9i  | 3958 | -13 - 23i | 4022 | -19 - 9i  | 4086 | -19 - 23i |
| 3639 | -13 - 53i | 3703 | -13 - 43i | 3767 | -19 - 53i | 3831 | -19 - 43i | 3895 | -13 - 11i | 3959 | -13 - 21i | 4023 | -19 - 11i | 4087 | -19 - 21i |
| 3640 | -9 - 49i  | 3704 | -9 - 47i  | 3768 | -23 - 49i | 3832 | -23 - 47i | 3896 | -9 - 15i  | 3960 | -9 - 17i  | 4024 | -23 - 15i | 4088 | -23 - 17i |
| 3641 | -9 - 51i  | 3705 | -9 - 45i  | 3769 | -23 - 51i | 3833 | -23 - 45i | 3897 | -9 - 13i  | 3961 | -9 - 19i  | 4025 | -23 - 13i | 4089 | -23 - 19i |
| 3642 | -11 - 49i | 3706 | -11 - 47i | 3770 | -21 - 49i | 3834 | -21 - 47i | 3898 | -11 - 15i | 3962 | -11 - 17i | 4026 | -21 - 15i | 4090 | -21 - 17i |
| 3643 | -11 - 51i | 3707 | -11 - 45i | 3771 | -21 - 51i | 3835 | -21 - 45i | 3899 | -11 - 13i | 3963 | -11 - 19i | 4027 | -21 - 13i | 4091 | -21 - 19i |
| 3644 | -9 - 55i  | 3708 | -9 - 41i  | 3772 | -23 - 55i | 3836 | -23 - 41i | 3900 | -9 - 9i   | 3964 | -9 - 23i  | 4028 | -23 - 9i  | 4092 | -23 - 23i |
| 3645 | -9 - 53i  | 3709 | -9 - 43i  | 3773 | -23 - 53i | 3837 | -23 - 43i | 3901 | -9 - 11i  | 3965 | -9 - 21i  | 4029 | -23 - 11i | 4093 | -23 - 21i |
| 3646 | -11 - 55i | 3710 | -11 - 41i | 3774 | -21 - 55i | 3838 | -21 - 41i | 3902 | -11 - 9i  | 3966 | -11 - 23i | 4030 | -21 - 9i  | 4094 | -21 - 23i |
| 3647 | -11 - 53i | 3711 | -11 - 43i | 3775 | -21 - 53i | 3839 | -21 - 43i | 3903 | -11 - 11i | 3967 | -11 - 21i | 4031 | -21 - 11i | 4095 | -21 - 21i |

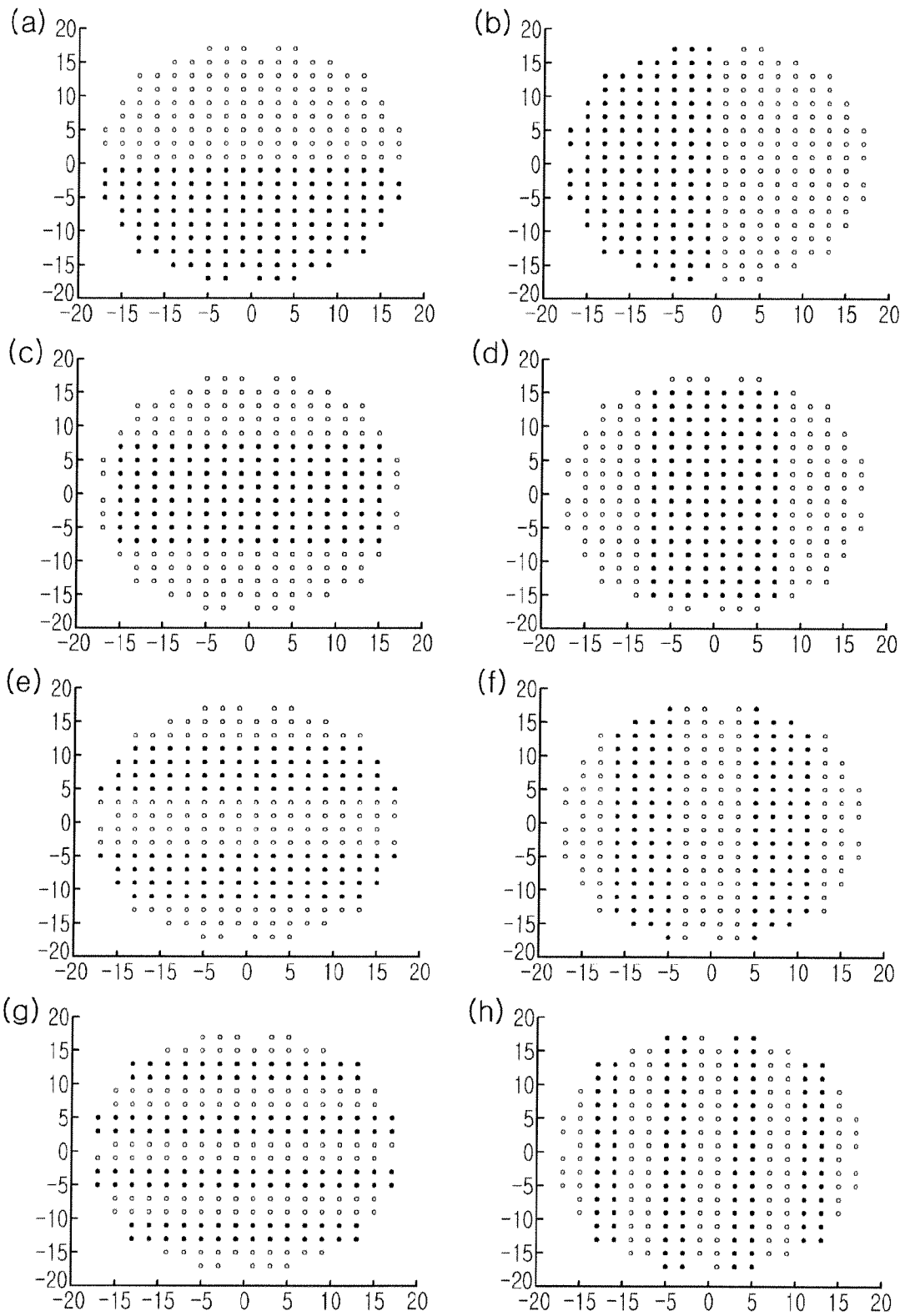
**Fig. 32**

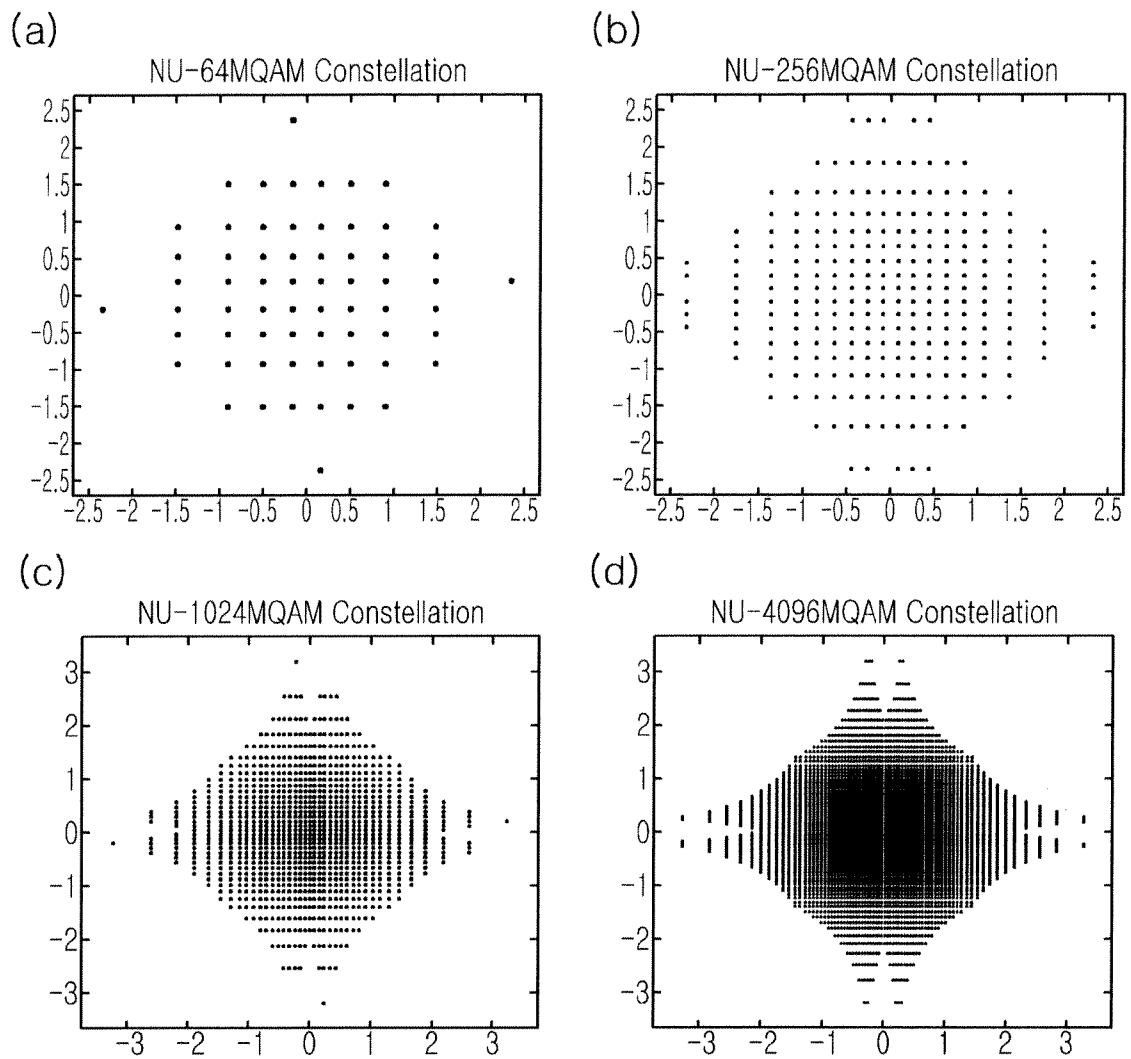
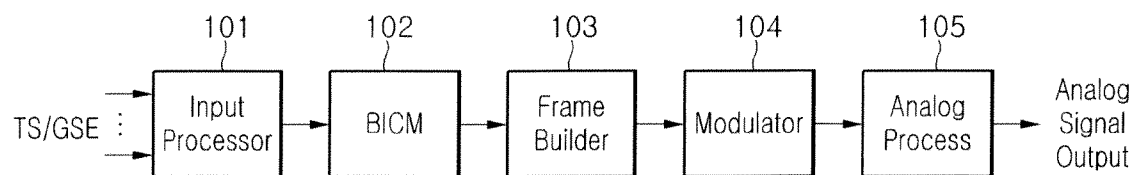
**Fig. 33****Fig. 34**

Fig. 35

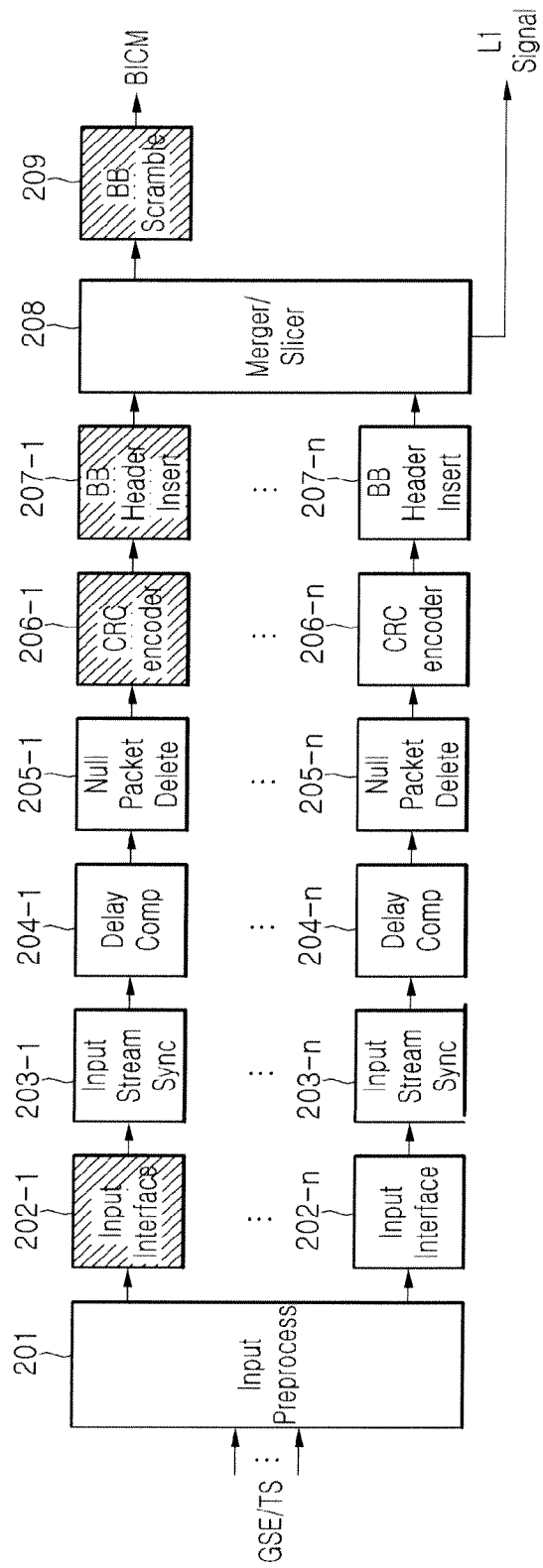


**Fig. 36**

| TS/GS (2 bits)                               | SIS/MIS (1 bit)            | CCM/ACM (1 bit)    | ISSYI (1 bit)                | NPD (1bit)                  | EXT (2bits)             |
|----------------------------------------------|----------------------------|--------------------|------------------------------|-----------------------------|-------------------------|
| 00 = GFPS<br>11 = TS<br>01 = GCS<br>10 = GSE | 1 = single<br>0 = multiple | 1 = CCM<br>0 = ACM | 1 = active<br>0 = not-active | 1= active<br>0 = not-active | Reserved for future use |

| Field      | Size (Bytes) | Description                                                                                                                                                                                                                                                                                                                                                 |
|------------|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MATYPE     | 2            | As described above                                                                                                                                                                                                                                                                                                                                          |
| UPL        | 2            | User Packet Length in bits, in the range [0,65535]                                                                                                                                                                                                                                                                                                          |
| DFL        | 2            | Data Field Length in bits, in the range [ 0,53760]                                                                                                                                                                                                                                                                                                          |
| SYNC       | 1            | A copy of the User Packet Sync-byte                                                                                                                                                                                                                                                                                                                         |
| SYNCD      | 2            | The distance in bits from the beginning of the DATA FIELD to the first complete UP of the data field. SYNCD=0 <sub>0</sub> means that the first UP is aligned to the beginning of the Data Field. SYNCD = 65535 <sub>0</sub> means that no UP starts in the DATA FIELD.                                                                                     |
| CRC-8 MODE | 1            | The XOR of the CRC-8 (1-byte) field with the MODE field (1-byte). CRC-8 is the error detection code applied to the first 9 bytes of the BBHEADER.<br>MODE (8 bits) shall be: <ul style="list-style-type: none"> <li>• 0<sub>0</sub> Normal Mode</li> <li>• 1<sub>0</sub> High Efficiency Mode</li> <li>• Other values : reserved for future use.</li> </ul> |

