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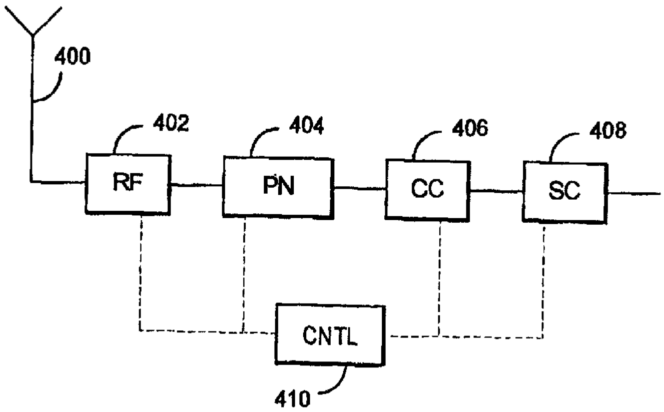
(54) Title: A DATA TRANSMISSION METHOD, AND A CELLULAR RADIO SYSTEM

(57) Abstract



The invention relates to a data transmission method in a cellular radio system, and a cellular radio system, which comprises in each cell at least one base station (200), and a number of subscriber terminal equipments (202-206) connected to one or more base stations, the transmitter of said system comprising means (404) for multiplying the signal of each user by more than one pseudorandom sequences. For enabling a high spectral efficiency and advantageous interference cancellation, the transceiver of the system comprises means (404) for multiplying the signal of the user by more than one pseudorandom sequence, the data transfer rate of the signal substantially remaining the same. The transmitter further comprises means (404, 410, 402) for transmitting the signals of different users multiplied by the same pseudorandom sequences distinguished from each other by means of time-division.

A data transmission method, and a cellular radio system

Field of the Invention

The invention relates to a data transmission method in a cellular radio system, comprising in each cell at least one base station, and a number of subscriber terminal equipments connected to one or more base stations, in which system the signal of each user is multiplied by one or more pseudorandom sequences.

Background Art

The present invention is suited for use in particular in cellular radio systems utilizing code division multiple access. Code Division Multiple Access, CDMA is a multiple access method, which is based on the spread spectrum technique, and which has been applied recently in cellular communication systems, in addition to the prior FDMA and TDMA methods. CDMA has several advantages over the prior methods, such as spectral efficiency and the simplicity of frequency planning.

In CDMA, the narrow-band data signal of the user is multiplied to a relatively wide band by means of a spreading code having a remarkably broader band than the data signal. Bandwidths used in known test systems are e.g. 1.25 MHz, 10 MHz and 25 MHz. In connection with the multiplication, the data signal spreads onto the whole of the band used. All users transmit simultaneously by using the same frequency band. An individual spreading code is used on each connection between the base station and the mobile station, and the signals of the users may be distinguished from each other in the receivers on the basis of the spreading code of each user. A CDMA transmission in accordance with prior art is illustrated in Figure 1, in which the horizontal axis represents time and the vertical axis pseudorandom codes.

Transmissions 100-106 of different users are simultaneously transmitted on the same frequency distinguished with different codes. It is also known to provide a user with more than one code, but this is made for increasing the data transfer rate. Then a user who has been provided with two spreading codes, for example, may multiply part of his symbols to be transmitted by one code and part by another code, and thus accomplish a double transmission capacity as compared with a user transmitting with one code.

Adapted filters in the receivers are synchronized with the desired signal, which is identified on the basis of the spreading code. The data signal is returned in the receiver onto the original band by multiplying it by the same spreading code as in connection with the transmission. The signals which have been multiplied by some other spreading code neither correlate nor return to the narrow band in an ideal case. They thus appear as noise from the point of view of the desired signal. It is endeavoured to select the spreading codes of the system so that they are not mutually correlated, in other words, they are orthogonal. In practice, the spreading codes are not non-correlated, and the signals of other users complicate the detection of the desired signal by distorting the received signal. This interference caused by the users for each other is termed as multiple access interference.

