The W-CDMA Scheme with Parallel Matched Filter and Its Enhancement

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Abstract: - Enhancement of the W-CDMA scheme is studied in this paper based on its characteristic evaluation of the scheme provided by the authors. The advantages of the W-CDMA are wide spreading and coherent demodulation with a pilot channel. The pilot level is optimized to give the maximum capacity of the system. New configuration of the W-CDMA is then investigated to increase transmission data rate and capacity of mobile communications. This structure, with parallel matched filter, has been proposed for synchronization and demodulation under severe multipath environments. The parallel matched filter is configured by an analog MOS device with the conventional digital circuits. The power consumption and dimension of the LSI are reduced effectively by the simultaneous approach to the system and circuit configuration.

Key-Words: - Synchronization, Pilot signal, Matched filter, W-CDMA, Mobile communications.

1 Introduction

In the conventional CDMA schemes, narrow band approach has been provided for wideband data (i.e. high data rate) transmission in radio channels. These narrow band sub-channels were actualized with *n*-ary codes and multiple carrier frequency channels[1].

Multipath transmission in radio channel is the one of the distinguished tough problems. It reduces bandwidth extremely less than 0.4 MHz at 1.8 GHz radio frequency[2]. It indicates clearly that wideband data is not transmitted in urban radio channels. Notwithstanding a wideband approach was proposed first by the authors. The W-CDMA is provided by this approach[3][4][5][6].

The W-CDMA system provides high-speed data transmission over radio channels by spectrum wide spreading and continuous pilot signal.

This paper describes configuration of enhanced W-CDMA system and its characteristic evaluation and a novel configuration of analog matched filters to realize compact system with low power consumption. The coherent demodulation using continuous pilot signal was proved to be advantageous for high-speed data transmission.

2 Radio System Configuration

Due to multipath propagation and Doppler effect, rapid phase rotation appeared at the input of demodulator. Estimation and compensation of these phase rotation are needed before demodulation. Wideband transmission of high-speed data is impossible except this processing.

It is important to perform reliable synchronization for high-speed data transmission. A pilot signal is transmitted continuously together with data signal in this system. Accurate initial acquisition and precise tracking is achieved by continuous pilot transmission (pilot channel). Estimation and compensation of phase rotation is achieved effectively with high resolution using continuous pilot signal. And highly improved demodulation of received data is also provided using the received pilot signal.

3 Design

3.1 Transmitter

Transmitter is shown in Fig.1 for the reverse link. Walsh codes $\psi 1$ and $\psi 2$ are assigned for traffic and signaling channels. A PN code ϕ is assigned to pilot channel. The pilot signal is fed to I-channel only, which is transmitted continuously embedded in the I-channel of data in the traffic channel.

Data signal is fed to I and Q-channels of QPSK modulator. They are fed to QPSK modulator. The pilot signal is composed of Walsh-0 and PN codes. I and Q components of data signal are composed of Walsh-1 and PN codes.

3.2 Receiver

Coherent radio transmission scheme is shown in Fig.2. The (i)Continuous pilot signal is transmitted through a pilot channel, (ii) the pilot channel is composed of O-QPSK and QPSK for reverse and forward links respectively, (iii) pilot signal is added in each I channel of O-QPSK and QPSK, (iv) coherent demodulation is achieved by estimation and compensation of phase rotation using the pilot channel.

3.3 Coherent demodulation

Coherent demodulation is one of the most distinguished feature of the W-CDMA[7]. The process is as follows; (i) estimation of rapid phase rotation caused by multipath radio propagation with high-speed Doppler shift in frequency is well realized by the use of continuous pilot transmission. (pilot channel), (ii) compensation of rapid phase rotation is well done by simplified logic operations, (iii) high performance for high speed data transmission is realized by coherent demodulation. This system will be applied to wireless LANs with high performances and simplified configurations.

3.4 Synchronization by a parallel matched filter

A parallel matched filter is provided in this study for synchronization with long correlation. Acquisition and tracking are achieved precisely using continuous pilot signal and the parallel matched filter. A pair of one-bit-data-length correlators are provided for coherent demodulation based on phase estimation and compensation using the vectors *u* and *v* as shown in Fig.2.

Synchronization is to decide the value and the time of the maximum peak of correlation. Over-sampling of 4 points per 1 chip is done to get precise decision (fine resolution) of each path. Correlation is done between the input and the pilot waveforms. The correlation operation is executed at 8-bit-length. An analog matched filter is introduced because of simple and compact configuration with low power consumptions.

Correlation is executed with a correlator separated into 4 components. The correlator is achieved by a matched filter with transversal filter configuration.

