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Influence of Phase Difference between the Groups on BER Performance in the 2M-Plex System

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SUMMARY Recently, there has been increasing interest in Code Division Multiplex (CDM) systems. We reported the CDM system using the Δ-chip shift multiplex operation. So far the performance of this system evaluated under the optimum Δ. In this letter, we evaluate an influence of the phase difference between the groups on BER performance in 2M-plex system.
key words: *spread spectrum communication, code division multiplex, manchester code, communication systems and transmission equipment*

1. Introduction

Recently, there has been increasing interest in Code Division Multiplex (CDM) systems.[(1)–(6)] In the CDM systems, each channel is assigned a particular pseudonoise (PN) sequence. In the receiver, the signals from the other channels appear as additive interference (co-channel interference) because the cross-correlation value between the PN sequences exists. Therefore one of the problems is how to suppress co-channel interference. Many works have been carried out on the reduction methods, for example, the PN sequences with good correlation properties,[(1)–(3)] the scheme of cancelling co-channel interference[(4)] and the system using half chip shifted PN sequence groups.[(5)]

We reported the CDM system using the 'Δ-chip shift' multiplex operation and manchester coded sequences.[(6)] This system can increase the number of channels by two times or three times compared with the basic CDM system. The phase difference between the groups (Δ) is very important to determine the performance of this CDM systems. We found that the optimum Δ is 2/3 [chip]. So far the performance of this system has been evaluated under the condition of optimum Δ.[(6)]

In this letter, we evaluate an influence of the phase difference between the groups on Bit Error Rate (BER) performance in the 2M-plex system.[(7),(8)]

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2. 2M-Plex System Using 'Δ-Chip Shift' Multiplex Operation

In this section, we explain the structure of the 2M-plex system.

The 'Δ-chip shift' multiplex operation[(6),(7)] can reduce co-channel interference. Therefore the number of channels may increase.

Figure 1 illustrates the structure of the 2M-plex system using the 'Δ-chip shift' multiplex operation, were τ is a period of sequence and τ' is equal to Δ [chip]. The 2M-plex system consists of Group 1 and the Δ-chip shifted version of Group 1, i.e., Group 2. The co-channel interference between any two sequences in the same group is zero, but the co-channel interference between one group and another exits. The 2M-plex system can achieve two times as many as the number of channels in the basic CDM system. The cancelling system (on canceller) operates as follows: after the only sequence of maximum interference channel is cancelled in the received signals, the signal of desired data is redemodulated.

3. Performance Evaluation

In this section, we analyze the influence of phase difference between the groups on BER performance. Moreover, we compare the performance of four 2M-plex systems which use spreading codes based on M-sequence. The 2M-plex system uses spreading codes

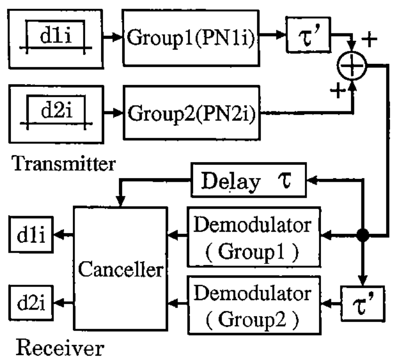

Fig. 1 The structure of 2M-plex system.

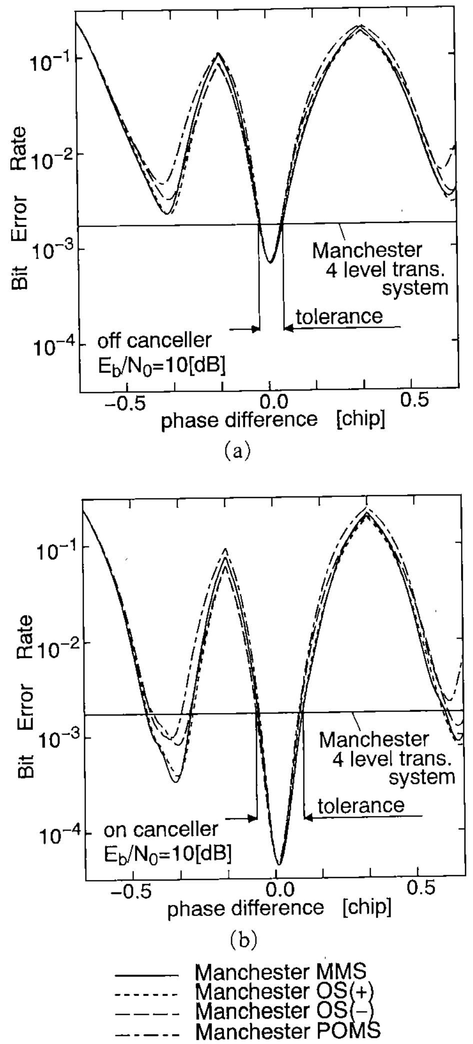

Fig. 2 (a) BER vs. phase difference between groups at $E_b/N_0=10$ [dB] (off-canceller).
(b) BER vs. phase difference between groups at $E_b/N_0=10$ [dB] (on-canceller).