The quality of the transmission depends on the number of users, in particular in the direction of transmission from the base station to the terminal equipment. The more users there are in the system, the higher is the power the base station must use for transmission. This generates interference to surrounding cells.

It is previously known to carry out interference cancellation for the received signal with the aid of which cancellation e.g. the quality of the received signal may be improved. Heretofore, plans have been made to use interference cancellation methods mainly at the base stations, since the processing required at the terminal equipment has been too complicated to implement.

Summary of the Invention

A preferred object of the present invention is thus to implement a data transmission method and system, with the aid of which the spectral efficiency may further be improved, in particular in the direction of transmission from the base station to the terminal equipment. The preferred aim of the invention is further to implement a data transmission method with the aid of which interference cancellation methods may advantageously be applied in subscriber terminal equipments, as well. Another preferred aim of the invention is to implement a data transmission method with the aid of which the implementation of macrodiversity is simpler than heretofore.

Accordingly, the invention provides a data transmission method in a cellular radio system, comprising in each cell at least one base station, and a number of subscriber terminal equipments connected to one or more base stations, in which system the signal of each user is multiplied by one or more pseudorandum sequences, said method comprising the steps of:

multiplying the signal of the user by more than one pseudorandom sequences, the data transfer rate of the signal substantially remaining the same, and

distinguishing the signals of different users multiplied by the same pseudorandom sequences from each other by means of time-division.

The invention further provides a cellular radio system, which comprises in each cell at least one base station, and a number of subscriber terminal equipments connected to one or more base stations, the transmitter of said system comprising means for multiplying the signal of each user by more than one pseudorandom sequences, wherein:

the transceiver of the system comprises means for multiplying the signal of the user by more than one pseudorandom sequences, the data transfer rate of the signal substantially remaining the same, and wherein:

the transmitter comprises means for transmitting the signals of different users multiplied by the same pseudorandom sequences distinguished from each other by means of time-division.

Embodiments of the invention thus enable improving the spectral efficiency in the direction of transmission from the base station to the terminal equipment, by utilizing suboptimal detection of the signal of several information channels in the subscriber terminal equipment. The base station generally refers herein to a device that processes and further transmits information of several channels.

Advantageously, the information channels are brought into a strongly parallel form, which enables effective application of interference cancellation algorithms in the terminal equipments. Interference cancellation of a terminal equipment is linearly complex as a function of parallel information channels, which is not possible in a conventional CDMA system. A strongly parallel transmission enables a time-division transmission in the direction of transmission from the base station to the terminal equipment. The terminal equipment may then use time intervals that are free from transmission e.g. for monitoring other base stations or for processing the received signal more effectively.

Brief Description of the Drawings

In the following, the invention will be described in greater detail with reference to the examples in accordance with the attached drawings, in which:

Figure 1 illustrates a previously disclosed, prior art transmission technique,

Figure 2 illustrates an example of a cellular radio system in which the method of the invention may be applied,

Figures 3a-3c illustrate different alternatives in accordance with the invention for distinguishing the signals of different users by means of time-division,

Figure 4 is a block diagram illustrating the structure of the base station of the cellular radio system embodying the invention, and

Figure 5 is a block diagram illustrating an example of the structure of the terminal equipment of the cellular radio system of the invention.

The Preferred Embodiments of the Invention

Figure 2 illustrates a part of the cellular radio system in which the method of the invention may advantageously be applied. A cellular radio network comprises in each cell at least one base station 200, and a number of subscriber terminal equipments 202-206 connected to the base station. The base station switches the calls from the terminal equipments via a base station controller, a mobile services switching centre, or similar, to a public telephone network or another terminal equipment.