Fig. 37

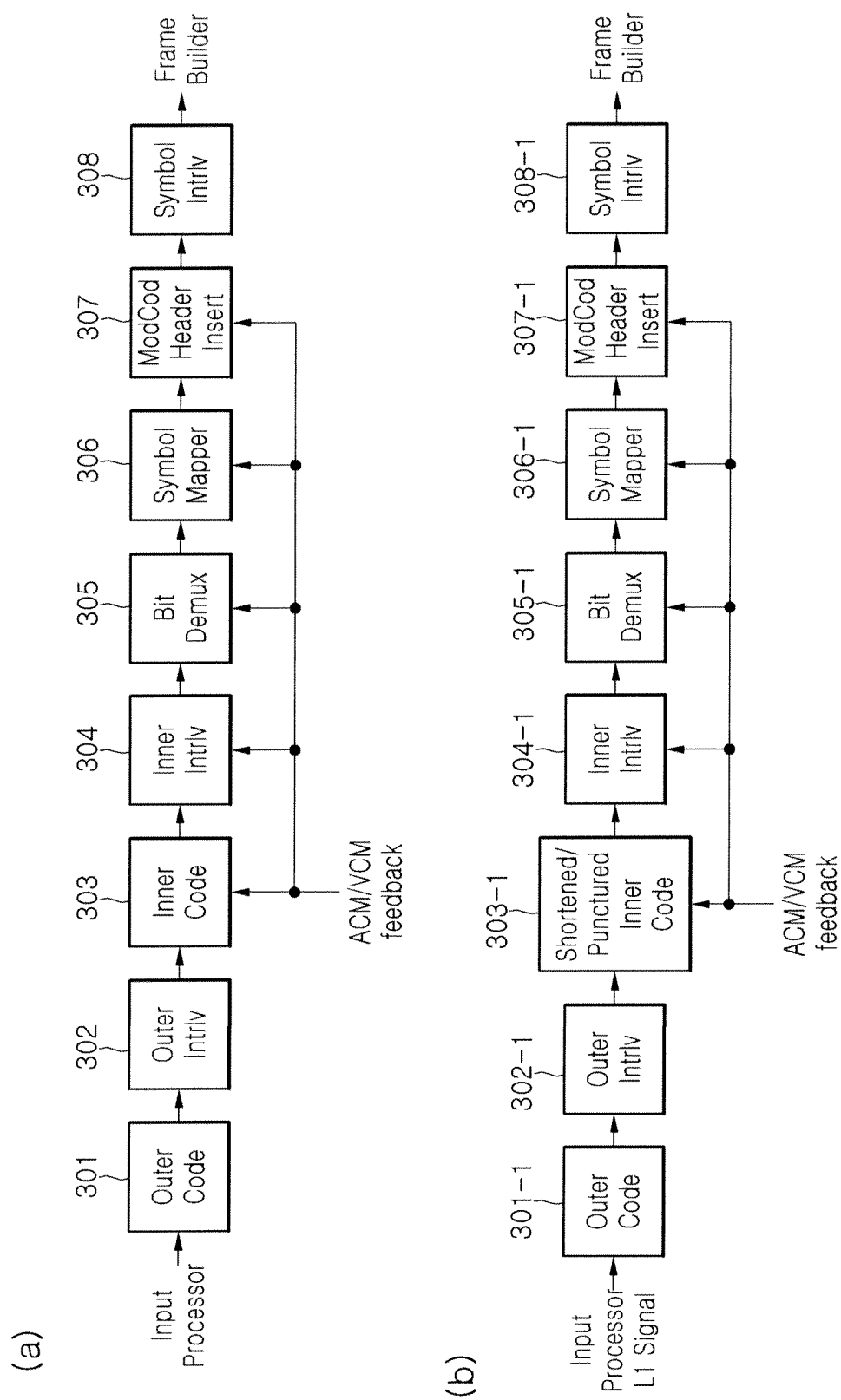


Fig. 38

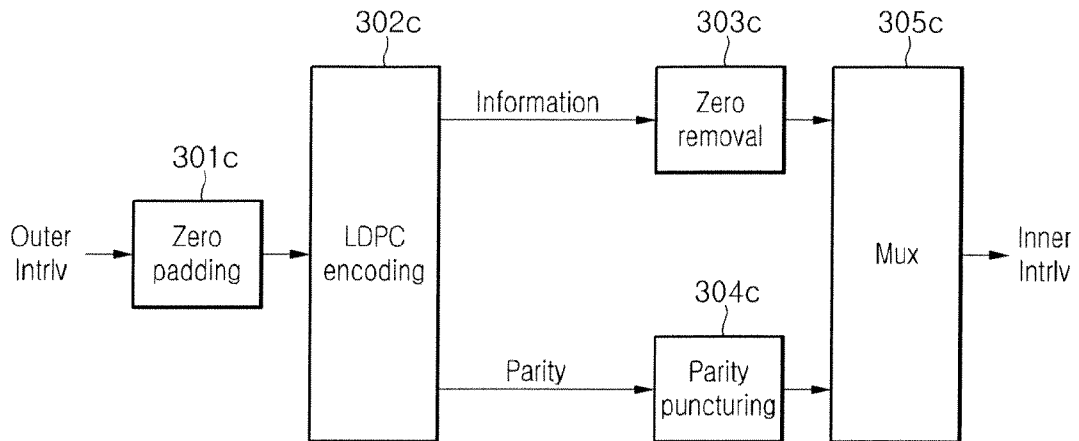


Fig. 39

|                     |      |      | Case 1     | Case 2     |
|---------------------|------|------|------------|------------|
| Capacity (bit/s/Hz) |      |      | Modulation | Modulation |
| 6                   | 1/2  | 3.0  | NU-MQAM    | NU-QAM     |
|                     | 2/3  | 4.0  | NU-MQAM    | NU-QAM     |
|                     | 3/4  | 4.5  | NU-MQAM    | NU-MQAM    |
|                     | 4/5  | 4.8  | MQAM       | MQAM       |
|                     | 5/6  | 5.0  | MQAM       | MQAM       |
|                     | 8/9  | 5.3  | MQAM       | MQAM       |
|                     | 9/10 | 5.4  | MQAM       | MQAM       |
| 8                   | 1/2  | 4.0  | NU-MQAM    | NU-QAM     |
|                     | 2/3  | 5.3  | NU-MQAM    | NU-QAM     |
|                     | 3/4  | 6.0  | NU-MQAM    | NU-MQAM    |
|                     | 4/5  | 6.4  | NU-MQAM    | NU-MQAM    |
|                     | 5/6  | 6.7  | MQAM       | MQAM       |
|                     | 8/9  | 7.1  | MQAM       | MQAM       |
|                     | 9/10 | 7.2  | MQAM       | MQAM       |
| 10                  | 1/2  | 5.0  | NU-MQAM    | NU-QAM     |
|                     | 2/3  | 6.7  | NU-MQAM    | NU-QAM     |
|                     | 3/4  | 7.5  | NU-MQAM    | NU-MQAM    |
|                     | 4/5  | 8.0  | NU-MQAM    | NU-MQAM    |
|                     | 5/6  | 8.3  | NU-MQAM    | NU-MQAM    |
|                     | 8/9  | 8.9  | MQAM       | MQAM       |
|                     | 9/10 | 9.0  | MQAM       | MQAM       |
| 12                  | 1/2  | 6.0  | NU-MQAM    | NU-QAM     |
|                     | 2/3  | 8.0  | NU-MQAM    | NU-QAM     |
|                     | 3/4  | 9.0  | NU-MQAM    | NU-MQAM    |
|                     | 4/5  | 9.6  | NU-MQAM    | NU-MQAM    |
|                     | 5/6  | 10.0 | NU-MQAM    | NU-MQAM    |
|                     | 8/9  | 10.7 | MQAM       | MQAM       |
|                     | 9/10 | 10.8 | MQAM       | MQAM       |

Fig. 40

|                     |      |      | Case 1     | Case 2     | Case 2     |
|---------------------|------|------|------------|------------|------------|
| Capacity (bit/s/Hz) |      |      | Modulation | Modulation | Modulation |
| 2                   | 1/2  | 3.0  | QAM        | QAM        | QAM        |
|                     | 2/3  | 4.0  | QAM        | QAM        | QAM        |
|                     | 3/4  | 4.5  | QAM        | QAM        | QAM        |
|                     | 4/5  | 4.8  | QAM        | QAM        | QAM        |
|                     | 5/6  | 5.0  | QAM        | QAM        | QAM        |
|                     | 8/9  | 5.3  | QAM        | QAM        | QAM        |
|                     | 9/10 | 5.4  | QAM        | QAM        | QAM        |
| 4                   | 1/2  | 3.0  | QAM        | QAM        | QAM        |
|                     | 2/3  | 4.0  | QAM        | QAM        | QAM        |
|                     | 3/4  | 4.5  | QAM        | QAM        | QAM        |
|                     | 4/5  | 4.8  | QAM        | QAM        | QAM        |
|                     | 5/6  | 5.0  | QAM        | QAM        | QAM        |
|                     | 8/9  | 5.3  | QAM        | QAM        | QAM        |
|                     | 9/10 | 5.4  | QAM        | QAM        | QAM        |
| 6                   | 1/2  | 3.0  | QAM        | QAM        | QAM        |
|                     | 2/3  | 4.0  | QAM        | QAM        | QAM        |
|                     | 3/4  | 4.5  | QAM        | QAM        | QAM        |
|                     | 4/5  | 4.8  | QAM        | QAM        | QAM        |
|                     | 5/6  | 5.0  | QAM        | QAM        | QAM        |
|                     | 8/9  | 5.3  | QAM        | QAM        | QAM        |
|                     | 9/10 | 5.4  | QAM        | QAM        | QAM        |
| 8                   | 1/2  | 4.0  | QAM        | QAM        | QAM        |
|                     | 2/3  | 5.3  | QAM        | QAM        | QAM        |
|                     | 3/4  | 6.0  | QAM        | QAM        | QAM        |
|                     | 4/5  | 6.4  | QAM        | QAM        | QAM        |
|                     | 5/6  | 6.7  | QAM        | QAM        | QAM        |
|                     | 8/9  | 7.1  | QAM        | QAM        | QAM        |
|                     | 9/10 | 7.2  | QAM        | QAM        | QAM        |
| 10                  | 1/2  | 5.0  | NU-MQAM    | NU-QAM     | MQAM       |
|                     | 2/3  | 6.7  | NU-MQAM    | NU-QAM     | MQAM       |
|                     | 3/4  | 7.5  | NU-MQAM    | NU-MQAM    | MQAM       |
|                     | 4/5  | 8.0  | NU-MQAM    | NU-MQAM    | MQAM       |
|                     | 5/6  | 8.3  | NU-MQAM    | NU-MQAM    | MQAM       |
|                     | 8/9  | 8.9  | MQAM       | MQAM       | MQAM       |
|                     | 9/10 | 9.0  | MQAM       | MQAM       | MQAM       |
| 12                  | 1/2  | 6.0  | NU-MQAM    | NU-QAM     | MQAM       |
|                     | 2/3  | 8.0  | NU-MQAM    | NU-QAM     | MQAM       |
|                     | 3/4  | 9.0  | NU-MQAM    | NU-MQAM    | MQAM       |
|                     | 4/5  | 9.6  | NU-MQAM    | NU-MQAM    | MQAM       |
|                     | 5/6  | 10.0 | NU-MQAM    | NU-MQAM    | MQAM       |
|                     | 8/9  | 10.7 | MQAM       | MQAM       | MQAM       |
|                     | 9/10 | 10.8 | MQAM       | MQAM       | MQAM       |

