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A proposed strategy for Reduction in Peak-to-Average Power Ratio with advanced Parallel Anti Interference techniques

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Abstract. *In MC-CDMA system Peak-to-Average Power Ratio (PAPR) is major problem. High PAPR leads to nonlinear distortion of the amplifier and results in inter-carrier self-interference plus out-of-band radiation. Many approaches have been proposed to solve the PAPR problem in multicarrier systems, which include amplitude clipping, clipping and filtering, coding, tone reservation, tone injection, active constellation extension, and multiple signal representation techniques. All those techniques have their own drawbacks, such as transmit signal power increase, BER increase, data rate loss, computational complexity increase. Imperfect cross-correlation characteristics of the spreading codes and the multipath fading make the orthogonality among the users lost, and then cause MAI, which produces serious BER degradation in the system. Due to the ability of detecting all the users simultaneously with reduced latency, the PIC is also especially attractive for an uplink MC-CDMA system. Hence a new semi-blind channel estimation and multi-user data detection based on PIC have been proposed, which cancels interference partly by adjusting interference cancellation factors (ICF). There are two working modes in the system: pilot transmission (PT) mode and data transmission (DT) mode. Also in the partial interference cancellation techniques there is a new algorithm known as HEBB's rule is proposed and simulations in both DS-CDMA and MC-CDMA systems show that the proposed Hebb-PPIC detector has strong anti-MAI ability and its performance of bit error rate (BER) is improved on the basis of conventional PIC.*

Keywords:- Partial parallel interference cancellation (PPIC), interference cancellation factors (ICF), Hebb learning rule, multi-access interference (MAI), bit error rate (BER).

Introduction

CDMA system is limited by interference and MAI will be the main factor of damaging system performance when the number of users is relatively large. The methods of rejecting MAI mainly include improving the design of spreading code, power control, space filtering and multiuser detection [1, 2]. Multiuser detection applies the correlation between the expected user and interference users to MAI cancellation. As one of nonlinear multiuser detection approaches, PIC can obtain obvious performance improvement at the cost of low computing complexity and short processing delay. So it has a bright future in engineering.

In PIC process, due to the correlation between the spreading codes of each user, MAI is introduced into the decision variables after matched filtering, which will impact the decision to each user's information bits. To solve this problem more efficiently, we multiply the generated interference signals by ICF. Such is partial parallel interference cancellation. The method to select ICF is investigated by many experts, but in most cases the expressions are too complex to be used in practice [3, 4].
In this paper recurrent neural network based on Hebb learning rule is used to train a very short period of test sequence (1000 bits) to acquire ICF. MATLAB simulation results show that in the condition of serious interference and low signal-to-noise ratio (SNR), especially of "nearfar" scenario, its BER performance is better than conventional PIC.