Estimation and compensation of phase rotation with highly improved demodulation of received traffic data have been achieved by utilizing received pilot signal.

This structure, with parallel matched filter, has been proposed for synchronization and demodulation under multipath environments. A parallel matched filter is configured by an analog MOS device instead of conventional digital components. The power consumption and dimension of the device are reduced by the combination of system and hardware approaches[8].

4 Evaluation

4.1 Synchronization time

Fig.3 shows the characteristics of synchronization to a target cell. The horizontal and the vertical axis show the calculation time (ms) and acquisition success rate respectively. Acquisition success rate is defined the ratio of success times and total times of synchronizing events. The synchronization is achieved within about 30 ms.

4.2 Bit Error Rate vs. Eb/N0

Fig.4 shows the characteristics of Bit Error Rate vs. E_b/N_0. The maximum ration combining is utilized. In the block of legends in Fig.4, TPC stands for the case with Transmitting Power Control function. Possible number of paths for combining are 1 path, 2paths, and 3 paths. Transmitter power control has been applied for each number of paths conducted. The required E_b/N_0 is about 4dB for BER $1x10^{-3}$.

5 Conclusion and Acknowledgements

It has been clarified in this paper, that coherent transmission of data using continuous pilot signals. The parallel matched filter is quite effective to realize the reliable synchronization and coherent demodulation under multipath radio environment.

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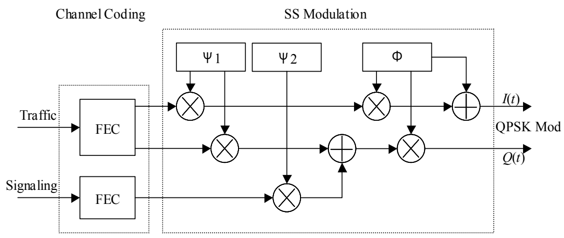

Fig.1 Transmitter of reverse link.

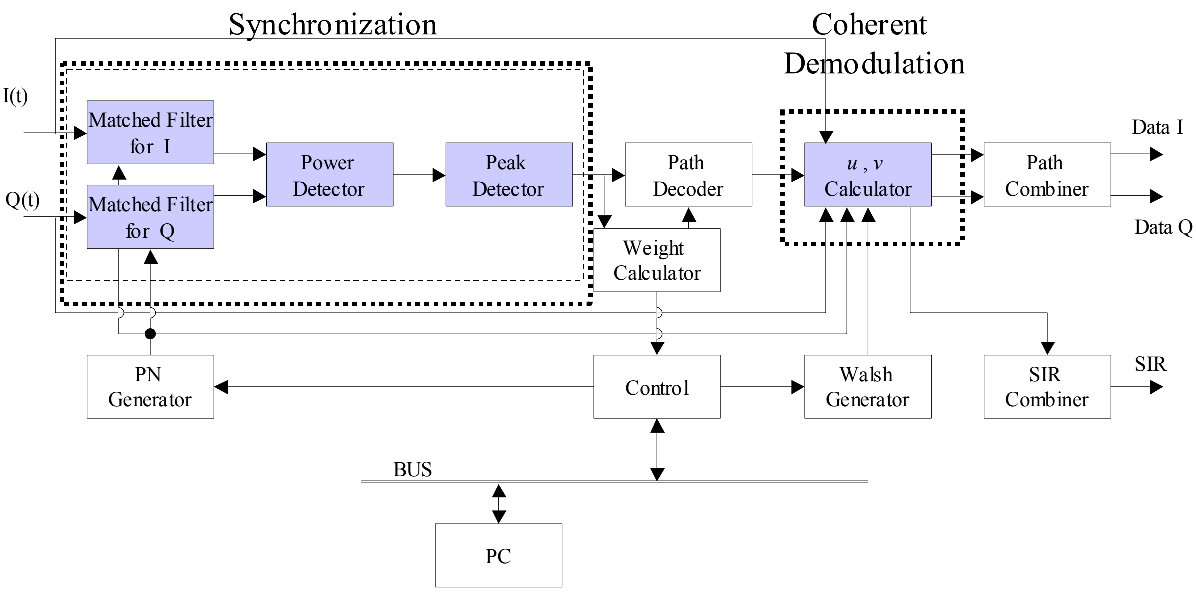

Fig.2 Receiver and Synchronization of reverse link.