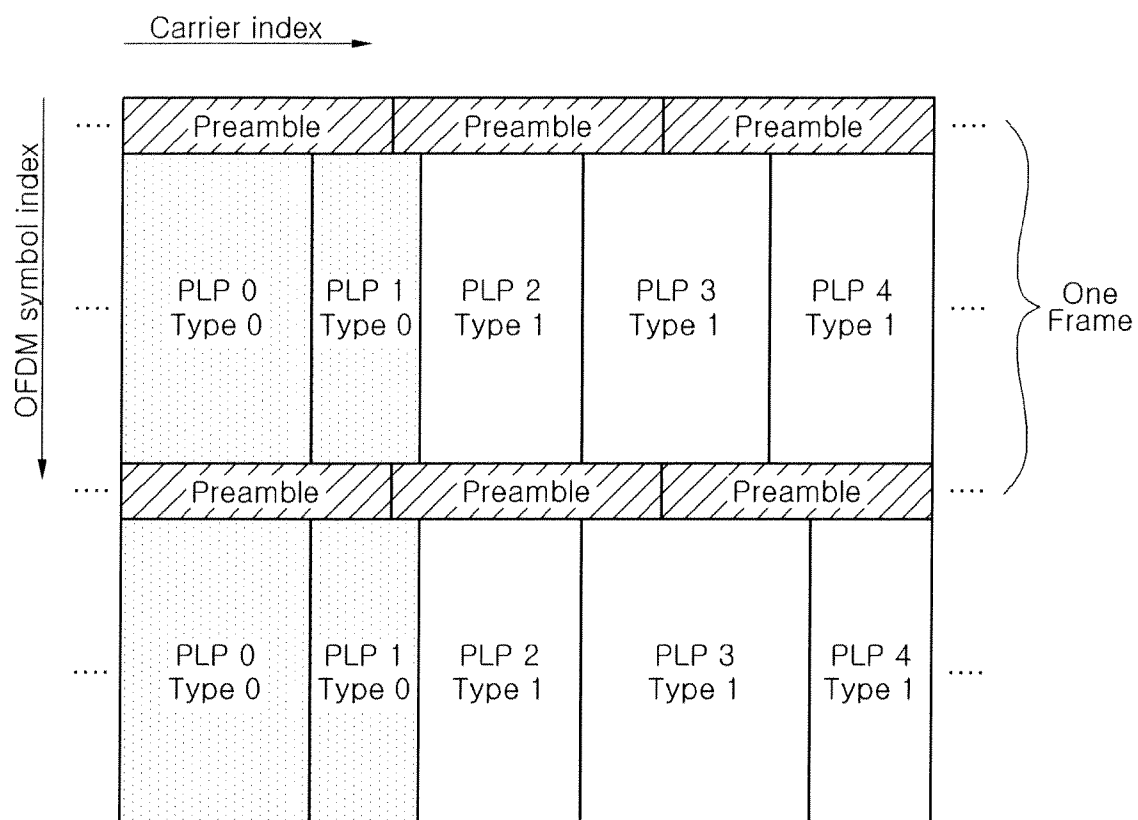
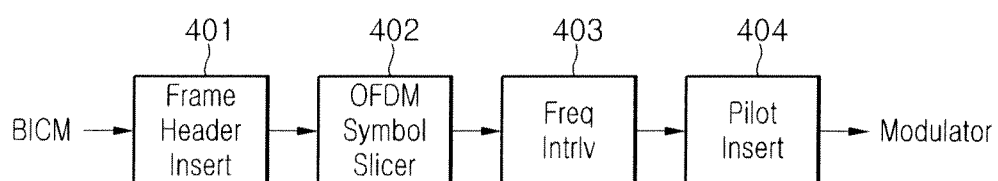
**Fig. 41****Fig. 42**