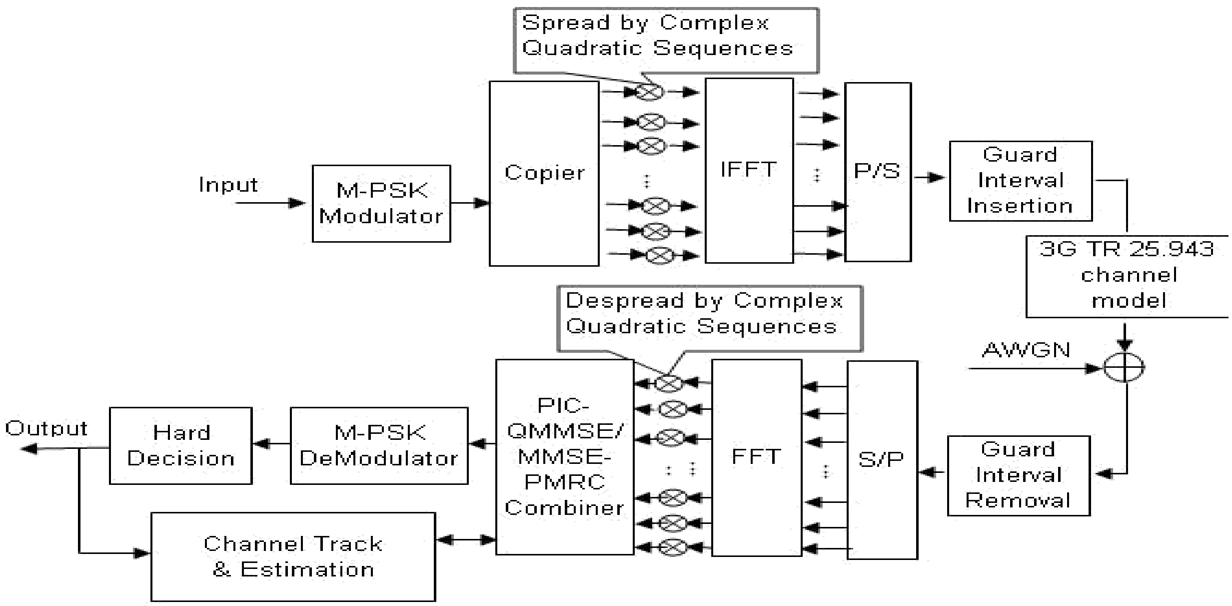

Fig. 1: MC-CDMA System Mode

HEBB-PPIC Model

A. Synchronous DS-CDMA Model

Consider a DS-CDMA system where K users transmit their information synchronously over a common additive white Gaussian noise (AWGN) channel. The received signal at the base station can be modeled as where Aj is received amplitude of the jth user, bj(i) is transmitted symbol (±1) of the jth user in, t∈[iT,(i +1)T]j(t) is signature waveform of the jth user, T is symbol(bit) interval, and n(t) is AWGN with zero mean and at wo-sided power spectral density of σ 2W/Hz. Using a chip matched filter (MF) and sampling at the chip rate, the continuous-time received signal in (1)during the ith symbol interval, , can be converted to the following discrete-time N-vector:

B. MC-CDMA Model

In a MC-CDMA system where K users transmit their information synchronously over a common additive white Gaussian noise (AWGN) channel, the received nth chip of the ith bit at the base station can be described in discretetimeform where is channel impulse response, is the AWGN vector with zero mean and a two-sided power spectral density of W/Hz andΣ , where j A is received amplitude of the jth user, N is spreading gain (as same as the number of carriers) and , where and are the ith bit and kth chip of the jth user respectively.

C. Hebb Learning Rule

Hebb learning rule is one of the neural network learning rules widely used. It was proposed by Donald Hebb in 1949 as a potential mechanism for the brain to adjust its neuron synapse and from then on it has been used in training artificial neural network [7].Hebb learning rule is based on Hebb assumption [8]:when an axon of cell A is near enough to excite a cell Band repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A's efficiency, as one of the cells firing B, is increased. Hebb assumption means that if a positive input pj results in a positive output ai, wij should be increased, which is a kind of mathematics explanation for it, i.e., where pjq is the jth element of the qth input vector pq, aiq is the ith element of network output when the qth input vector is entered into the network and α is a positive constant called as learning rate.

It should be noticed that based on (4) Hebb assumption can be expanded as follows: the variation of weights is proportional to the product of active values from each side of synapse. Therefore, weights will increase not only when pj and ai are both positive but also when they are both negative. Besides, Hebb rule will decrease weights as long as pj and ai have opposite signs.

Receiver for Uplink MC-CDMA Systems

Recently, in uplink MC-CDMA systems, pre-equalization at the transmitter have been proposed. Indifferent single-user pre-equalization techniques which are used for uplink MC-CDMA systems have been compared and the corresponding, it is impossible to keep the orthogonality in the received multiplexed uplink signal at the base station.

