



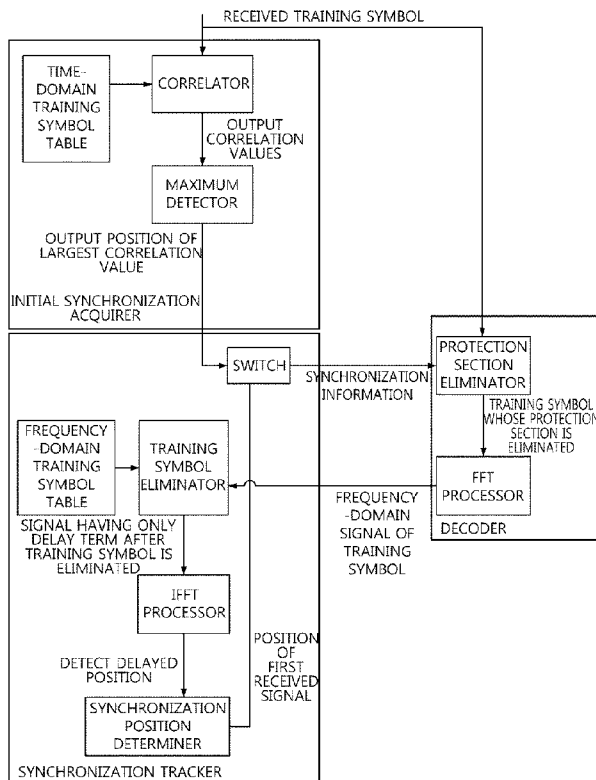
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[Continued on next page]

(54) Title: APPARATUS AND METHOD FOR ACQUARING FRAME SYNCHRONIZATION

[Fig. 2]



(57) Abstract: Present invention relates to an apparatus and method for acquiring frame synchronization. The method includes the steps of receiving a training symbol through a channel, calculating correlation values between the training symbol and received signals in time-domain, determining a training symbol position of the biggest correlation value, informing the training symbol position to a Sync tracker and executing FFT for analysing the received signals in frequency-domain after eliminating a protection block according to the training symbol position.

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## Description

# APPARATUS AND METHOD FOR ACQUARING FRAME SYNCHRONIZATION

### Technical Field

- [1] The present invention relates to technology for acquiring frame synchronization in an orthogonal frequency division multiplexing (OFDM)-based system.

### Background Art

- [2] An orthogonal frequency division multiplexing (OFDM)-based system uses a training symbol that a transmitter and a receiver know to indicate the start of a frame. The receiver must find the training symbol, which indicates the start of the frame, so that the transmitter and the receiver can perform normal communication. The present invention relates to technology for acquiring frame synchronization in an OFDM-based system.
- [3] FIG. 1 is a block diagram illustrating a conventional method of acquiring synchronization. In this case, frame synchronization is acquired using a method of calculating a correlation value with respect to a received training symbol to find a maximum position.
- [4] When this method is used in a channel state in which multiple paths exist, a maximum position varies according to powers of the respective paths as shown in FIG. 3. Thus, it is difficult to know an accurate maximum position, and an unstable value may be obtained.
- [5] Meanwhile, a fast Fourier transform (FFT) must be performed with respect to a signal corresponding to a first path among signals received through several paths to eliminate inter-symbol interference (ISI). Based on conventional art, it is impossible to know which correlation value's position corresponds to a signal received through the first of multiple paths, and thus ISI may occur.
- [6] Accordingly, the present invention suggests an accurate and stable method of acquiring frame synchronization by detecting a maximum position according to each path and obtaining the position of a signal received through the first path.

### Disclosure of Invention

#### Technical Problem

- [7] The present invention is directed to accurately and stably acquiring frame synchronization.

