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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 :
H04B 7/005

A1

(11) International Publication Number: WO 94/19876

(43) International Publication Date: 1 September 1994 (01.09.94)

(21) International Application Number: PCT/US94/01150

(22) International Filing Date: 1 February 1994 (01.02.94)

(30) Priority Data:
020,482 22 February 1993 (22.02.93) US

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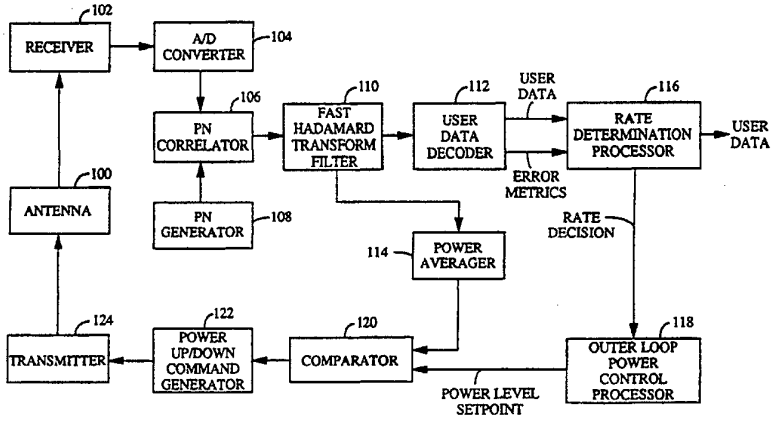
(81) Designated States: AT, AU, BB, BG, BR, CA, CH, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK, LU, MG, MN, MW, NL, NO, NZ, PL, RO, RU, SD, SE, SK, UA, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: METHOD AND SYSTEM FOR THE DYNAMIC MODIFICATION OF CONTROL PARAMETERS IN A TRANSMITTER POWER CONTROL SYSTEM



(57) Abstract

In a communication system in which direct sequence spread spectrum modulation techniques are used, interference is generated in communications by remote stations since the communications share the same frequency spectrum. In order to increase system capacity the power level of the remote station transmitters are controlled by the local station. A setpoint in generated at the local station by a power control processor (118) and compared by a comparator (120) with the remote station signal strength measured at the local station by a power averager (114). The result of this comparison is used to generate power level adjustment commands by a command generator (122) which are transmitted to the remote station. The remote station is responsive to the power level adjustment commands for increasing or decreasing remote station transmitter power. In a spread spectrum communication system in which data is encoded at variable data rates, the local station determines via a rate determination processor (116) the rate at which received data was encoded by the transmitting remote station. The data is decoded by decoder (112) at each possible rate with error metrics generated that are representative of the quality of the data decoded at each rate. A rate decision algorithm is used by processor (116) to evaluate the error metrics and make a decision on the rate at which the data was transmitted. A pattern match of rate decisions is used by processor (118) to modify a setpoint so as to closely control the transmitting power of the remote station as a function of the quality of the received data.

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METHOD AND SYSTEM FOR THE DYNAMIC MODIFICATION OF CONTROL PARAMETERS IN A TRANSMITTER POWER CONTROL SYSTEM

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates generally to digital communication systems and, more specifically, to a method and apparatus for adjusting transmitter power in such systems both to minimize interference among transmitters operating simultaneously and to maximize the quality of individual communications.

II. Description of the Related Art

In a cellular telephone or personal communication system (PCS), a large number of "mobile stations" communicate through cell sites or "base stations." The transmitted signal experiences multipath fading as the mobile station moves in relation to features in the environment that reflect the signal. Controlling mobile station transmitter power to overcome multipath fading is described in U.S. Patent No. 5,056,109, titled "METHOD AND APPARATUS FOR CONTROLLING TRANSMISSION POWER IN A CDMA MOBILE CELLULAR TELEPHONE SYSTEM," issued on October 8, 1991 to the assignee of the present invention and incorporated herein by reference.

If the mobile station transmits an excessively powerful signal, it will interfere with the transmitted signals of other mobile stations. If the mobile station transmits an insufficiently powerful signal, the base station will be unable to recover the transmitted information from the received signal. In the above-referenced patent, the base station measures the power of the signal received from a mobile station and transmits power adjustment commands to the mobile station over a separate channel. The commands instruct the mobile station to increase or decrease transmission power to maintain the average received signal power at a predetermined level. The base station must periodically adjust the transmission power of the mobile station to maintain an acceptable balance between interference and signal quality as the mobile station moves.