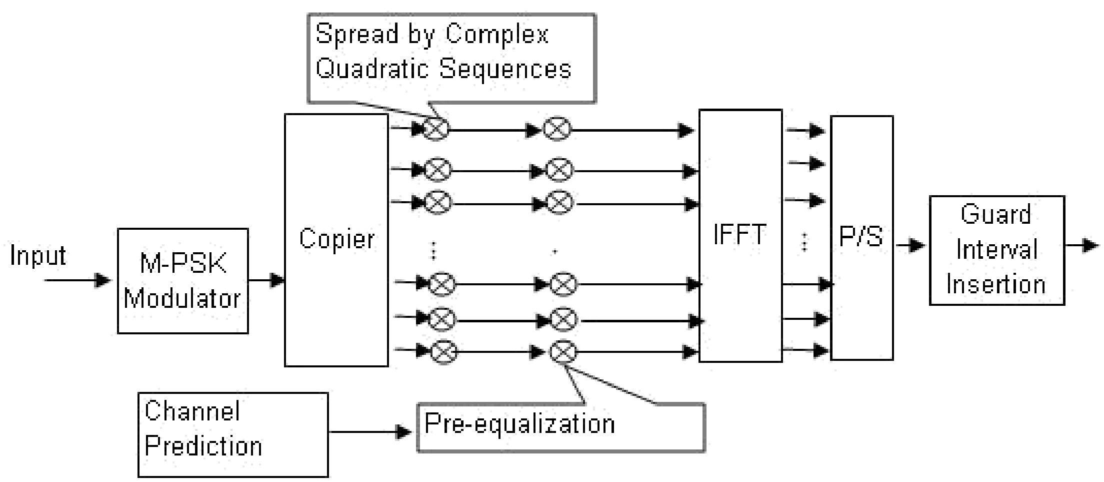

Fig. 2: Up-link MC-CDMA System

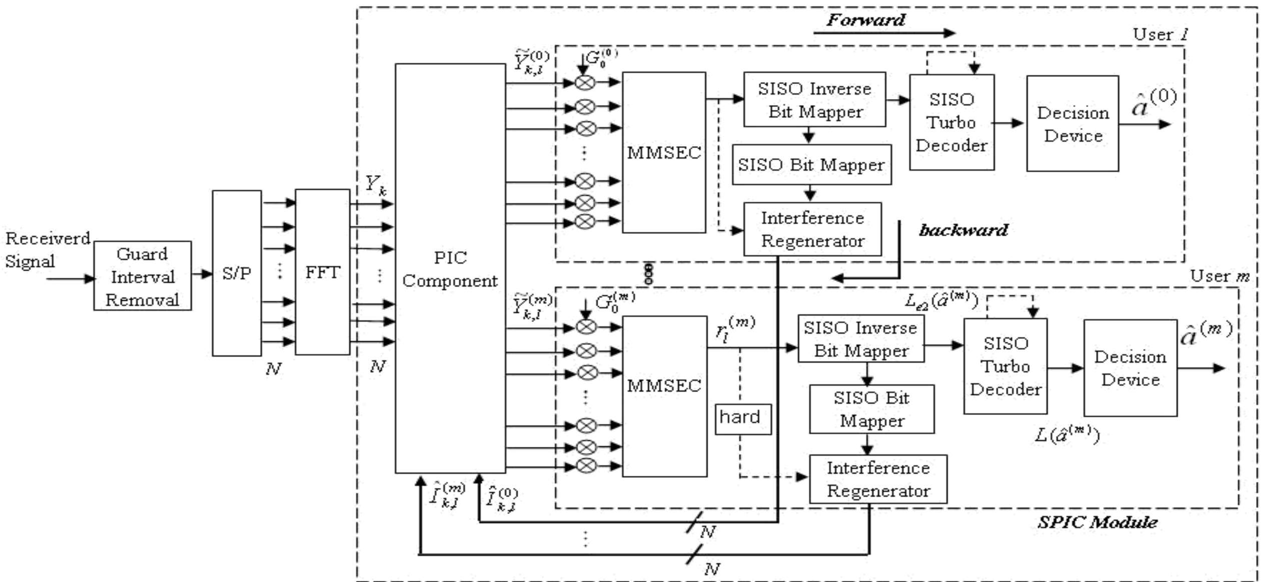

Fig. 3: Proposed SPIC receiver.