#### Technical Solution

- [8] In an orthogonal frequency division multiplexing (OFDM)-based system, an initial synchronization process is required to perform communication between a transmitter

and a receiver. To this end, the receiver must detect a first signal of a frame consisting of a predetermined training symbol. Conventionally, a correlator is prepared to acquire synchronization using a time-domain signal before a fast Fourier transform (FFT). To prevent inter-symbol interference (ISI) in an OFDM-based system, a signal received through a first path of several paths must be detected. However, when the conventional method is used in a channel state in which multiple paths exist, it is impossible to distinguish a signal received through the first path from signals received through other paths. Thus, the present invention suggests a synchronization acquiring method that uses a conventional correlation value of a time-domain signal before FFT and detects a position delayed according to each path to eliminate ISI in a multipath environment. Also, when only a conventional correlator is used, it is difficult to obtain a precise maximum position. However, when delayed positions are detected according to paths using the suggested method, an accurate synchronization position can be obtained, and thus it is possible to find a stable synchronization position.

### **Advantageous Effects**

- [9] The present invention can accurately recognize frame synchronization of a signal received through a first path in a multipath channel environment in comparison with conventional art, and thus it is possible to know a start time point of a frame and prevent inter-symbol interference (ISI), which is fatal to an orthogonal frequency division multiplexing (OFDM) system.
- [10] Also, since received signals can be detected according to paths, a stable value can be obtained when a synchronization position is determined.

### **Brief Description of Drawings**

- [11] FIG. 1 is a block diagram illustrating a conventional method of acquiring frame synchronization.
- [12] FIG. 2 is a block diagram illustrating a suggested method of acquiring frame synchronization.
- [13] FIG. 3 is a simulation result obtained when only a correlator is used according to a conventional method.
- [14] FIG. 4 is a simulation result obtained when the suggested method is applied to the conventional method.

### **Mode for the Invention**

- [15] The present invention can be modified in various ways and have several example embodiments. Specific example embodiments of the present invention will be shown in the drawings and described in detail. However, the present invention is not limited to the example embodiments disclosed below, but can be implemented in various types. Therefore, the present example embodiments are provided for complete

disclosure of the present invention and to fully inform the scope of the present invention to those ordinarily skilled in the art.

[16] The present invention involves receiving training symbols passed through channels via an antenna, calculating correlation values between a training symbol in the time domain and received signals, determining the largest one of the correlation values as a position at which the training symbol is located, informing the position to a synchronization tracker, removing a protection section according to the position, and then performing a fast Fourier transform (FFT) to analyze the signal in the frequency domain.

[17] In an orthogonal frequency division multiplexing (OFDM)-based system, a first symbol of a frame is a training symbol that a transmitter and a receiver know. The transmitter performs an inverse FFT (IFFT) on a frequency-domain value

$$P(k)$$

of the training symbol and then transmits the IFFT-processed value via an antenna.

$$[18] \quad p(n) = \sum_{k=0}^{N-1} P(k) e^{j\frac{2\pi}{N}nk}$$

(1)

[19] A training symbol

$$p(n)$$

in the time domain transmitted after the IFFT-processed value is delayed as shown in Equation (2) and received by the receiver.

$$[20] \quad p(n - \tau) = \sum_{k=0}^{N-1} P(k) e^{j\frac{2\pi}{N}(n-\tau)k} = \sum_{k=0}^{N-1} P(k) e^{j\frac{2\pi}{N}nk} e^{-j\frac{2\pi}{N}\tau k}$$

(2)

[21] To find this signal, the receiver calculates a correlation value with respect to the training symbol in the time domain and finds a maximum position.

[22] Based on the found maximum position, a protection section is eliminated from the received signal, and an FFT is performed on the signal.

$$[23] \quad P'(k) = \sum_{n=0}^{N-1} \left[ \sum_{k=0}^{N-1} P(k) e^{j\frac{2\pi}{N}nk} e^{-j\frac{2\pi}{N}\tau k} \right] e^{-j\frac{2\pi}{N}\tau k}$$

(3)

[24] Equation (3) is expanded into Equation (4) below.

$$[25] \quad P'(k) = \sum_{n=0}^{N-1} \left[ p(n) e^{-j\frac{2\pi}{N}nk} \right] e^{-j\frac{2\pi}{N}\tau k}$$

(4)

[26] Equation (4) is a result obtained after the FFT, in which the training symbol  $P(k)$

is multiplied by a phase rotation term

$$e^{-j\frac{2\pi}{N}\tau k}$$

generated by delay.