Fig. 43

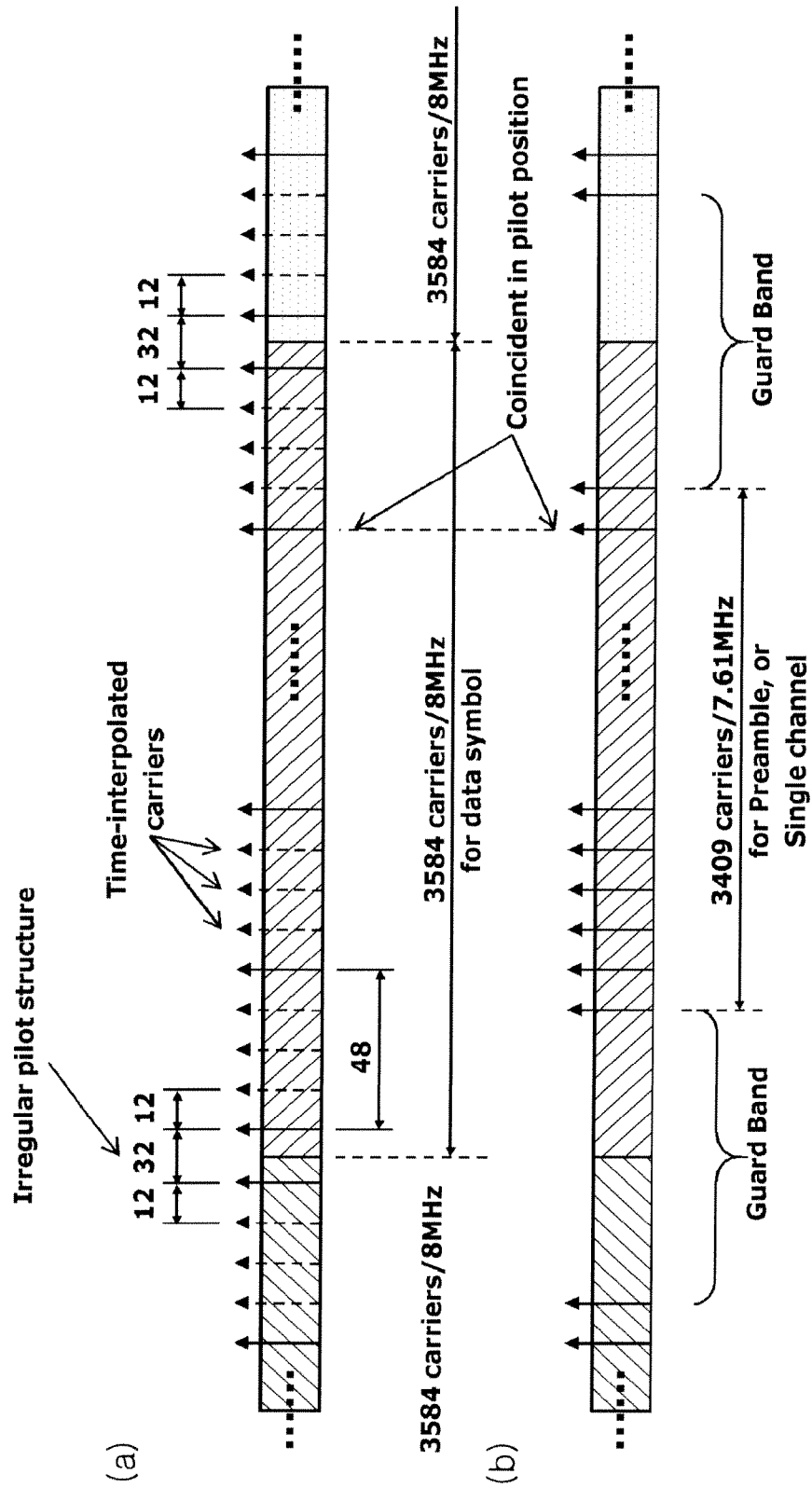


Fig. 44

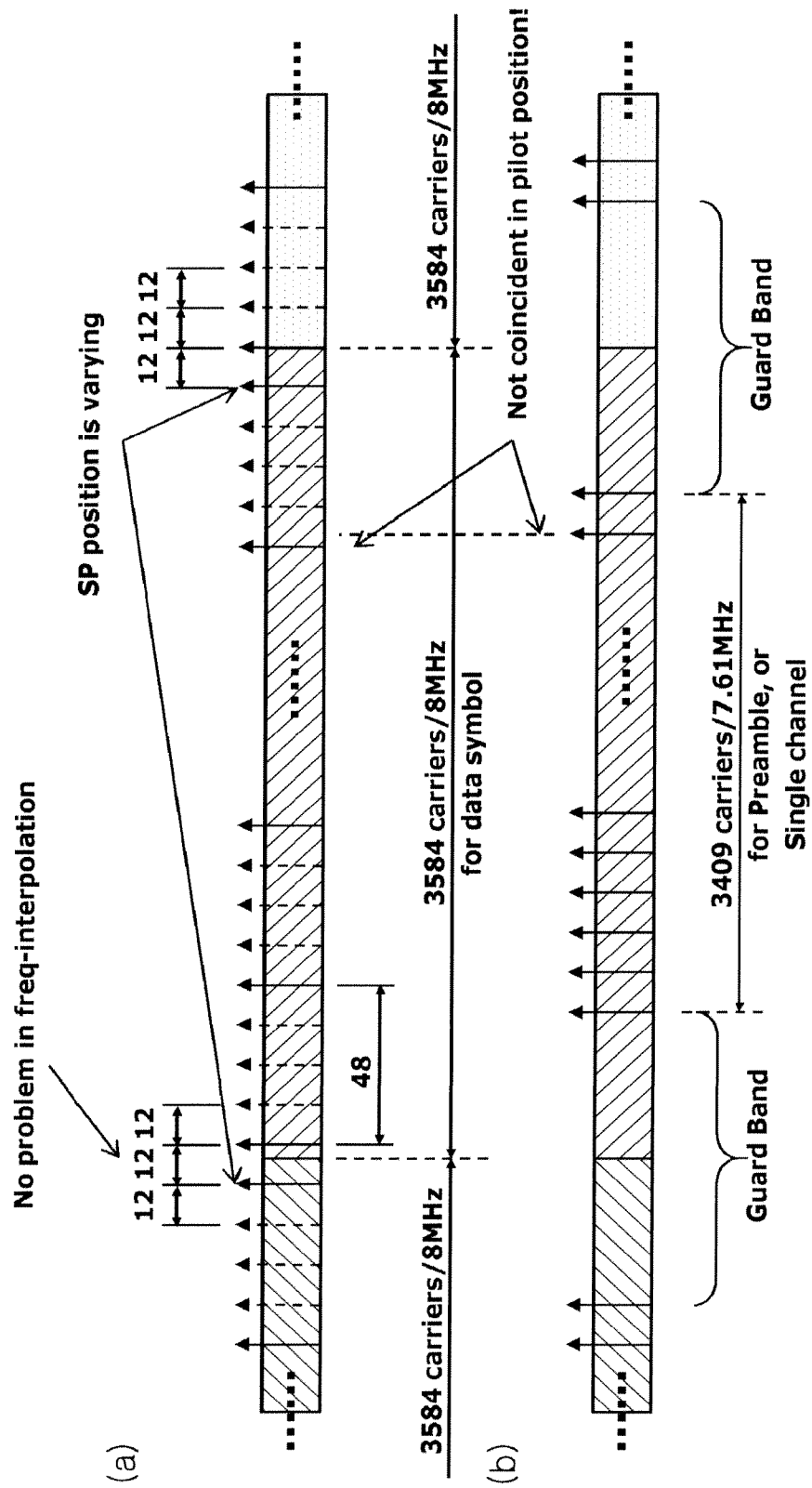


Fig. 45

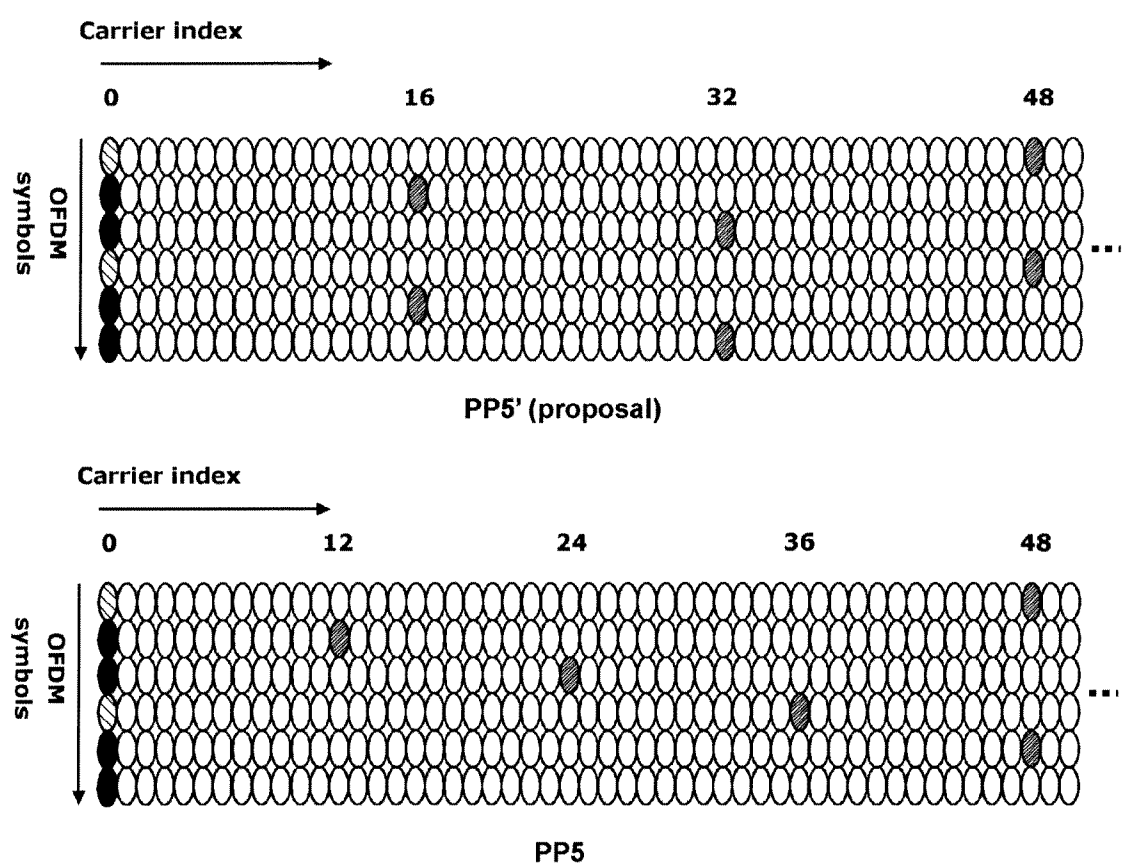


Fig. 46

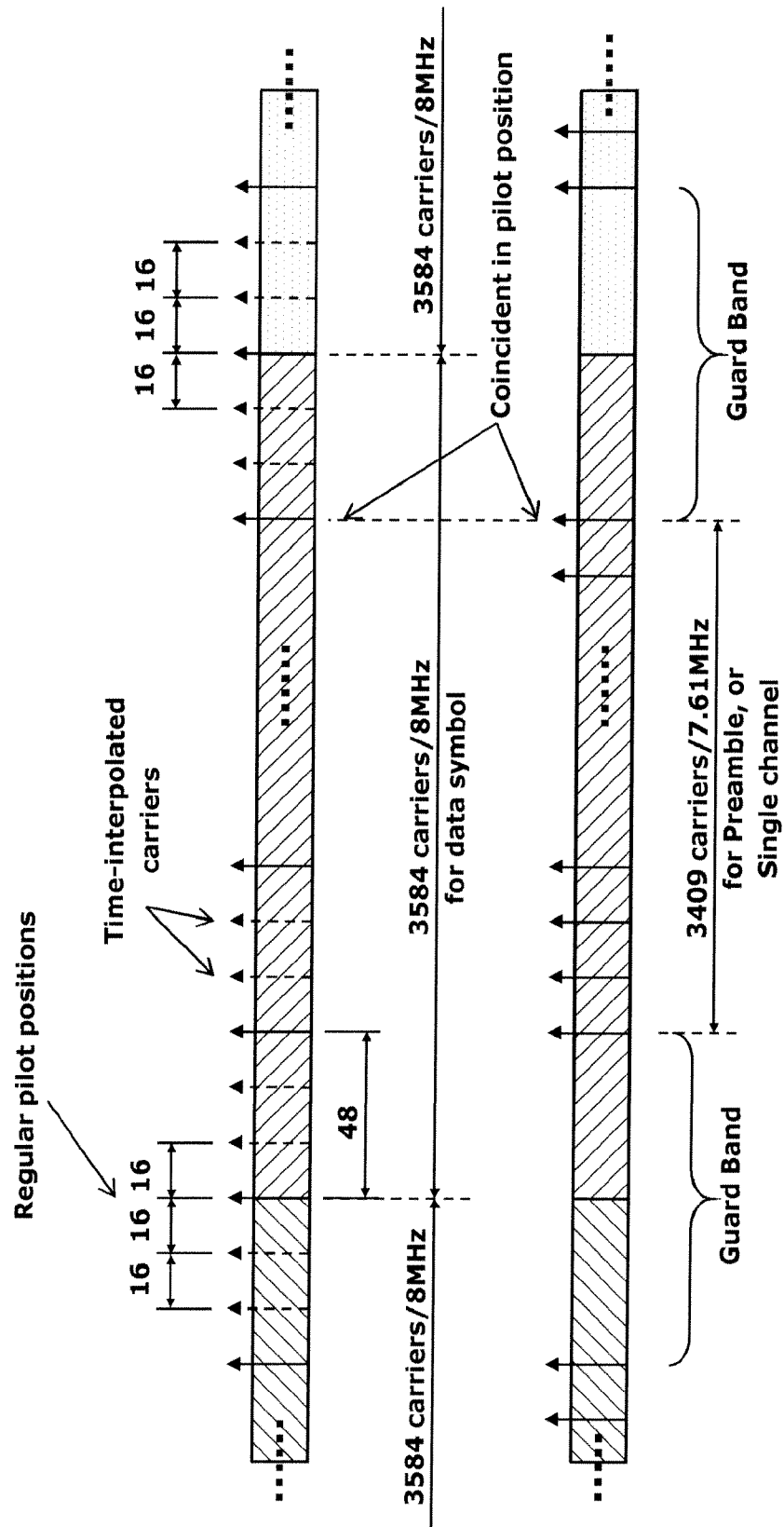


Fig. 47

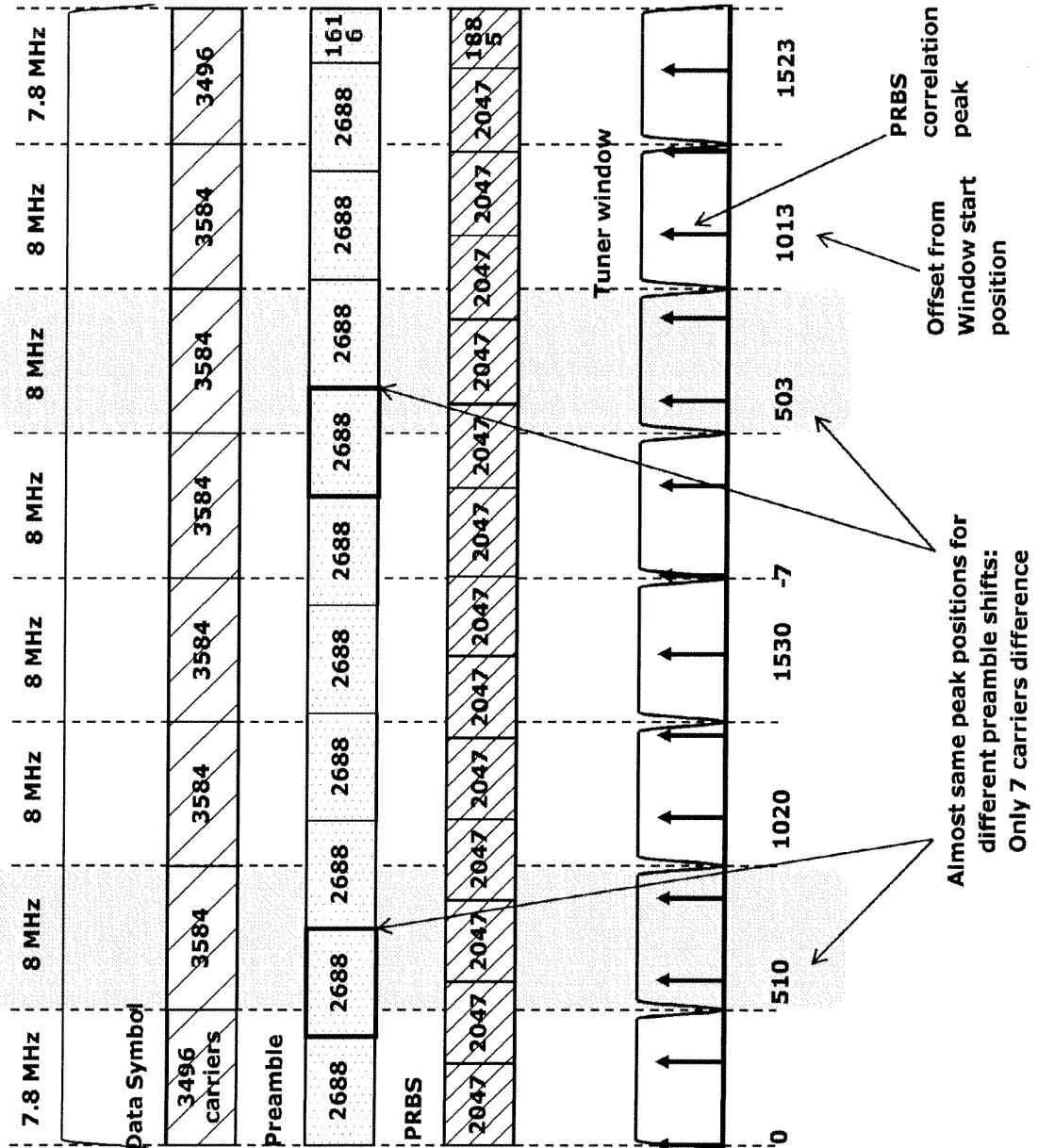


Fig. 48

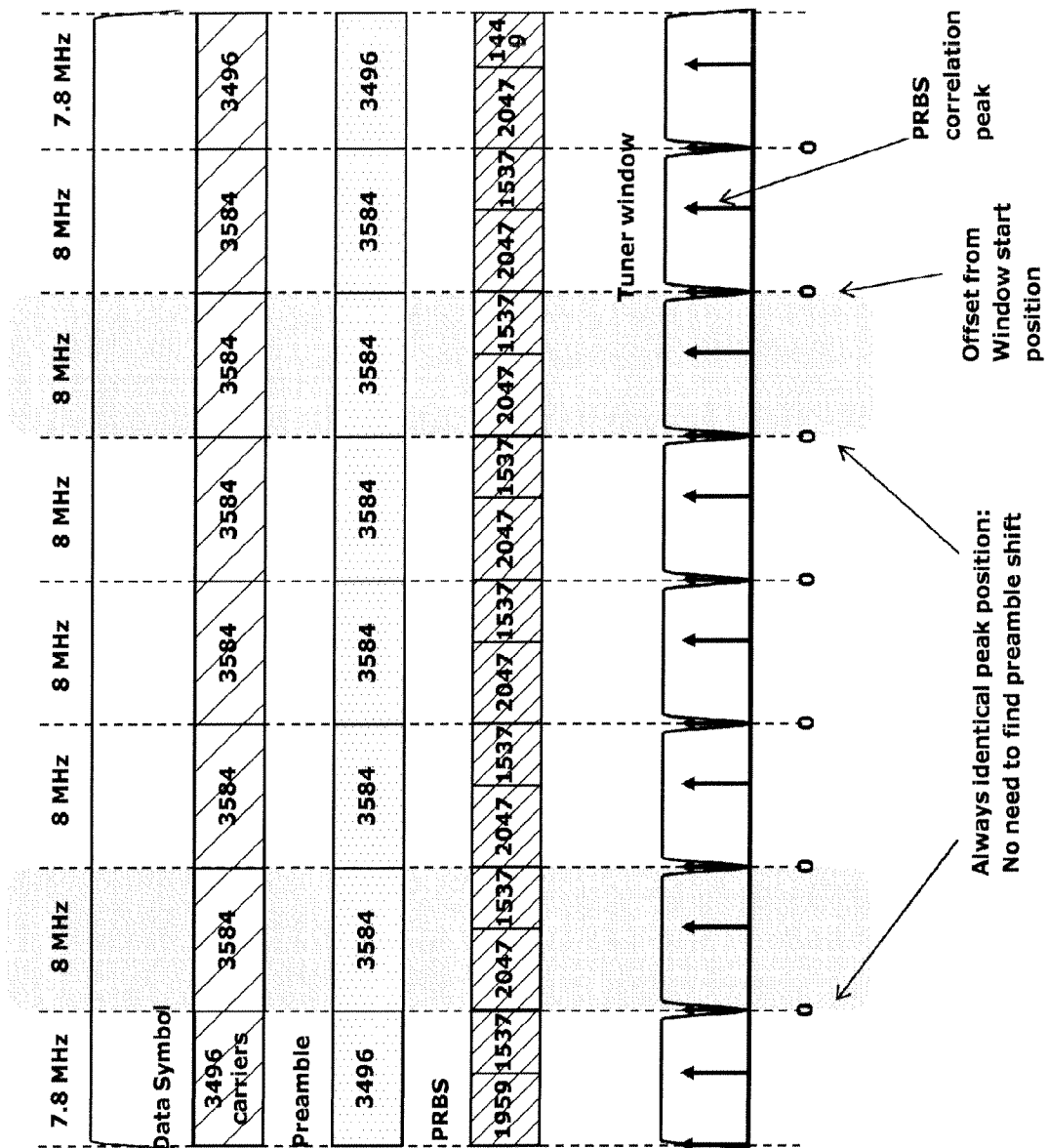


**Fig. 49**

|                     |     |     |     |     |     |     |
|---------------------|-----|-----|-----|-----|-----|-----|
| Delay<br>( $\mu$ s) | 0.2 | 0.4 | 0.8 | 1.2 | 2.5 | 15  |
| Att.<br>(dB)        | -11 | -14 | -17 | -23 | -32 | -40 |