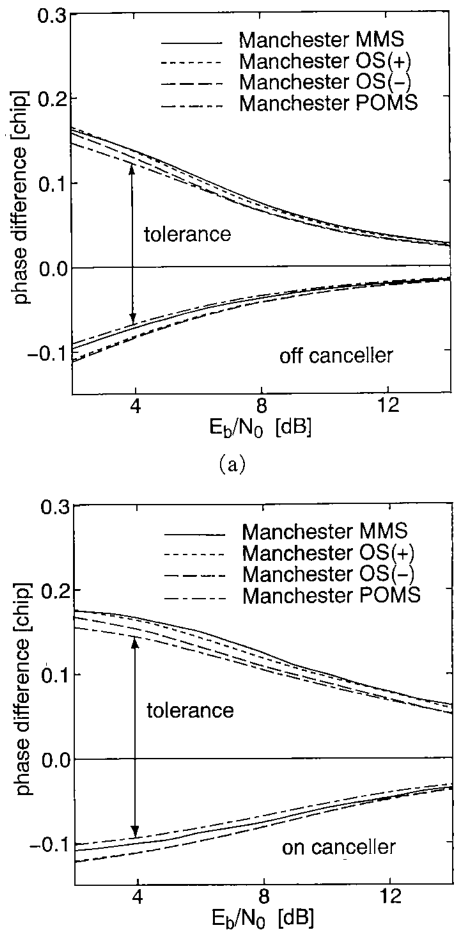

Fig. 3 (a) Tolerance at each E_b/N_0 (off-canceller).
(b) Tolerance at each E_b/N_0 (on-canceller).

that transform a chip waveform into manchester signaling, namely Manchester coded orthogonal sequences (Manchester OS),[1] Manchester coded modified M-sequences (Manchester MMS)[2] and Manchester coded pseudo orthogonal M-sequences (Manchester POMS),[3),(6] And Manchester OS has two different types of sequence according to sign of additional chip viz., Manchester OS(+) and Manchester OS(−).

Figures 2(a) and 2(b) show the BER versus phase difference between the groups at $E_b/N_0=10$ [dB]. Figure 2(a) is in the case of off-canceller and figure 2(b) is in the case of on-canceller. Here E_b is the transmitted signal energy for each message bit and N_0 is the noise power spectrum density. And we define the phase difference as zero when $\Delta=2/3$ [chip], that was reported as the optimum Δ. Figures 3(a) and 3(b) show the tolerance at each E_b/N_0. Tolerance is the

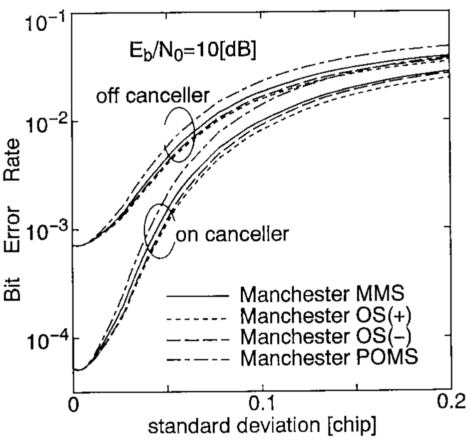

Fig. 4 BER vs. standard deviation at $E_b/N_0=10$ [dB].

phase difference where the 2M-plex system is superior to the Manchester coded 4-level transmission system. This Manchester coded 4-level transmission system uses both 4-ary multiamplitude signaling[9] and manchester signaling.

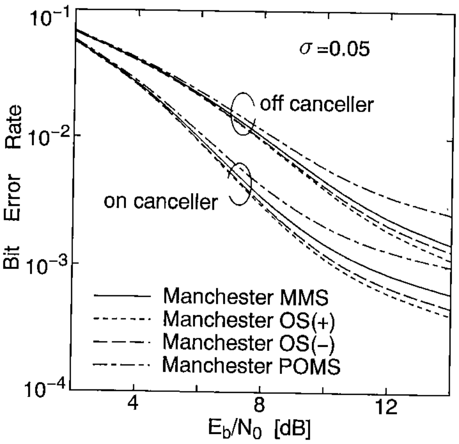

Fig. 5 BER vs. E_b/N_0 at $\sigma=0.05$.

We consider that Group 1 and Group 2 signals are independently generated and the synchronization system between the groups uses phase locked loop. It is known that jitter has Gaussian distribution when phase locked loop is used in the presence of small Gaussian noise. Therefore we assumed that the phase difference has a Gaussian distribution. Figure 4 shows the BER versus standard deviation (σ) of Gaussian distribution at $E_b/N_0=10$ [dB]. Figure 5 shows BER versus E_b/N_0 at $\sigma=0.05$ [chip]. The performance of the 2M-plex system using Manchester OS(+) is best in those of four systems.

4. Conclusions

The influence of the phase difference between the groups on BER has been discussed. The 2M-plex systems used manchester coded sequences as spreading code. We obtained three points.

1. The tolerant range of the phase differences, where the 2M-plex system is superior to the Manchester coded 4-level transmission system, exists.
2. The performance of the 2M-plex system depends on spreading codes because each sequence has its own correlation properties.
3. In both off-canceller and on-canceller, the performance of the 2M-plex system using Manchester OS(+) is best in those of four systems.

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