[27] To calculate only the phase term

$$e^{-j\frac{2\pi}{N}\tau k}$$

generated by delay, the training symbol term is eliminated by multiplying Equation (4) by the training symbol in the frequency domain.

[28] (Here, the frequency-domain value of the training symbol is assumed to be 1 or -1.)

[29] When an IFFT is performed on a value obtained by multiplying Equation (4) by the training symbol in the frequency domain, Equation (5) is obtained.

$$[30] \quad t(n) = \sum_{k=0}^{N-1} e^{j\frac{2\pi}{N}(-\tau)k} e^{j\frac{2\pi}{N}nk} = \sum_{k=0}^{N-1} e^{j\frac{2\pi}{N}(n-\tau)k}$$

(5)

[31] Here, only when

$$n=\tau$$

, does the result become N. In other words, as shown in FIG. 4, the result becomes N at a delayed position and becomes 0 with respect to other values of n. Thus, it is possible to know the accurate delayed position. Equation (5) is a result obtained in a single path, and Equation (6) is an IFFT result obtained when multiple paths exist.

$$[32] \quad tM(n) = \sum_{k=0}^{N-1} \left( e^{j\frac{2\pi}{N}(n-\tau_1)k} + e^{j\frac{2\pi}{N}(n-\tau_2)k} + \dots + e^{j\frac{2\pi}{N}(n-\tau_M)k} \right)$$

(6)

[33] When multiple paths exist, the results sequentially become N at the same position. In this case, using a position corresponding to a first-detected value for frame synchronization, it is possible to find an accurate synchronization position at which ISI can be

prevented.

- [34] FIG. 2 is a block diagram illustrating a suggested method of acquiring frame synchronization. A suggested apparatus for acquiring orthogonal frequency division multiple access (OFDMA) downlink frame synchronization includes
- [35] - a time-domain training symbol table storing a time-domain value of a training symbol used in common by a transmitter and a receiver,
- [36] - a correlator for calculating correlation values between received training symbols in the time domain and a training symbol that the receiver already knows,
- [37] - a maximum detector for determining the largest one of the correlation values output from the correlator and finding the position of the largest correlation value,
- [38] - a protection section eliminator eliminating the protection section of a received signal,
- [39] - an FFT processor for analyzing the frequency domain of the received signal,
- [40] - a training symbol eliminator for removing a training symbol term from the output of the FFT processor including a phase rotation term generated by delay and the training symbol term,
- [41] - a frequency-domain training symbol table storing a frequency-domain value of a training symbol used in common by the transmitter and the receiver,
- [42] - an IFFT processor for finding a delayed position based on the phase rotation term generated by delay,
- [43] - a synchronization position determiner for finding the first path among multiple paths, and
- [44] - a switch selecting one of synchronization positions output from an initial synchronization acquirer and a synchronization tracker. The apparatus according to an example embodiment of the present invention operates as described below.
- [45] In an OFDM-based system, a transmitter transmits a training symbol that a receiver also knows at the beginning of a frame to inform the start of the frame to the receiver. The receiver receives the training symbol passed through a channel via an antenna, and the received signal undergoes down conversion, demodulation, and analog/digital (A/D) conversion and becomes a baseband signal.
- [46] As illustrated in FIG. 2, a synchronization process may be divided by an initial synchronization acquirer and a synchronization tracker. The initial synchronization acquirer calculates correlation values between a training symbol in the time domain that the receiver knows and received signals. The initial synchronization acquirer determines the largest one of the correlation values as a position at which the training symbol is located, and informs the position to the synchronization tracker.
- [47] The synchronization tracker eliminates a protection section with respect to the position informed by the initial synchronization acquirer and then performs an FFT to

analyze the signals in the frequency domain.

[48] A signal output after the FFT consists of a training symbol term and a term generated by delay. Due to the training symbol eliminator, only the term generated by delay can be obtained from the signal. The training symbol eliminator multiplies the input signal by the training symbol in the frequency domain that the receiver already knows and makes a sign, thereby removing the training symbol term. An IFFT is performed on the signal that has only the phase rotation term generated by delay due to the training symbol eliminator so that a delayed position can be detected. Here, when multiple paths exist, the degree of delay can be detected according to the paths, and thus the synchronization position determiner can obtain the position of the first path.