Negligible  
Delay path

Fig. 50

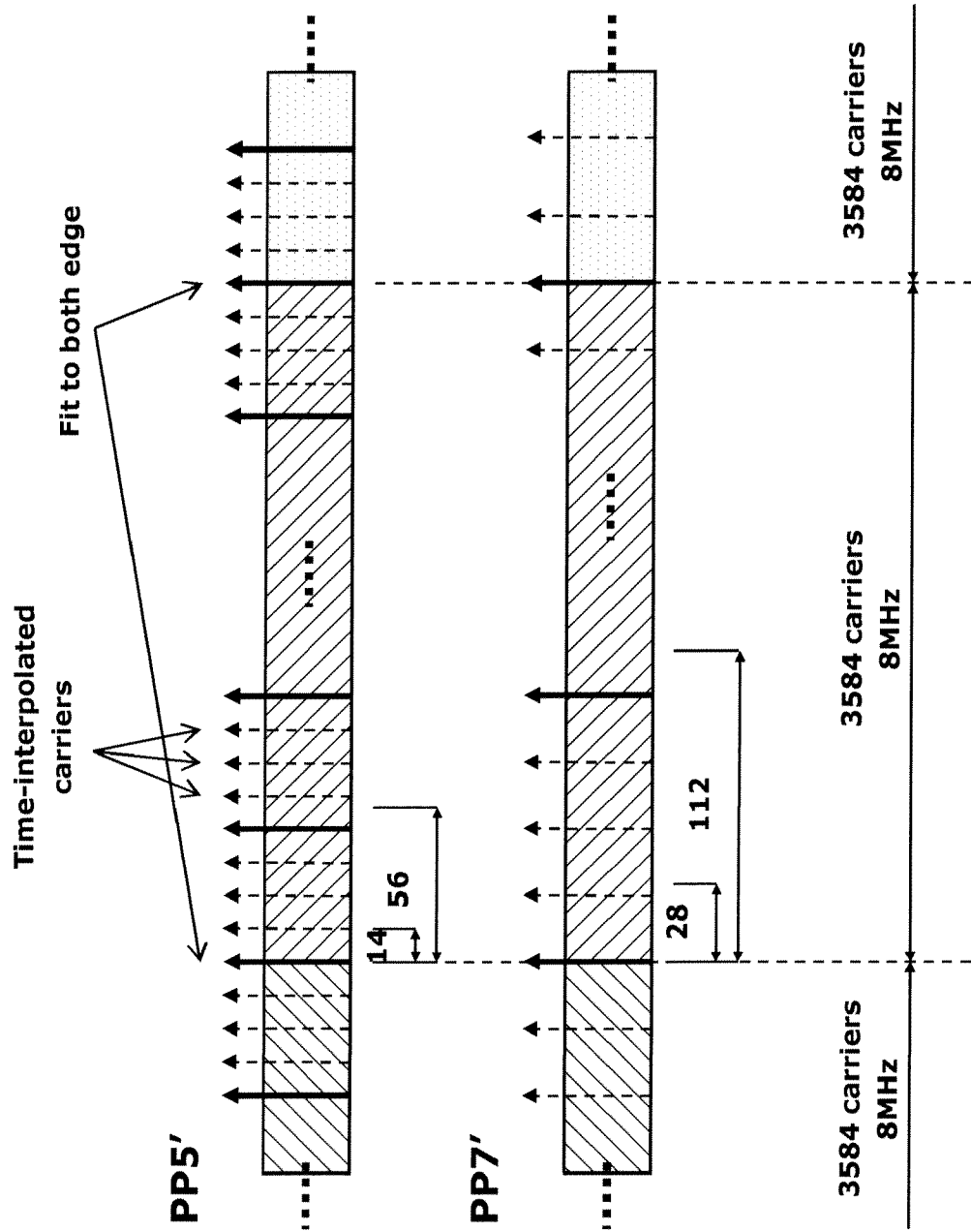


**Fig. 51**

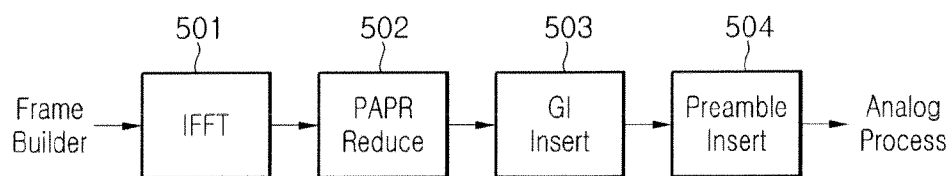


**Fig. 52**

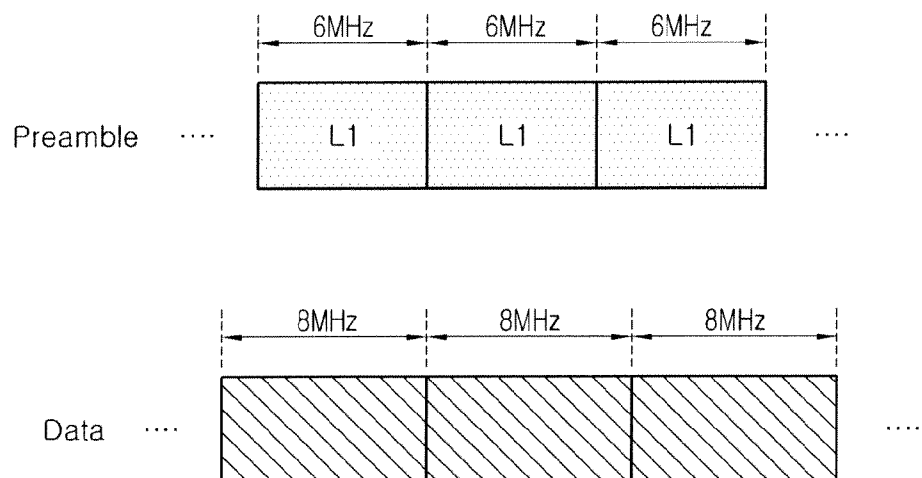


**Fig. 53**

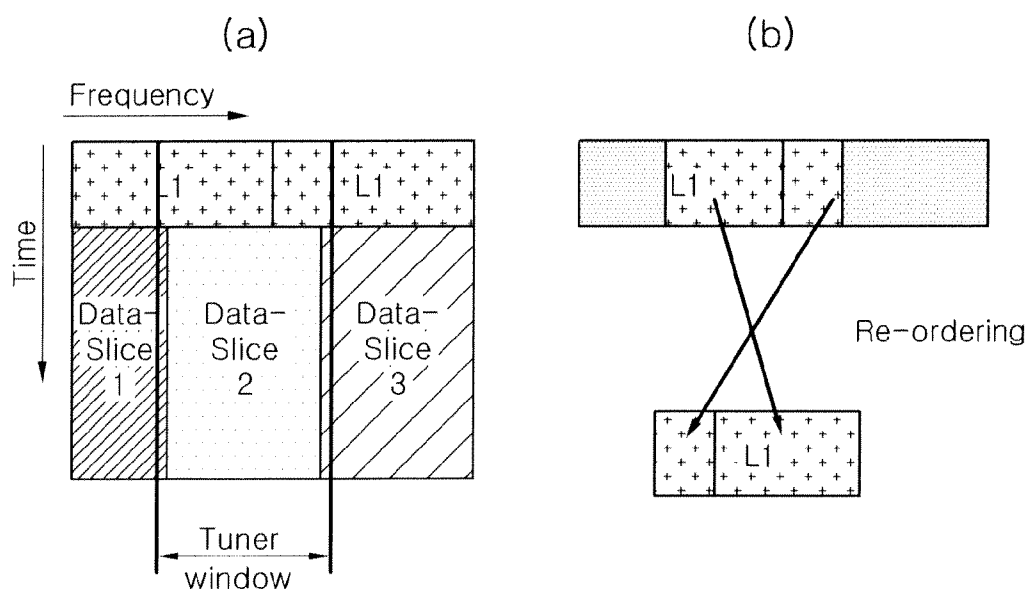


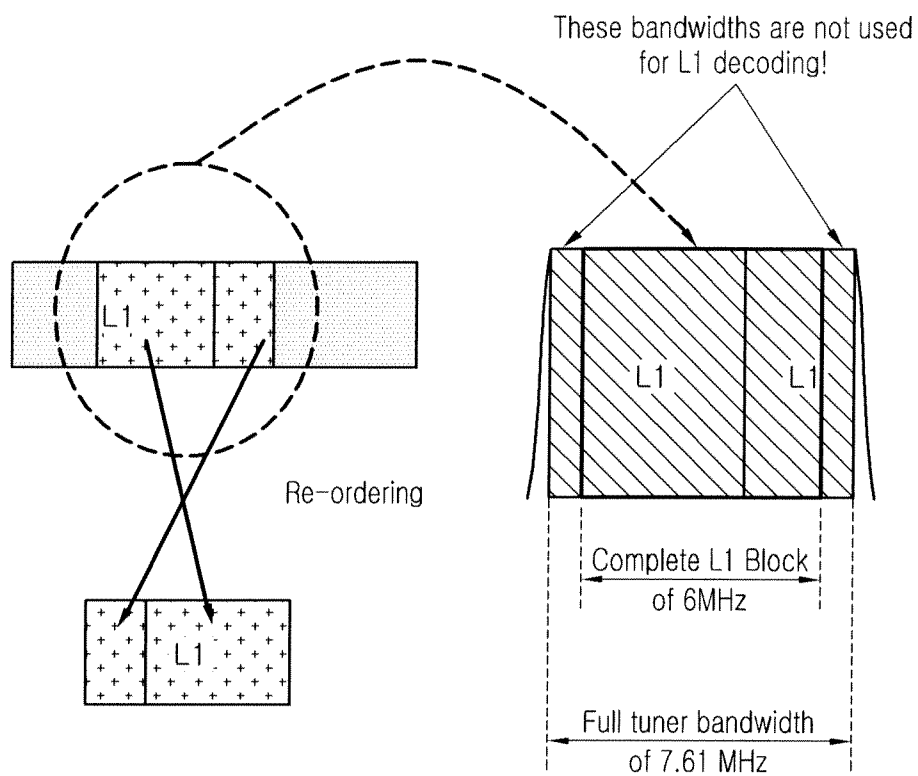
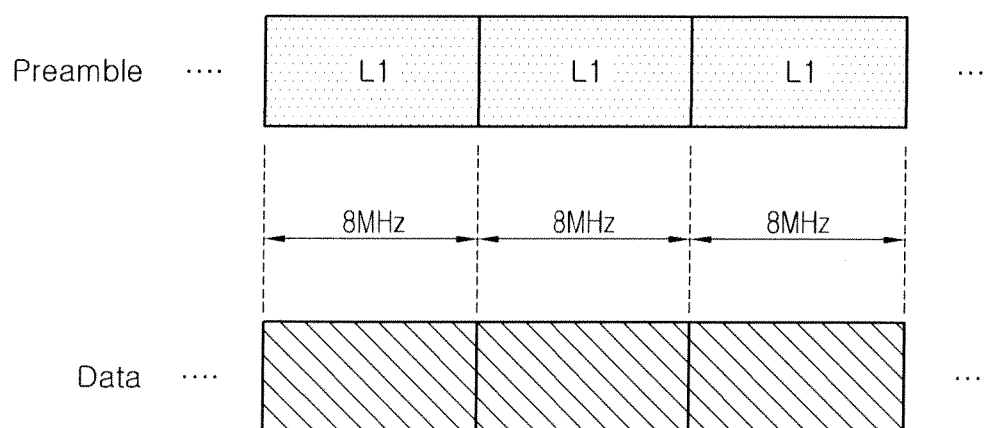
**Fig. 54****Fig. 55**