All terminal equipments transmit on the same frequency to the base station 200, which, in the solutions in accordance with the prior art, thus distinguishes the transmissions of different terminal equipments on the basis of the spreading code used by each terminal equipment. In the solution in accordance with the invention, the base station assigns from a group of available code sequences N codes to one user, and the user in question sends the information in parallel to the subscriber terminal equipment, the data transfer rate, however, substantially remaining the same. In the method of the invention, the base station thus transmits N symbols to the terminal equipment for each sequence of symbols, whereas in the conventional method, one symbol is transmitted. Since the data transfer rate substantially remains the same, the transmission of the symbols of the frame of each connection using several parallel transmissions does not last for the duration of the entire frame in the method of the invention. Thus, time-division may be applied among several users. Transmissions of several different users may be transmitted by using the same spreading codes, and the users may be distinguished from each other by means of time-division.

A possible embodiment of a parallel time-division transmission is illustrated in Figure 3a, in which the horizontal axis represents time, and the vertical axis different spreading codes. In the example of the figure, signals 300-306 of each user are transmitted each in an individual time-slot, so that the symbols of each user are multiplied by a spreading code, in the case of the first user by codes 100-106. Different users may use different codes. Different users may also have a different number of codes.

The disclosed time-division parallel transmission method enables an advantageous implementation of interference cancellation algorithms in the subscriber terminal equipment. The signal incoming to the terminal equipment is in this case a utility signal, not a multiple access interference signal. Furthermore, the terminal equipment has less parameters to be estimated: L*M, in which L represents the number of paths, and M the antenna diversity. The terminal equipment may further carry out interference cancellation using the same algorithms as the base station, since the terminal equipment has the capability to process the arrived transmission during the period of time when signals intended for other terminal equipments are being transmitted. Interference cancellation of the terminal equipment is linearly complex as a function of the number of the parallel transmissions.

During those time periods when the base station is transmitting the signal intended for other terminal equipments, the base station may monitor the transmission of other base stations. Parallel transmission also enables the terminal equipment to send the base station, on the signalling channel, the information whether the received signal has been subject to strong fading, or whether the detection of the signal has failed for some other reason. The base station may then allocate the terminal equipment in question a new time period, signal it to the terminal equipment and make a new attempt at transmitting. The re-transmission may also be carried out by means of so-called puncturing, i.e. by re-transmitting the information in parallel at such a moment of time that originally was reserved for some other connection. The connection in question then loses part of its information.

In the solution of the invention, a parallel transmission may be implemented in a number of ways. Generally, different users may have a different number of parallel channels at different moments of time. One possibility is the manner already disclosed above to assign each user an individual time-slot. This demands an accurate coordination of the base station, but enables the fact that the terminal equipments do not cause interference for each other. The restriction is, however, that high-power signals increase the peak power of the transmission of the base station. High-speed and high-power connections may use several time-slots.

Another possibility is that just a few users transmit in parallel, and other users apply the conventional transmission. This manner is illustrated in Figure 3b, in which there is one user 314 applying parallel transmission by utilizing several spreading codes, and the other users 310, 312 transmit an entire frame by using one spreading code. In a solution of this kind, user 314 transmitting in parallel interferes with other users, but, by assigning the parallel user a sufficient number of spreading codes, the interference may be limited to the duration of just a few symbols, and the interference may thus be eliminated by means of channel coding. Parallel transmission in accordance with this solution is suited for use in particular in such a situation in which the user is in the vicinity of the base station, and the transmission is carried out to said user with a low power due to favourable interference conditions. These users may utilize interference cancellation methods for attenuating high-power interferences.

Another possibility is to divide the users into two or more groups and assign an individual time-slot for the transmissions of each group. This is illustrated in Figure 3c, in which the users are divided into two groups 316 and 318, which are distinguished from each other by means of time-division. Within the groups, the spreading codes of the users differ from each other, and the members of the groups may have a different number of codes available.

Another possibility is to assign time-slots to each user in order in accordance with a desired code. Interferences between the cells are thus randomized.