[49] In an initial synchronization process, a synchronization signal of the initial synchronization acquirer is used, and then when a precise position is output from the synchronization tracker, a synchronization signal of the synchronization tracker is used.

### **Industrial Applicability**

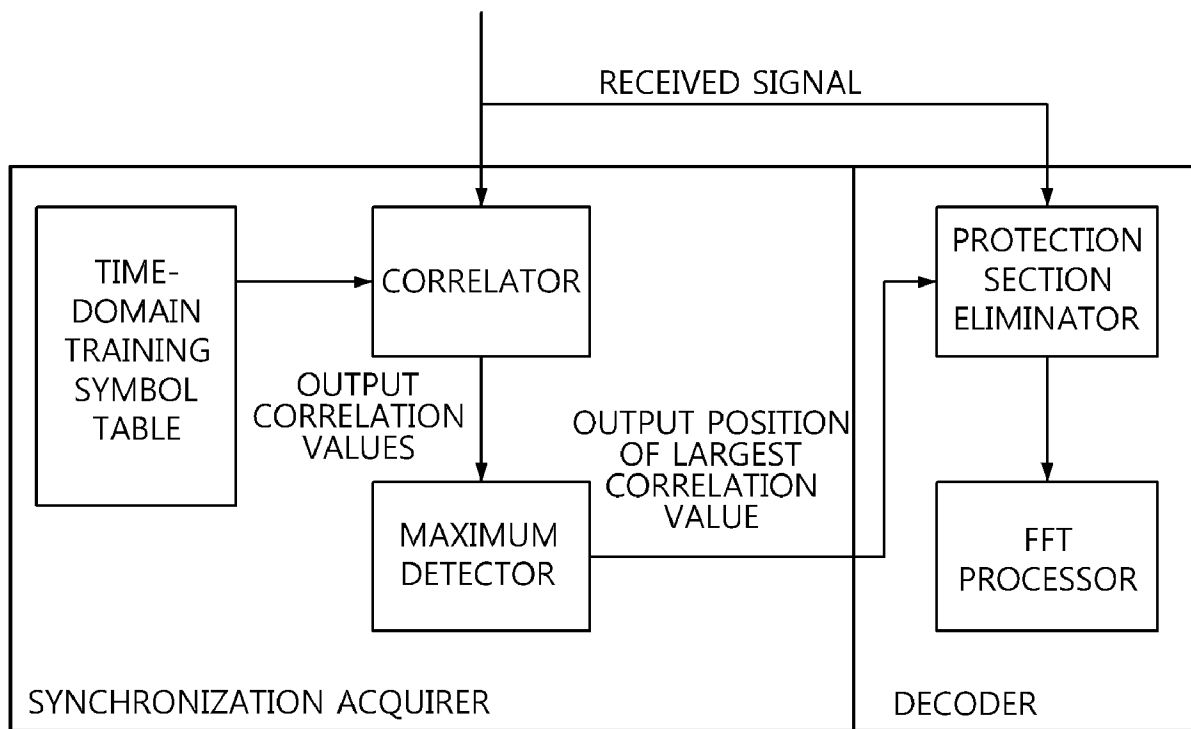
[50] The present invention can be used to acquire accurate and stable frame synchronization in an OFDM-based system.