The base station processor may monitor error rates in the received signal to select an optimal power level at which to maintain the average received signal. The base station processor detects errors as disclosed in copending U.S. patent application Serial No. _____, titled "METHOD AND APPARATUS FOR DETERMINING TRANSMISSION RATE IN A COMMUNICATIONS RECEIVER," and assigned to the assignee of the present invention. In the exemplary CDMA cellular telephone system described in the above-referenced U.S. patent and copending application, the mobile station transmits "frames" comprising "symbols," which represent digitized voice or other data. Further details on the exemplary CDMA cellular telephone system are described in U.S. Patent No. 5,103,459, titled "SYSTEM AND METHOD FOR GENERATING SIGNAL WAVEFORMS IN A CDMA CELLULAR TELEPHONE SYSTEM," issued April 17, 1992 to the assignee of the present invention and incorporated herein by reference.

The mobile station encodes frames at one of four rates; the rate is selected according to the needs of the user. The maximum rate, which is generally preferred for high quality voice transmissions or rapid data transmissions, is called "full rate." Rates of one half, one fourth, and one eighth of the full rate are called "half rate," "quarter rate," and "eighth rate," respectively. Each symbol of a frame to be encoded at half rate, quarter rate, and eighth rate is repeated two, four, and eight times, respectively, to fill the frame. The frame is then transmitted to the base station at a constant rate, regardless of the rate at which the symbols are encoded.

The base station has no advance notice of the data rate at which a received frame is encoded and the rate may be different from that of the previous received frame. The base station decodes each received frame at each of the four rates and produces a set of error metrics corresponding to each rate. The error metrics provide an indication of the quality of the received frame and may include a cyclic redundancy check (CRC) result, a Yamamoto Quality Metric, and a re-encoded symbol comparison result. The generation and use of these error metrics are well known in the art with details on the Yamamoto Quality Metric provided in the article "Viterbi Decoding Algorithm for Convolutional Codes with Repeat Request", Hirosuke Yamamoto et al., *IEEE Transactions on Information Theory* , Vol. IT-26, No. 5, September 1980. The set of error metrics for the decoding of each frame at each rate thus includes one or more of the CRC result, the Yamamoto Quality Metric, and the re-encoded symbol comparison result. The base station processor analyzes the sets of error metrics using a novel

decision algorithm and determines the most probable rate at which the received frame was encoded. The base station then uses the rate decision to select the corresponding decoded data from the multiple data rate decodings to recover the transmitted frame information.

The base station processor also produces an "erasure" indication if the quality of the frame data is too poor for the processor to determine the rate. Similarly, the processor produces a "full rate likely" indication if bit errors exist in the data but the rate is probably full rate. If an erasure occurs, the base station may simply discard the frame or may replace it with interpolated data.

It would be desirable to monitor the error rate of the received frames and to periodically adjust the transmission power level to maintain the error rate at an acceptable value. These problems and deficiencies are clearly felt in the art and are solved by the present invention in the manner described below.

SUMMARY OF THE INVENTION

The present invention comprises a method and apparatus for adjusting the power level of a remote transmitter to provide a substantially constant error rate in the received data. The present invention may be used in the base station of a cellular telephone system to maximize the number of mobile stations that may transmit simultaneously with minimal interference by enhancing control over the power of the signal that each mobile station transmits.

In the CDMA cellular telephone system described in the above-referenced U.S. patent, the mobile station transmits a signal comprising frames of digitized voice or other information to the base station at an initial power level or setpoint. As described in the above-referenced copending application, the information is encoded into either full rate, half rate, quarter rate, or eighth rate data frames. The base station receives the signal and decodes each frame at each of these rates. A corresponding set of error metrics is produced for each rate that provides an indication of the quality of the received information if the frame is decoded at that rate. The base station processor then analyzes the sets of error metrics using a decision algorithm and either provides an indication of the most probable rate at which the information was encoded or provides an "erasure" indication, i.e., an indication that the rate could not be determined with the desired probability of correctness.

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