Main parameters used in simulations are as shown in the below table:

TABLE 1: PARAMETERS TO SIMULATE UPLINK OF MC-CDMA SYSTEMS

Signal bit rate	4 MHz	Modulation scheme	256 QAM
Number of data sub-carriers	256	Cyclic prefix	16 us
FFT length	256	Channel model	Modified SUI with AWGN
Maximum Doppler Frequency	120Hz	OFDM symbol period	64 us
Spreading Sequences	Walsh codes	Turbo code rate	0.5

Simulation and Analysis

Based on the analysis above several computer simulations are presented in the conditions of ideal power control and "near-far" scenario to compare the performance of Hebb-PPIC with that of PIC or MF(namely DEC (de-correlation) in MC-CDMA system)detection. In order to pay more attention to the detection process, we assume that the channel only bring about time delay to signals (i.e., without amplitude attenuation and multi-path propagation) in both DS-CDMA and MC-CDMA systems. The BER curves of MF detector, PIC and Hebb-PPIC detectors (atstage 3) versus SNR under ideal power control in DS-CDMA system. From Fig. 2 we can see that the BER decreases all along with increasing of SNR and moreover, the

BER curve of Hebb-PPIC is under those of MF and PIC all the time. Especially when SNR is low (not exceeding 4dB),the BER of Hebb-PPIC is 1 to 2 percentage points lower than MF and 0.5 to 1 percentage points than PIC in [5],which indicates that Hebb-PPIC performs better in noisy communication environment.

Simulation 2 (in MC-CDMA system): K = 5 ; amplitude of users , ; m=5 ; N=1 Ai i =1,…,Kσ 2 = 1 N = 32 b=1000; λ =1/ 200 . The BER curves of PIC and Hebb-PPIC detectors at stage 3 versus number of active users are shown in Fig. 3.From Fig. 3 we can find that the BERs of both PIC and Hebb-PPIC decrease along with stage and especially from stage 1 to stage 2 they decrease very obviously and tend to be stable from stage 2 on, which shows that the PIC structure can be able to cancel MAI more efficiently compared with conventional MF detection (namely stage1 in this figure). On the other hand, the BER curve of Hebb-PPIC is under that of PIC all the while from stage 1to stage 5, which indicates that on the basis of PIC structure Hebb-PPIC improves the reception performance of system further, i.e., weakens the effect resulted from error cancellation in PIC. The BER curves of PIC and Hebb-PPIC detectors versus SNR under "near-far" scenario in MC-CDMA system (the weak user group).In Fig. 5a it can be easily seen that for weak users the BER level of PIC and Hebb-PPIC is far lower than that of DEC and even with the biggest SNR (10 dB) the BER of DEC (12%) is higher than that of PIC and Hebb-PPIC(about 11.5%) with the smallest SNR (0 dB). Although becoming nearer to the BER curve of PIC along with increasing of SNR, that of Hebb-PPIC is still under it.

The BER curves of PIC and Hebb-PPIC detectors versus SNR under "near-far" scenario in MC-CDMA system (the strong user group).From Fig. 5b we notice that compared with weak user group the distances between the three BER curves are not too large in the case of strong user group, and when SNR is relatively small (0~2 dB) the BER of DEC is even lower than that of PIC, which is because that small SNR means serious interference while this will result in error decision and cancellation which will influence the veracity of decisions at the next stage. But with SNR increasing (bigger than 2 dB), the advantage of PIC will emerge that its BER is 1 to 2 percentage points lower than DEC's. However the performance of Hebb-PPIC is better than PIC and DEC all along and the former's BER is generally 1.5 percentage points lower than the latter's. Comparing Fig. 4 and 5 we can find that when the user signals are weak PIC, especially Hebb-PPIC, will play an important role in improving reception performance and rejecting "near-far" effects.

Conclusion

The Hebb-PPIC algorithm is simulated in two conditions of idea power control and "near-far" scenario. Simulation results indicate that no matter which parameter changes among stage number, SNR and number of active users, the BER performance of Hebb-PPIC is better than conventional PIC; and moreover, compared with most of the PPIC algorithms proposed by now, Hebb-PPIC has the advantage of small computing quantity, low complexity and easy implementation and it can adjust ICF at any moment of channel variation, so it owns practicability in engineering.