[51] While the invention has been shown and described with reference to certain example embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

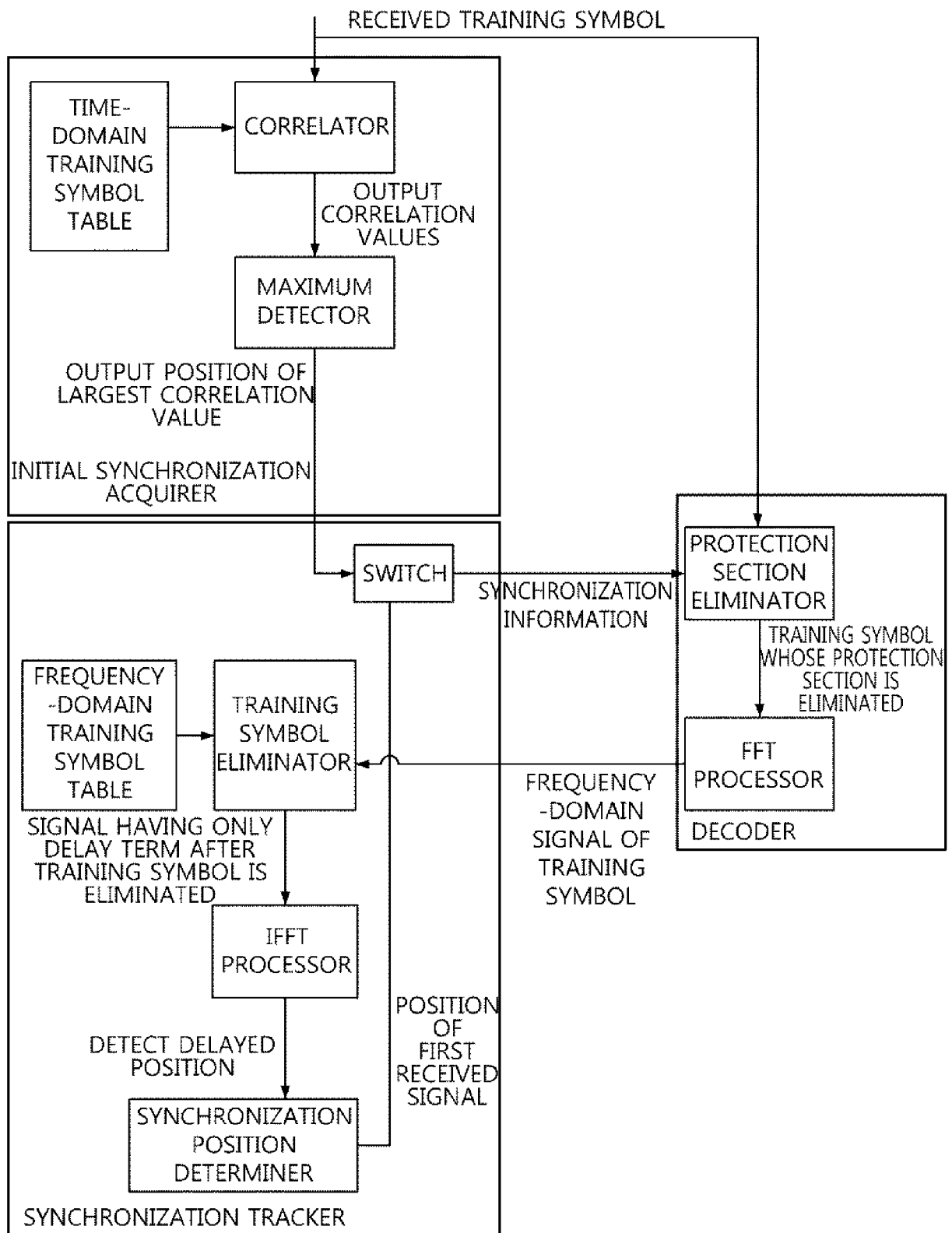
## Claims

- [1] An apparatus for acquiring frame synchronization, comprising:  
a time-domain training symbol table configured to store a time-domain value of a training symbol used in common by a transmitter and a receiver;  
a correlator configured to calculate correlation values between received training symbols in a time domain and a training symbol that the receiver already knows;  
a maximum detector configured to determine the largest one of the correlation values output from the correlator and find a position of the largest correlation value;  
a protection section eliminator configured to eliminate a protection section of a received signal;  
a fast Fourier transform (FFT) processor configured to analyze a frequency domain of the received signal;  
a training symbol eliminator configured to eliminate a training symbol term from an output of the FFT processor including a phase rotation term generated by delay and the training symbol term;  