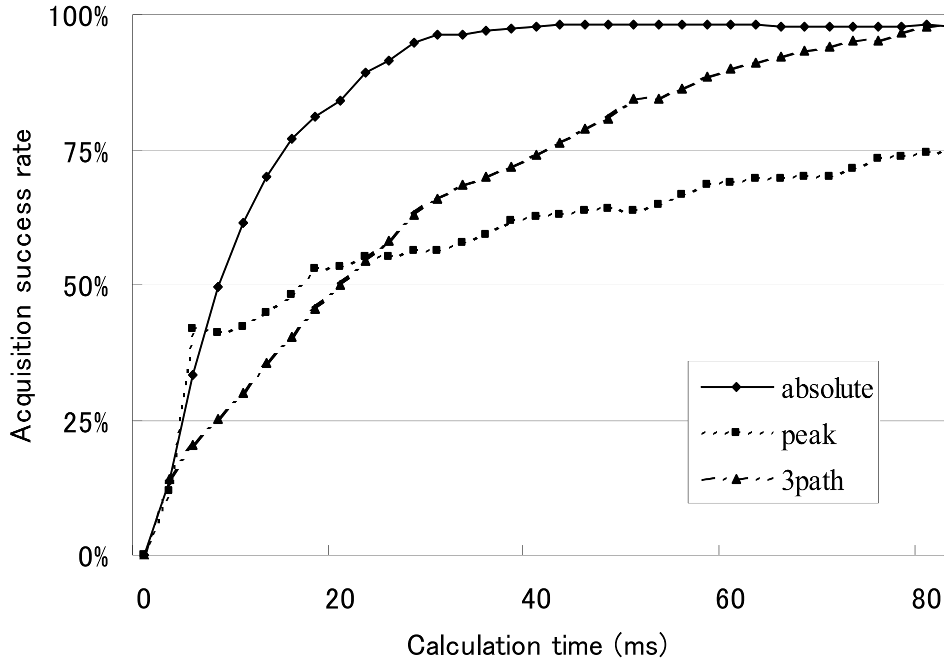

Fig.3 Characteristics of synchronization.

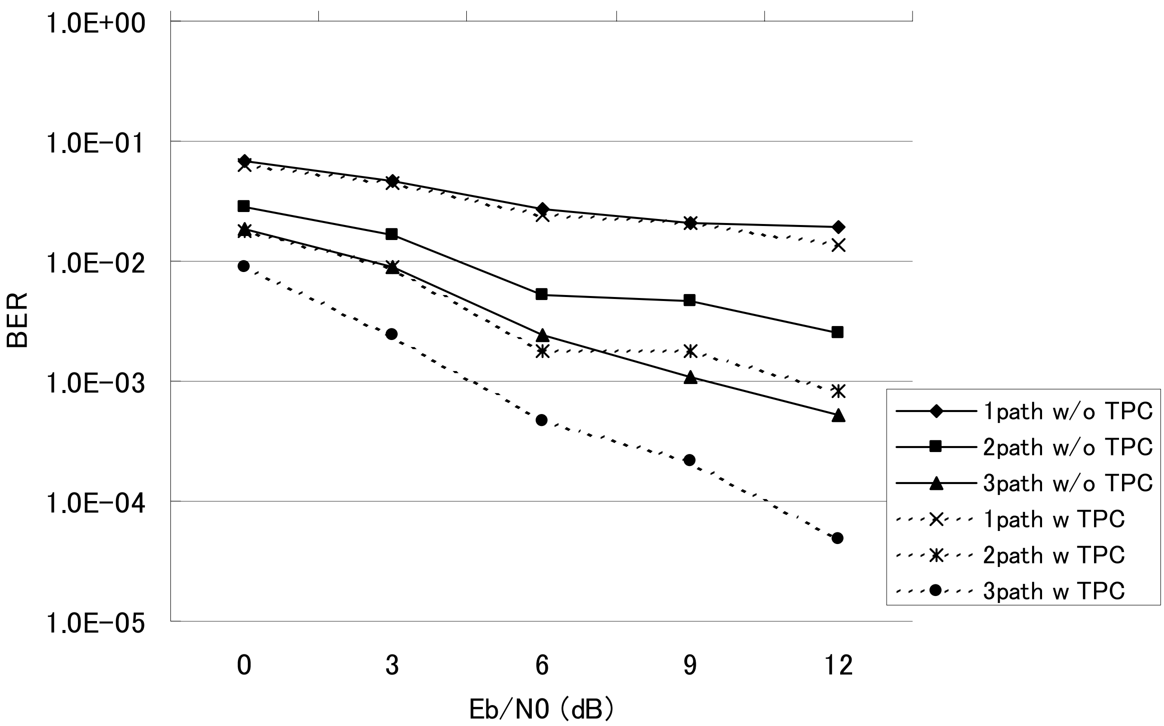

Fig.4 Characteristics of BER vs. E_b/N_0.