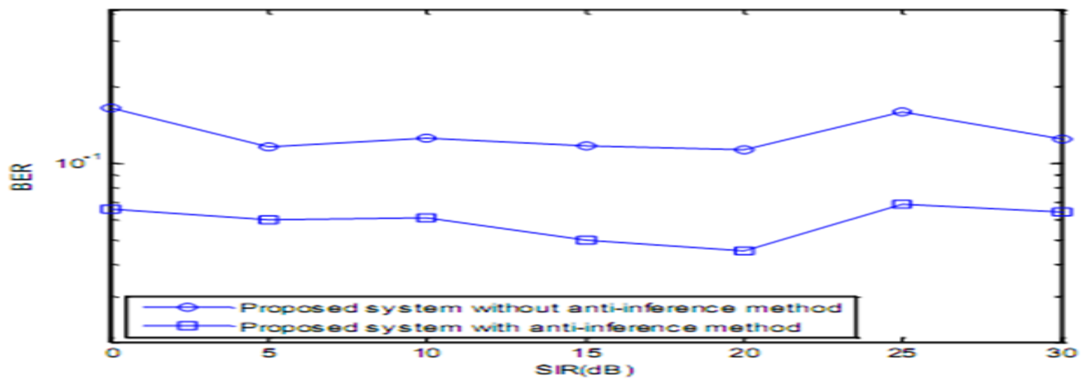

Fig. 4: Comparison results of the proposed system with/without interference mitigation policy under the pulse interference.

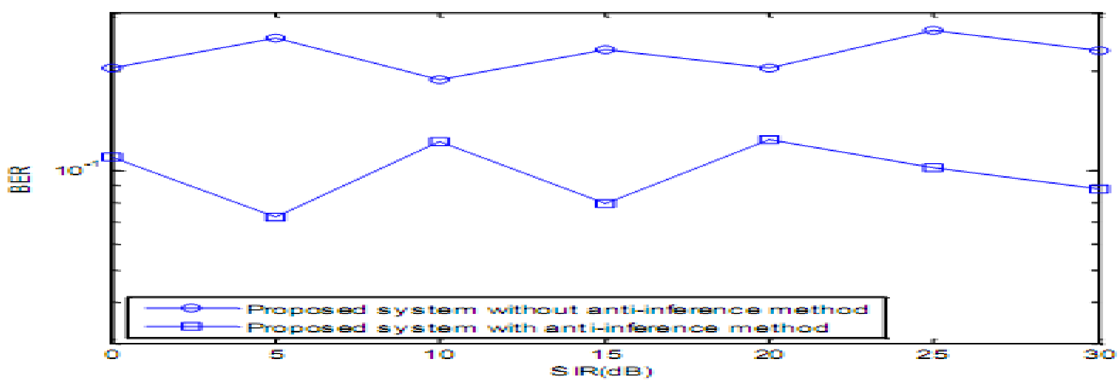

Fig. 5: Comparison results of the proposed system with/without interference mitigation policy under the partial band interference.

Future Aspects & Limitations

A. Future Aspects

In CDMA systems multi-access interference (MAI) is a very important component resulting in poor reception performance, however parallel interference cancellation (PIC) can solve this problem to some extent. But in PIC process error cancellation of interference resulting from error decision at the former stage will influence the veracity of decision at this stage. Considering this we proposed a partial parallel interference cancellation (PPIC) multiuser detector based on Hebb learning rule which cancels interference partly by adjusting interference cancellation factors (ICF).Simulations in both DS-CDMA and MC-CDMA systems show that the proposed Hebb-PPIC detector has strong anti-MAI ability and its performance of bit error rate (BER) is improved on the basis of conventional PIC in both conditions of ideal power control and "near-far" scenario.

B. Limitations

Though being simple, the classical Hebb's rule has some disadvantages. Depending on the application area of MC-CDMA systems, some drawbacks are tolerable but some need improvement. Generally speaking, for the purpose of data processing and statistical analysis, the speed and power of computation are valued more than the resemblance between the model and the assumptions.

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