a frequency-domain training symbol table configured to store a frequency-domain value of the training symbol used in common by the transmitter and the receiver;  
an inverse FFT (IFFT) processor configured to find a delayed position based on the phase rotation term generated by delay;  
a synchronization position determiner configured to find a first path among multiple paths; and  
a switch configured to select one of synchronization positions output from an initial synchronization acquirer and a synchronization tracker.
- [2] A method of acquiring frame synchronization, comprising:  
receiving training symbols passed through channels via an antenna;  
calculating correlation values between a training symbol in a time domain and received signals;  
determining the largest one of the correlation values as a position at which the training symbol is located and informing the position to a synchronization tracker; and  
eliminating a protection section according to the position, and performing a fast Fourier transform (FFT) to analyze the signals in a frequency domain.

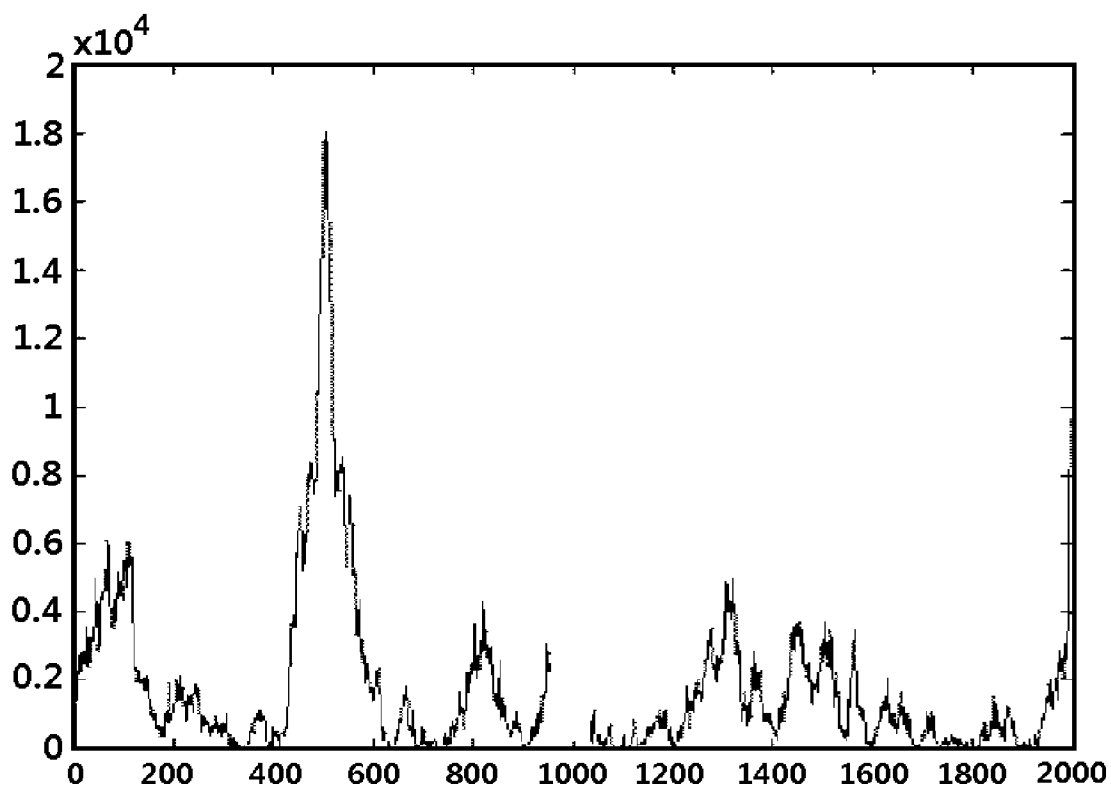
[Fig. 1]