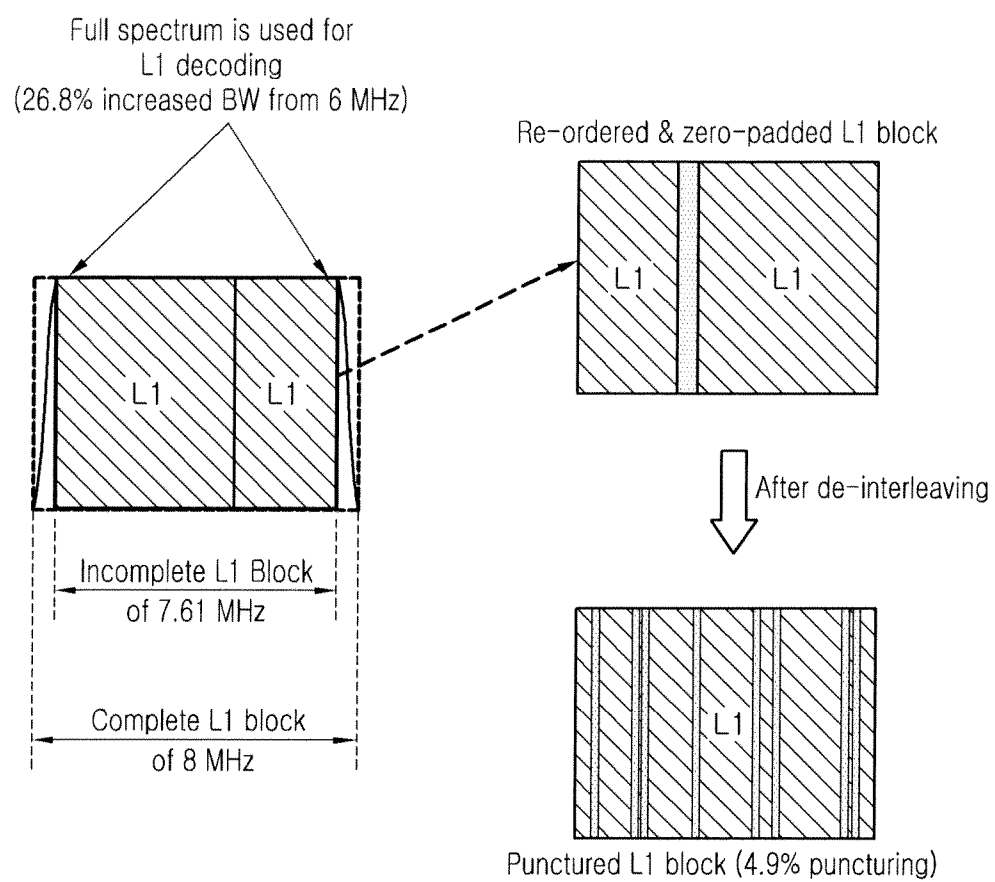
**Fig. 56**

**Fig. 57**

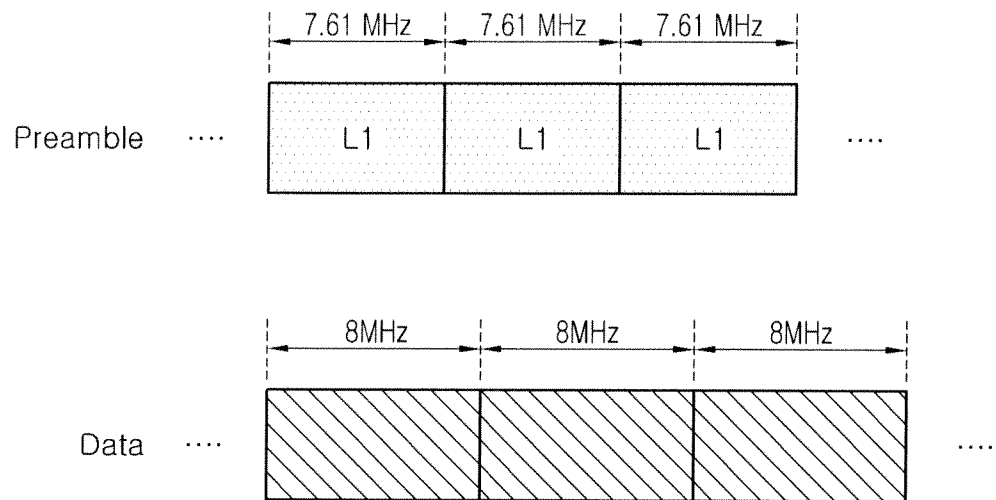


**Fig. 58**

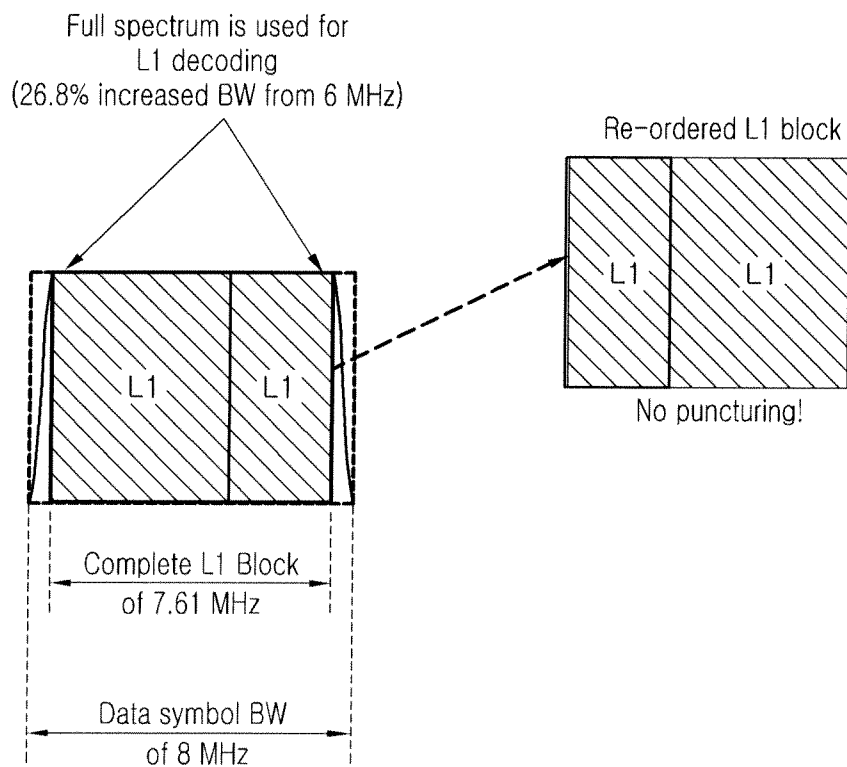


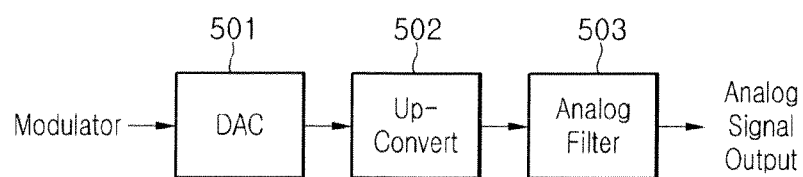
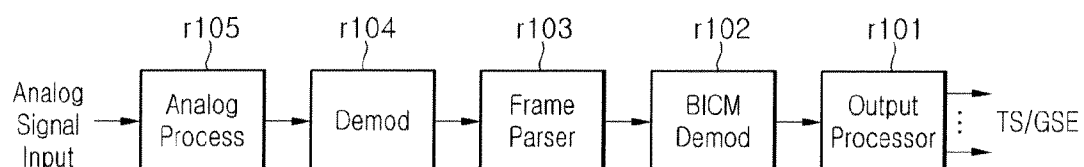
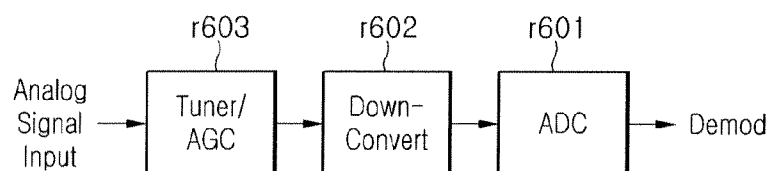
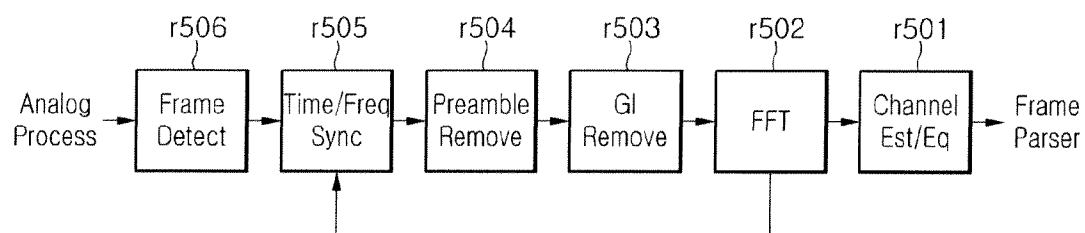
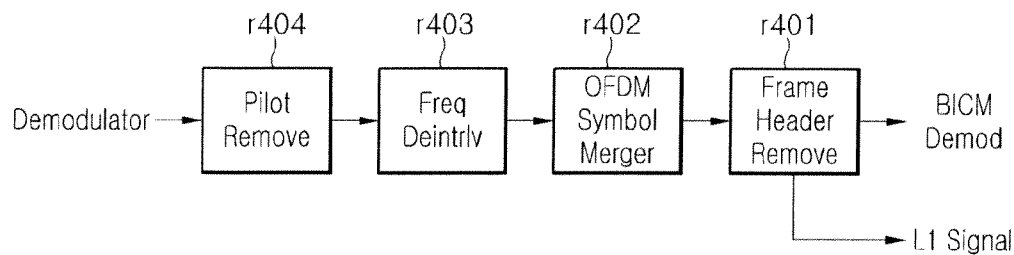
**Fig. 59****Fig. 60****Fig. 61****Fig. 62****Fig. 63**