Let us now study the structure of the cellular radio system of the invention by means of the block diagram of Figure 4. A transmitter comprises a coder 408, in which speech coding is carried out for a signal to be transmitted, and a channel coder 406, in which channel coding is carried out for the speech coded signal. Thereafter, the channel coded signal is applied to means 404, in which the data signal to be transmitted is multiplied by a spreading code in ways known to a person skilled in the art. In the transmitter of the invention, the signal of the user is multiplied in means 404 by more than one spreading codes, and it is distinguished by means of time-division from the signals of at least some of the users. In view of technique, time-division transmission may be implemented in the same way as in known TDMA systems. The signal obtained in this way is further applied via a radio frequency means 402 to be transmitted by means of an antenna 400.

The transmitter further comprises control and calculation means 410, which control the operation of the elements mentioned above. The control and calculation means are typically implemented by means of a processor. The control means may also be implemented by means of other electronic components, such as discrete logical components. The apparatus naturally comprises other components than those shown in the figure, such as filters and converters, as is obvious to a person skilled in the art, but for the sake of clarity they are not shown in the figure.

The transceiver of the cellular radio system of the invention comprises means 404 for multiplying the symbols to be transmitted by one or more spreading codes. Multiplication with the spreading code is carried out in manners directed per se to persons skilled in the art.

Figure 5 is a block diagram illustrating the overall structure of the CDMA terminal equipment receiver in accordance with the invention. The receiver comprises an antenna 500, by means of which the received signal is applied via radio frequency elements 502 to a converter means 504, in which the received signal is converted into a digital form. The signal digitized in this way is further applied to demodulation means 506, in which the signal is correlated with the used spreading codes. The output signal 506 of the demodulation means, which is returned onto the original narrow band, is applied to interference cancellation means 514, in which interference cancellation is carried out for the signal by means of known interference cancellation methods. The signal purged of interferences is applied to a channel decoder 508 and from there to other elements of the receiver, such as a speech decoder 510.

The receiver further comprises control and calculation means 512, which control the operation of the elements mentioned above. The control and calculation means are typically implemented by means of a processor. The control means may also be implemented by means of other electronic components, such as dedicated logic. The apparatus naturally also comprises other components than those shown in the figure, such as filters and converters, as is obvious to a person skilled in the art, but for the sake of clarity they are not shown in the figure.

The claims defining the invention are as follows:

1. A data transmission method in a cellular radio system, comprising in each cell at least one base station, and a number of subscriber terminal equipments connected to one or more base stations, in which system the signal of each user is multiplied by one or more pseudorandom sequences, said method comprising the steps of:

multiplying the signal of the user by more than one pseudorandom sequences, the data transfer rate of the signal substantially remaining the same, and

distinguishing the signals of different users multiplied by the same pseudorandom sequences from each other by means of time-division.

2. A method as claimed in claim 1, said method comprising the further steps of:

assigning an individual time-slot to the transmission of each user.

3. A method as claimed in claim 1, said method comprising the further steps of:

dividing the users into two or more groups, and

assigning an individual time-slot to the transmissions of each group.

4. A method as claimed in claim 1, said method comprising the further steps of:

assigning each user time-slots in order in accordance with a desired code.

5. A method as claimed in claim 1, said method comprising the further steps of:

assigning several time-slots to the transmission of a user requiring a large capacity or a high transfer rate.

6. A method as claimed in claim 1, whereby each user receives all the time a signal multiplied by an individual pseudorandom sequence.

7. A method as claimed in claim 1, said method comprising the further steps of:

applying the method in the direction of transmission from the base station to the subscriber terminal equipment.

8. A method as claimed in claim 7, said method comprising the further steps of:

processing by the receiver of the received signal during those time-slots during which it does not receive a signal.

9. A method as claimed in claim 7, said method comprising the further steps of:

carrying out interference cancellation for the received signal.

10. A method as claimed in claim 7, said method comprising the further steps of:

monitoring by the receiver of the transmission of the adjacent base stations during those time-slots during which it does not receive a signal.