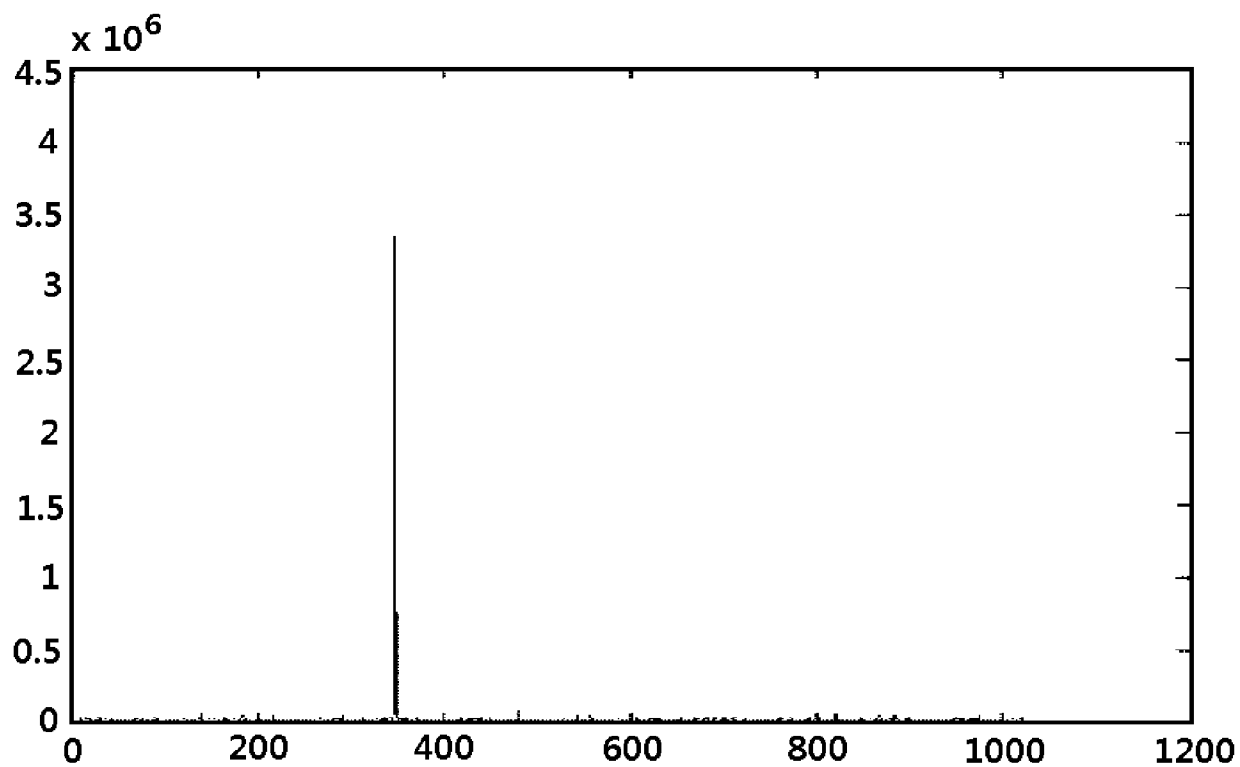
[Fig. 2]



[Fig. 3]



[Fig. 4]



**A. CLASSIFICATION OF SUBJECT MATTER***H04L 27/26(2006.01)i, H04L 7/00(2006.01)i, H04W 56/00(2009.01)i*

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

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Utility models and applications for Utility models since 1975

Japanese Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal): "frame, synchronization, guard interval, FFT"

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 10-0471538 B1 (GI YEOL HAN et al.) 21 February 2005 See abstract; pages 3-5; claims 1-6; figures 2-4.	1-2
A	KR 10-2007-0120380 A (PANTECH & CURITEL COMMUNICATIONS, INC.) 24 December 2007 See abstract; paragraphs [0079]-[0089]; claims 1-13; figure 10.	1-2
A	KR 10-0739552 B1 (LG ELECTRONICS INC.) 16 July 2007 See abstract; pages 4-5; claims 1-6; figure 5.	1-2
A	KR 10-0635013 B1 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE et al.) 16 October 2006 See abstract; page 4; claims 1-9; figure 4.	1-2

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

\* Special categories of cited documents:

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"&amp;" document member of the same patent family

Date of the actual completion of the international search

07 AUGUST 2009 (07.08.2009)

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**10 AUGUST 2009 (10.08.2009)**

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**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

**PCT/KR2008/007067**

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