Fig. 64

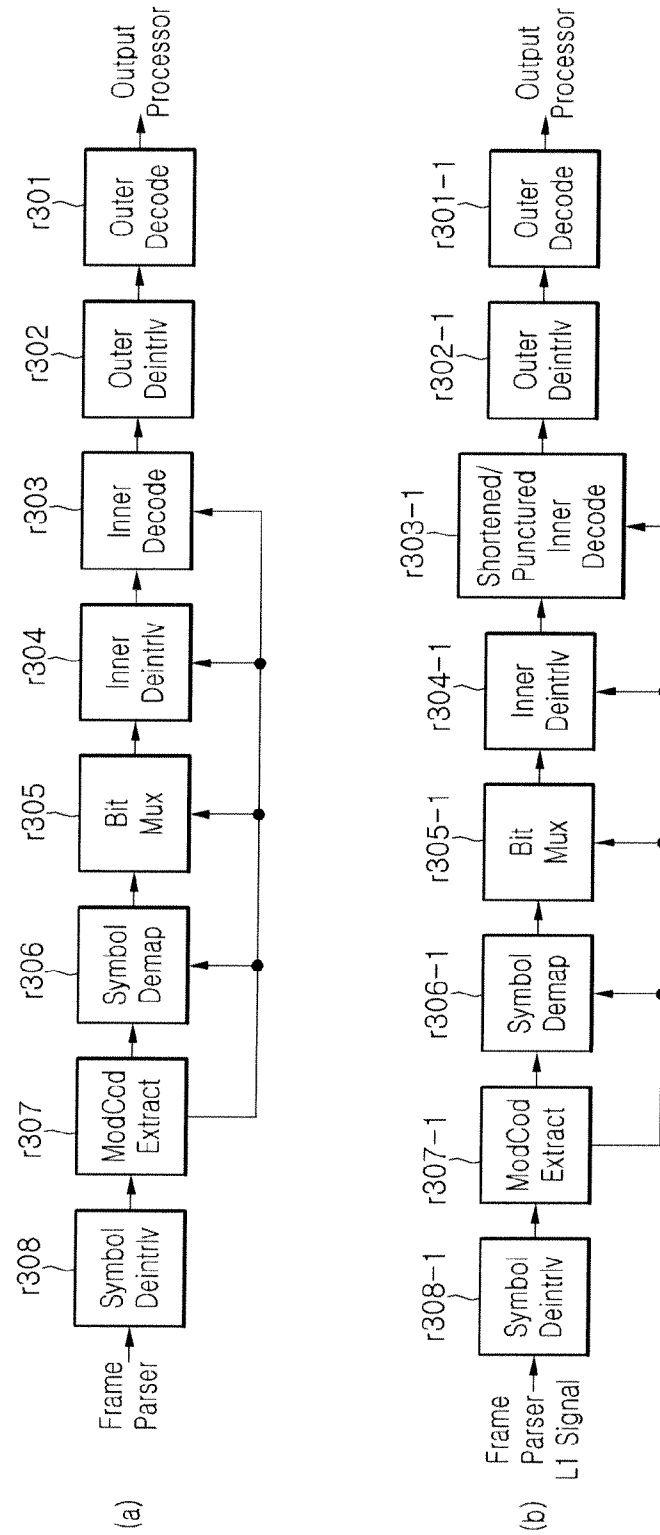


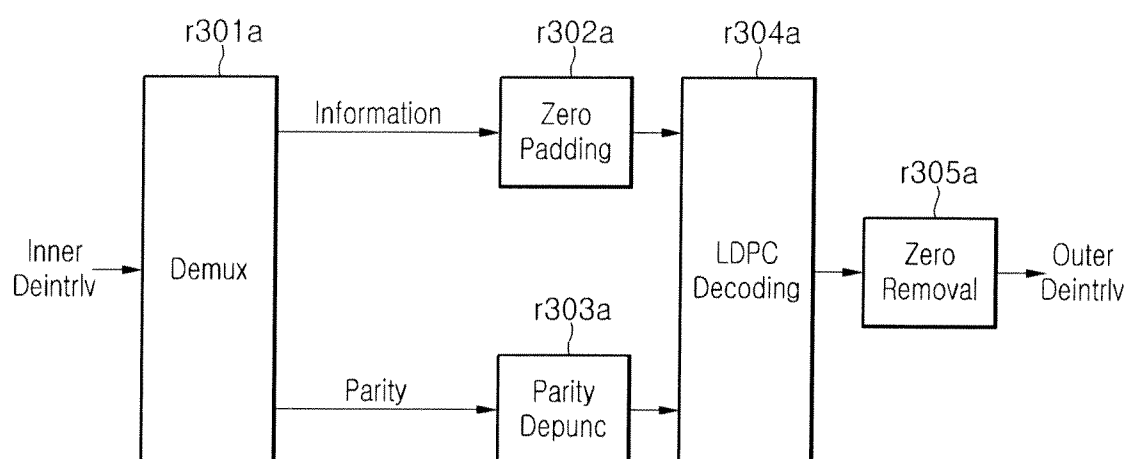
**Fig. 65**

Fig. 66

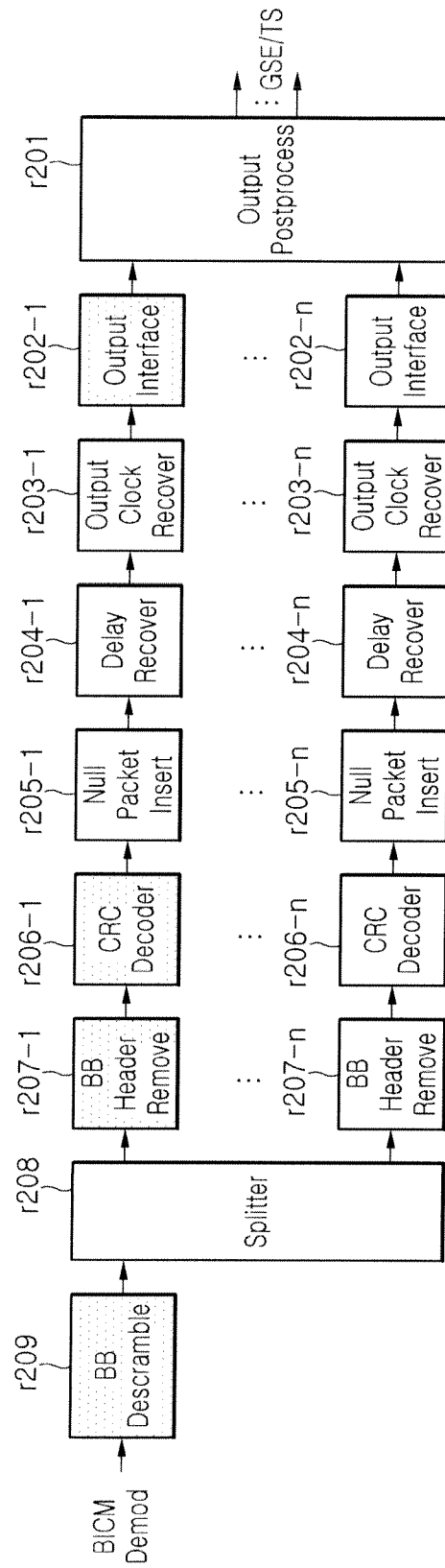


**Fig. 67**

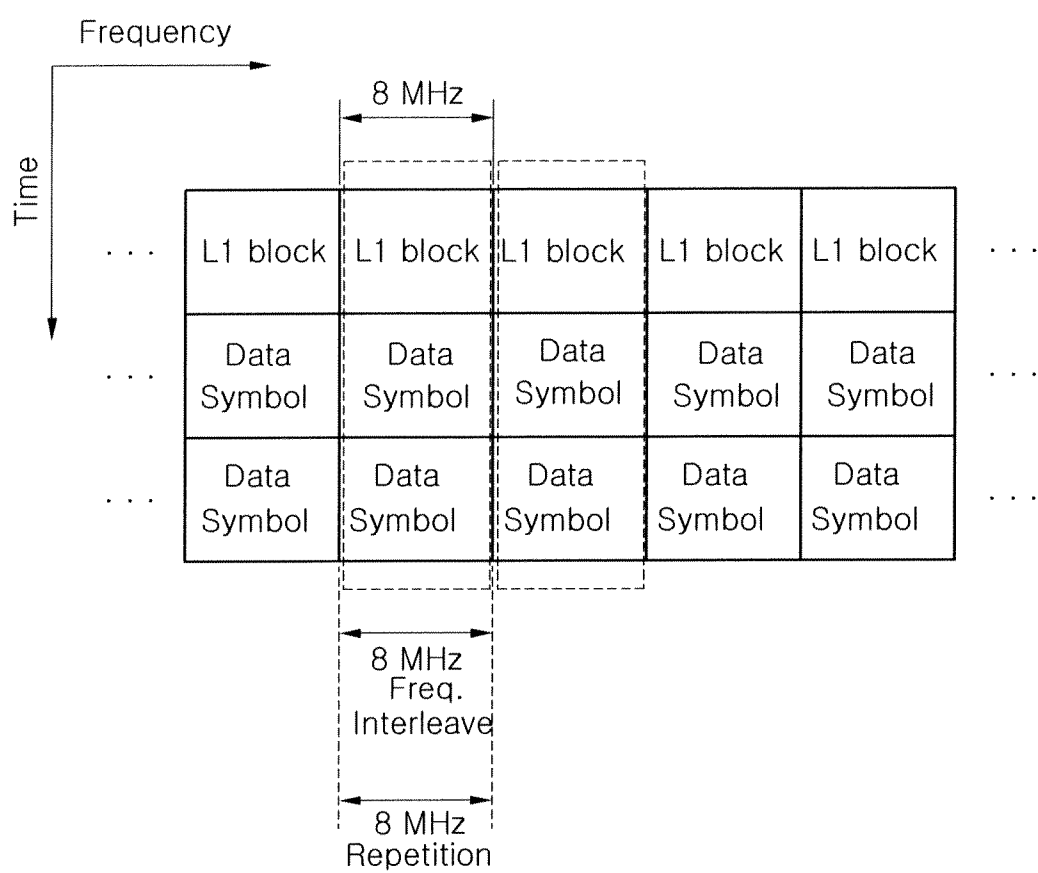


**Fig. 68**

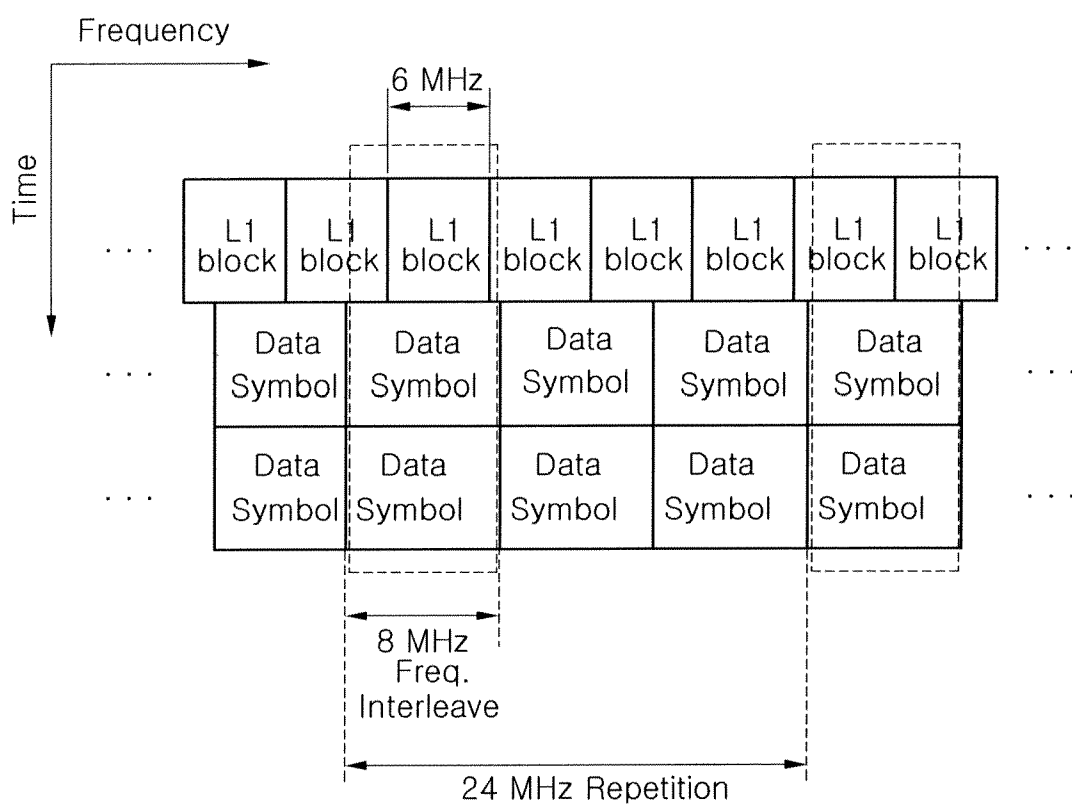


**Fig. 69**

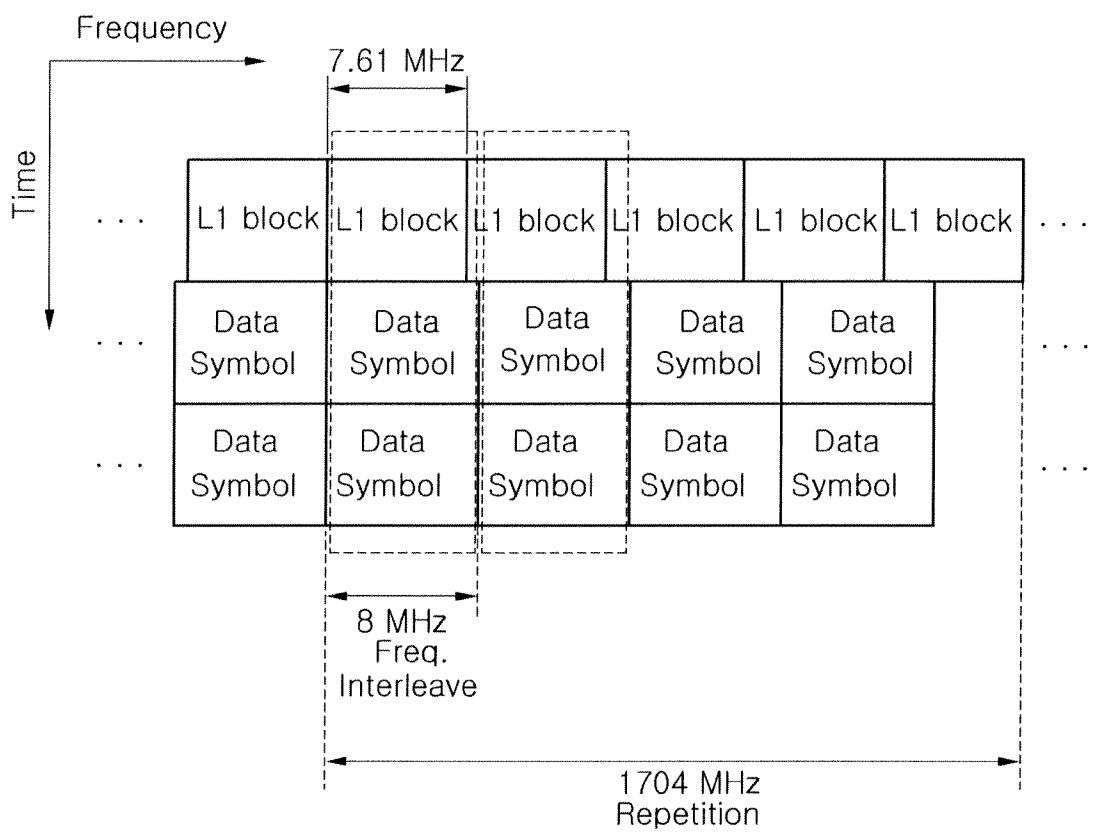


**Fig. 70**

| Field            | Bits  |                                                                              |
|------------------|-------|------------------------------------------------------------------------------|
| L1_span          | 12    | number of carriers spanned by L1 block within one OFDM symbol (Max=7.61 MHz) |
| num_chbon        | 3     | number of bonded channels                                                    |
| num_dslice       | 8     | number of data slices                                                        |
| num_plp          | 8     | number of PLPs                                                               |
| num_notch        | 5     | number of notch bands                                                        |
| for dslice {     |       |                                                                              |
| chbon_index      | 3     | bonded channel index                                                         |
| dslice_start     | 9     | start of data slice within one channel (8 MHz)                               |
| dslice_width     | 9     | width of data slice                                                          |
| }                |       |                                                                              |
| for plp {        |       |                                                                              |
| dslice_id        | 8     | data sliced ID                                                               |
| plp_id           | 8     | PLP ID                                                                       |
| plp_type         | 1     | PLP type (common/data)                                                       |
| plp_payload_type | 5     | PLP payload type (TS,GS,...)                                                 |
| }                |       |                                                                              |
| for notch {      |       |                                                                              |
| chbon_index      | 3     | bonded channel index                                                         |
| notch_start      | 9     | start of notch band within one channel (8 MHz)                               |
| notch_width      | 9     | width of notch band                                                          |
| }                |       |                                                                              |
| gi               | 1     | guard interval mode                                                          |
| sframe_id        | 16    | superframe ID                                                                |
| frame_id         | 16    | frame ID                                                                     |
| reserved         | 0     | rfu                                                                          |
| crc32            | 32    | CRC32                                                                        |
| Total            | 11760 |                                                                              |


 The number of L1 information bits varies according to various configurations/conditions

**Fig. 71**

|                      |       |                                                                                      |  |
|----------------------|-------|--------------------------------------------------------------------------------------|--|
| L1 info (bits)       | 11760 |  |  |
| L1 block (bits)      | 23520 |                                                                                      |  |
| 16 – QAM symbols     | 5880  | Maximum size                                                                         |  |
| Total carriers       | 3408  |                                                                                      |  |
| Preamble SP distance | 6     |                                                                                      |  |
| Data carriers        | 2840  |                                                                                      |  |
| Short LDPC           | 1.45  |                                                                                      |  |
| OFDM symbols         | 2.07  |                                                                                      |  |