11. A cellular radio system, which comprises in each cell at least one base station, and a number of subscriber terminal equipments connected to one or more base stations, the transmitter of said system comprising means for multiplying the signal of each user by more than one pseudorandom sequences, wherein:

the transceiver of the system comprises means for multiplying the signal of the user by more than one pseudorandom sequences, the data transfer rate of the signal substantially remaining the same, and wherein:

the transmitter comprises means for transmitting the signals of different users multiplied by the same pseudorandom sequences distinguished from each other by means of time-division.

12. A cellular radio system as claimed in claim 11, wherein the transceiver of the system comprises means for transmitting the signal intended for each user in individual time-slots.

13. A cellular radio system as claimed in claim 11, wherein the transceiver of the system comprises means for dividing the users into two or more groups and transmitting the signals of each group of users in individual time-slots.

14. A cellular radio system as claimed in claim 11, wherein the transceiver is a base station transceiver.

15. A cellular radio system as claimed in claim 14, wherein the receiver of the subscriber terminal equipment of the system comprises means for interference cancellation.

16. A data transmission method substantially as described herein with reference to accompanying drawings 2 to 5.

17. A cellular radio system substantially as described herein with reference to accompanying drawings 2 to 5.

DATED this Thirtieth Day of March 1998

Nokia Telecommunications OY

Patent Attorneys for the Applicant

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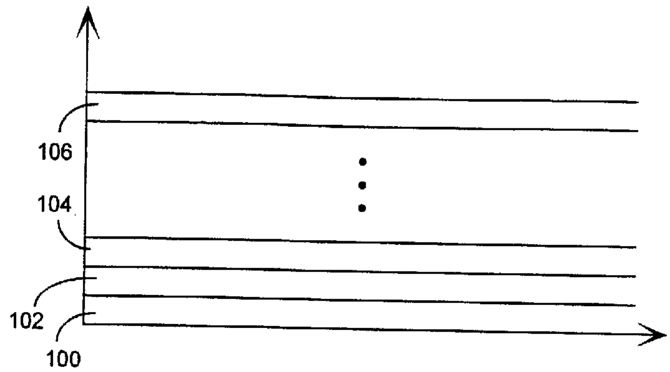