**Fig. 72**

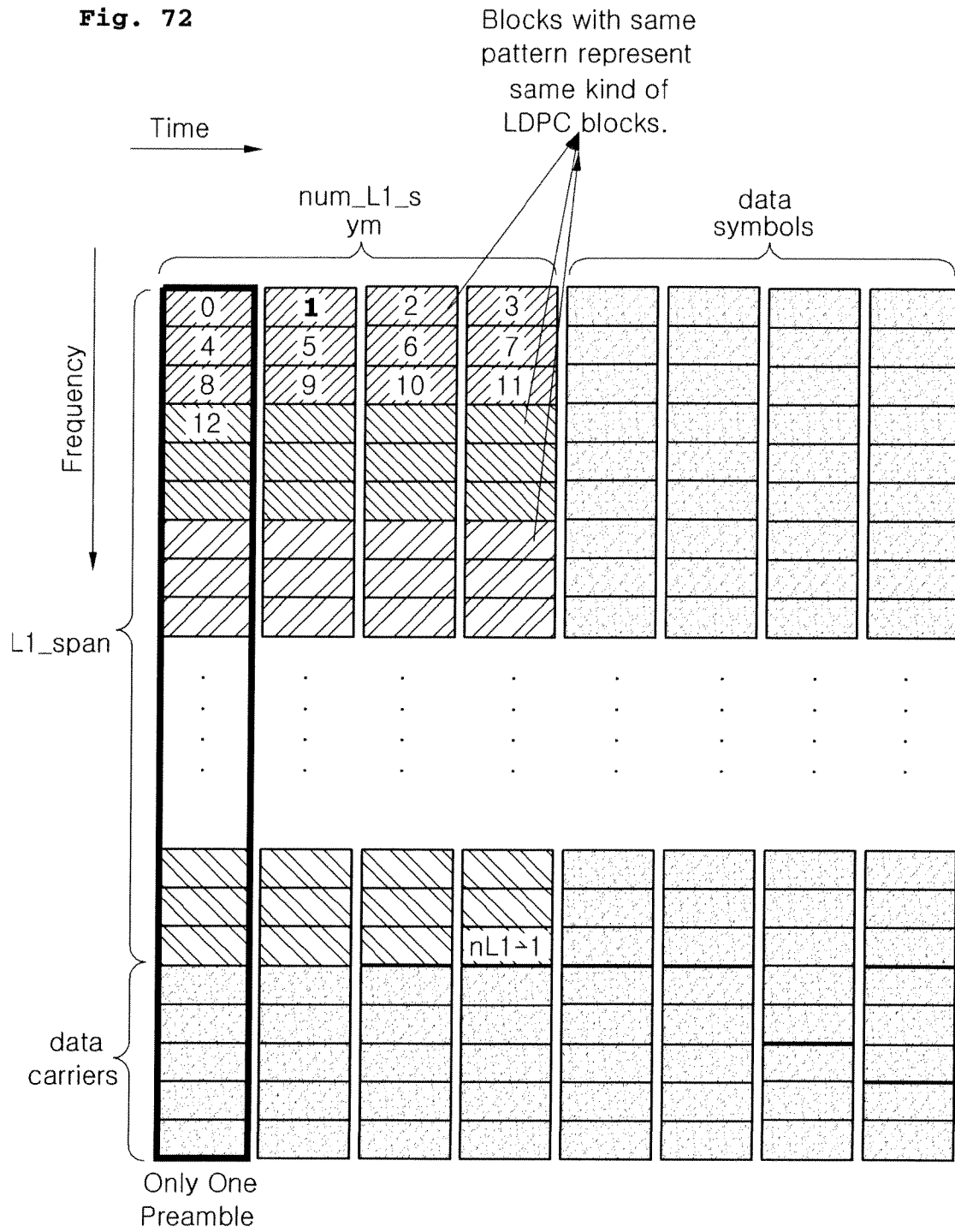


**Fig. 73**

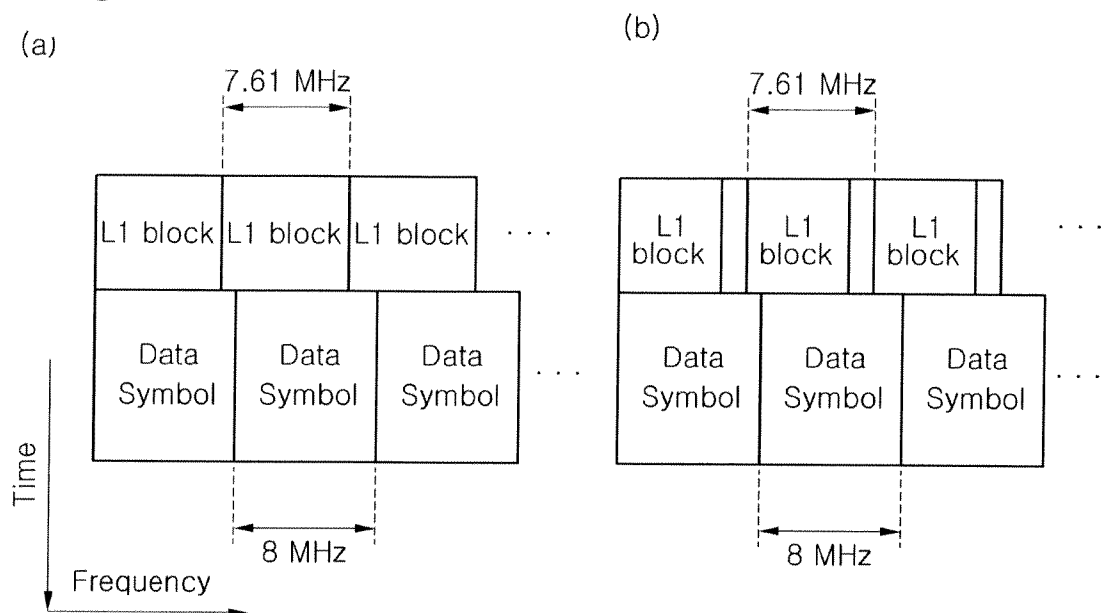
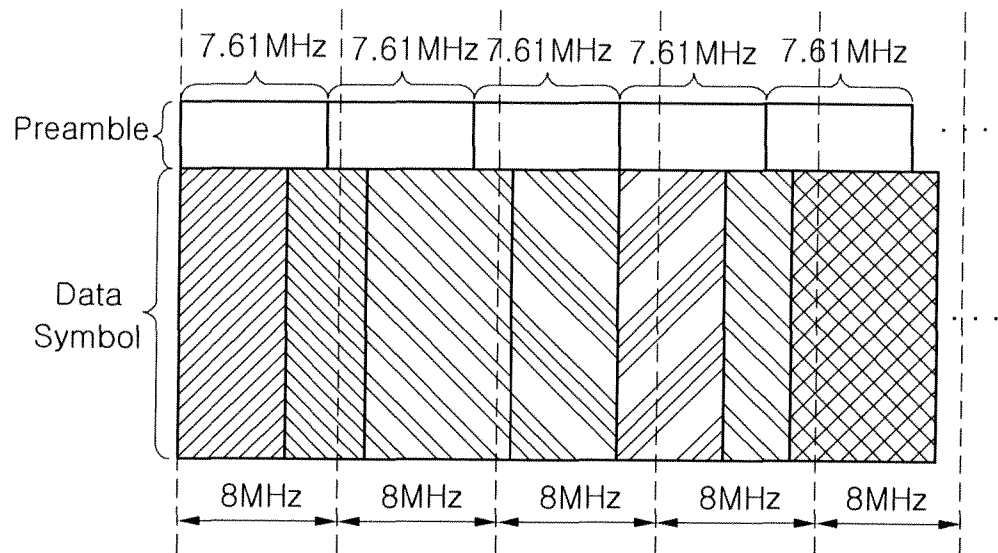


Fig. 74

| Field            | Bits  |                                                                              |
|------------------|-------|------------------------------------------------------------------------------|
| L1_column        | 9     | number of carriers spanned by L1 block within one OFDM symbol (Max=7.61 MHz) |
| L1_row           | 3     | number of OFDM symbols spanned by L1 block                                   |
| num_chbon        | 3     | number of bonded channels                                                    |
| num_plp          | 8     | number of data slices                                                        |
| num_dslice       | 8     | number of PLPs                                                               |
| num_notch        | 5     | number of notch bands                                                        |
| for dslice {     |       |                                                                              |
| chbon_index      | 3     | bonded channel index                                                         |
| dslice_start     | 9     | start of data slice within one channel (8 MHz)                               |
| dslice_width     | 9     | width of data slice                                                          |
| }                |       |                                                                              |
| for plp {        |       |                                                                              |
| dslice_id        | 8     | data sliced ID                                                               |
| plp_id           | 8     | PLP ID                                                                       |
| plp_type         | 1     | PLP type (common/data)                                                       |
| plp_payload_type | 5     | PLP payload type (TS, GS, ...)                                               |
| }                |       |                                                                              |
| for notch {      |       |                                                                              |
| chbon_index      | 3     | bonded channel index                                                         |
| notch_start      | 9     | start of notch band within one channel (8 MHz)                               |
| notch_width      | 9     | width of notch band                                                          |
| }                |       |                                                                              |
| gi               | 1     | guard interval mode                                                          |
| sframe_id        | 16    | superframe ID                                                                |
| frame_id         | 16    | frame ID                                                                     |
| reserved         | 16    | rfu                                                                          |
| crc32            | 32    | CRC32                                                                        |
| Total            | 11776 |                                                                              |

The number of L1 information bits varies  
according to various configurations/conditions

**Fig. 75**



## BERENDEZÉS ÉS ELJÁRÁS MŰSORSZÓRÓ JEL ADÁSÁRA ÉS VÉTELÉRE

### Szabadalmi igénypontok

1. Eljárás műsorszóró jel olyan vevőhöz való küldésére, amely dekódolja a műsorszóró jelet, a következőket tartalmazza:

bemeneti adatfolyam átalakítása PLP fizikai rétegű csővonal BB alapsávjába;  
adatok kódolása a PLP-nek a BB keretében FEC vevőoldali hibajavító sémával;  
bekezdő jelszakasz adatoknak bekezdő jelszakasz adatjelekbe és a kódolt adatoknak adatjelekbe való beágyazása;  
legalább egy adatszelet képzése az adatjelek alapján;  
az adatjelek időbeillesztése adatszelet szinten;  
a bekezdő jelszakasz adatjeleinek időbeillesztése;  
jelkeret képzése az időbeillesztett bekezdő jelszakasz adatjelei és az időbeillesztett adatjelekkel rendelkező legalább egy adatszelet alapján;  
a képzett jelkeret modulálása OFDM ortogonális frekvenciaosztásos multiplikálási eljárással; és  
a modulált jelkeret adása,

ahol egy L1 1-es rétegű blokk ugyanazzal a sáv szélességgel ismétlődik a bekezdő jelszakasz jeleiben a frekvenciatartományban,

ahol az ugyanaz a sáv szélesség 7,61 MHz, és ahol az ismételt L1 blokkokból két rész a vevő hangoló ablakán belül átrendeződik, az átrendeződött részek egy teljes L1 blokkot alakítanak ki, ahol az L1 blokk L1 információt tartalmaz az adatszelet jelzésére.

2. Eljárás az 1. igénypont szerint, ahol az L1 jelző információ réskezdet-információt tartalmaz, amely jelzi a jelkeretben lévő réssáv kiindulási helyét.
3. Az 1. igénypont szerinti eljárás, ahol az L1 jelző információ réskezdet-információt tartalmaz, amely jelzi a jelkeretben lévő réssáv szélességét.

4. Az 1. igénypont szerinti eljárás, ahol az L1 jelző információ részekdet-információt tartalmaz, amely jelzi a jelkeretben lévő réssáv csatornák számát.
5. Berendezés műsorszórási jel olyan vevőhöz való küldésére, amely dekódolja a műsorszórási jelet, a következőket tartalmazza:

bemeneti feldolgozó bemeneti adatfolyamnak PLP fizikai rétegű csővonal BB alapsáv keretébe való átalakítására;

kódoló egység a PLP-nek a BB keretében lévő adatok FEC vevőoldali hibajavító sémával való kódolására;

beágyazó jelszakasz adatbitjeinek bekezdési jelszakasz adatjeleibe, valamint adatbiteknek adatjelekbe való beágyazására;

első időbeillesztő az adatjelek adatszelet szinten való időbeillesztésére, ahol legalább egy adatszelet az adatjelek alapján épül fel;

második időbeillesztő a bekezdő jelszakasz adatjeleinek időbeillesztésére;

keretképző jelkeretnek az időbeillesztett bekezdő jelszakasz adatjelei és az időbeillesztett adatjelekkel rendelkező legalább egy adatszelet alapján való képzésére;

moduláló egység a képzett jelkeretnek OFDM ortogonális frekvencia-osztásos multiplexelési eljárással való modulálására; és

adóegység a modulált jelkeret adására,

ahol egy L1 1-es rétegű blokk ugyanazzal a sávszélességgel ismétlődik a bekezdő jelszakasz jeleiben a frekvenciatartományban,

ahol az ugyanaz a sávszélesség 7,61 MHz, és ahol az ismételt L1 blokkokból két rész a vevő hangoló ablakán belül átrendeződik, az átrendeződött részek egy teljes L1 blokkot alakítanak ki, ahol az L1 blokk L1 információt tartalmaz az adatszelet jelzésére.

6. Az 5. igénypont szerinti berendezés, ahol az L1 jelző információ részekdet-információt tartalmaz, amely jelzi a jelkeretben lévő réssáv kiindulási helyét.
7. Az 5. igénypont szerinti berendezés, ahol az L1 jelző információ részekdet-információt tartalmaz, amely jelzi a jelkeretben lévő réssáv szélességét.

8. A 6. igénypont szerinti berendezés, ahol az L1 jelző információ réskezdet-információt tartalmaz, amely jelzi a jelkeretben lévő réssáv csatornák számát.
9. Eljárás műsorszóró jel olyan vevőben való vételére, amely dekódolja a műsorszóró jelet, a következőket tartalmazza:

a műsorszóró jelnek OFDM ortogonális frekvenciaosztásos multiplexelés eljárás segítségével való demodulálása;

jelkeret nyerése a demodulált műsorszóró jelből, a jelkeret bekezdő jelszakasz jeleket és adatjeleket tartalmaz, ahol az adatjelek benne vannak legalább egy adatszeletben;

az adatjelek időkiszedése adatszelet szinten;

a bekezdő jelszakasz adatjeleinek időkiszedése;

az időkiszedett adatjelek adatbitekbe való kibontása;

az adatbitek kis sűrűségű paritásellenőrzéses dekódolási sémával való dekódolása;

és

a dekódolt adatbiteknek PLP fizikai rétegű csővonal BB alapsávi keretébe való átalakítása,

ahol egy L1 1-es rétegű blokk ugyanazzal a sávszélességgel ismétlődik a bekezdő jelszakasz jeleiben a frekvenciatartományban,

ahol az ugyanaz a sávszélesség 7,61 MHz, és ahol az ismételt L1 blokkokból két rész a vevő hangoló ablakán belül átrendeződik, az átrendeződött részek egy teljes L1 blokkot alakítanak ki, ahol az L1 blokk L1 információt tartalmaz az adatszelet jelzésére.

10. Eljárás a 9. igénypont szerint, ahol az L1 jelző információ réskezdet-információt tartalmaz, amely jelzi a jelkeretben lévő réssáv kiindulási helyét.
11. A 9. igénypont szerinti eljárás, ahol az L1 jelző információ réskezdet-információt tartalmaz, amely jelzi a jelkeretben lévő réssáv szélességét.
12. A 9. igénypont szerinti eljárás, ahol az L1 jelző információ réskezdet-információt tartalmaz, amely jelzi a jelkeretben lévő réssáv csatornák számát.

13. Vevő műsorszóró jel vételére, amely a következőket tartalmazza:

demoduláló egység a műsorszóró jelnek OFDM ortogonális frekvenciaosztásos multiplexelés eljárás segítségével való demodulálására;  
 megszerző egység keretelemző jelkeretnek a demodulált műsorszóró jelből való kinyerésére, a jelkeret bekezdő jelszakasz jeleket és adatjeleket tartalmaz, ahol az adatjelek benne vannak legalább egy adatszeletben;  
 első időkiszedő az adatjeleknek adatszelet szinten való időkiszedésére;  
 második időkiszedő a bekezdő jelszakasz adatjeleinek időkiszedésére;  
 kibontó egység az időkiszedett adatjelek adatbitekbe való kibontására;  
 dekódoló egység az adatbitek kis sűrűségű paritásellenőrzéses dekódolási sémával való dekódolására;  
 kimeneti feldolgozó a dekódolt adatbiteknek PLP fizikai rétegű csővonal BB alapsávi keretébe való átalakítására,  
 ahol egy L1 1-es rétegű blokk ugyanazzal a sáv szélességgel ismétlődik a bekezdő jelszakasz jeleiben a frekvenciatartományban,  
 ahol az ugyanaz a sáv szélesség 7,61 MHz, és ahol az ismételt L1 blokkokból két rész a vevő hangoló ablakán belül átrendeződik, az átrendeződött részek egy teljes L1 blokkot alakítanak ki, ahol az L1 blokk L1 információt tartalmaz az adatszelet jelzésére.

14. A 13. igénypont szerinti berendezés, ahol az L1 jelző információ réskezdet-információt tartalmaz, amely jelzi a jelkeretben lévő réssáv kiindulási helyét.
15. A 13. igénypont szerinti berendezés, ahol az L1 jelző információ réskezdet-információt tartalmaz, amely jelzi a jelkeretben lévő réssáv szélességét.
16. A 13. igénypont szerinti berendezés, ahol az L1 jelző információ réskezdet-információt tartalmaz, amely jelzi a jelkeretben lévő réssáv csatornák számát.