Fig. 1

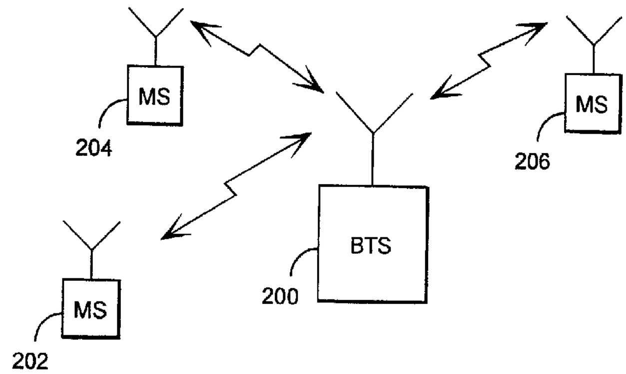

Fig. 2

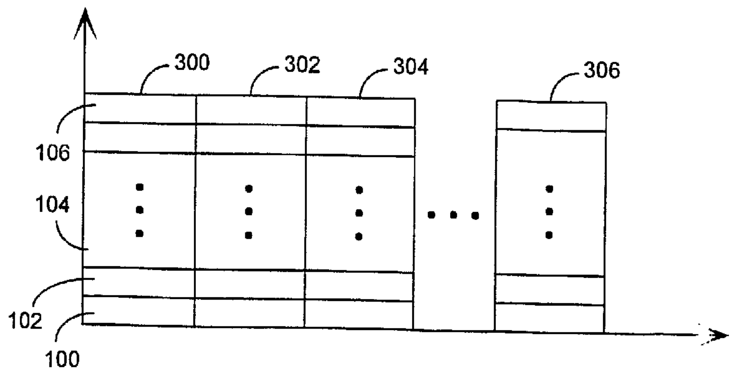

Fig. 3a

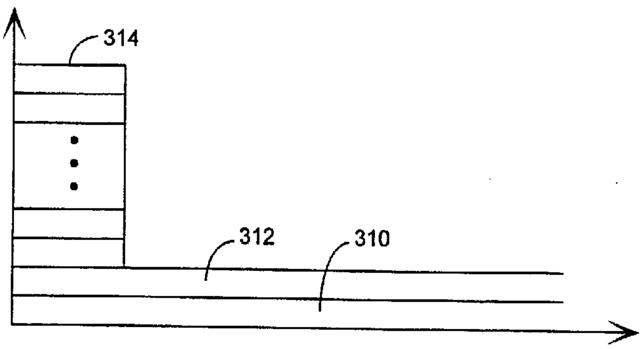

Fig. 3b

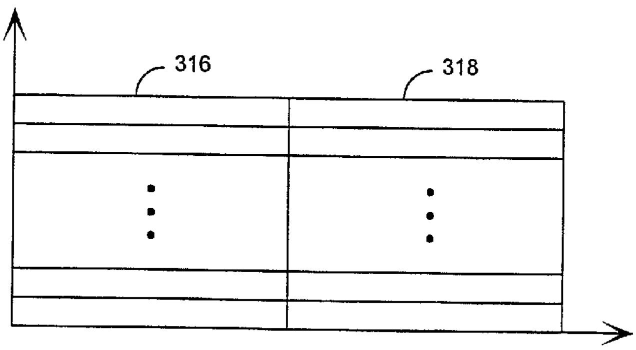

Fig. 3c

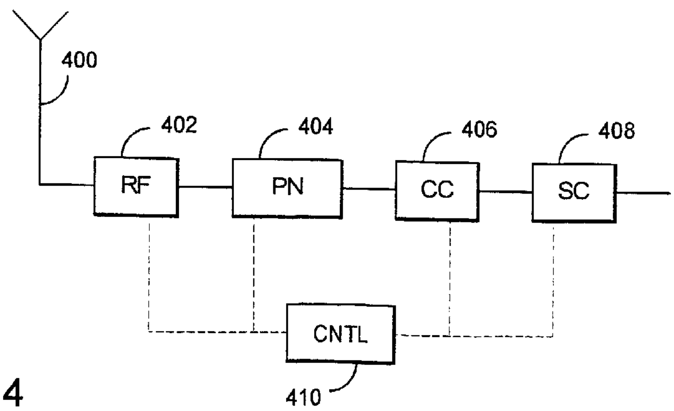

Fig. 4

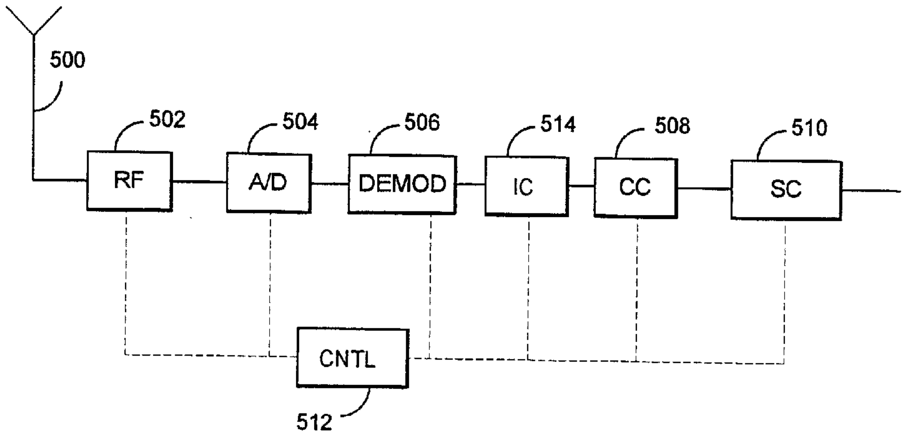

Fig. 5