REMOTE CONTROL MULTIPLE MOBILE TARGET SYSTEM WITH CDMA

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ABSTRACT

At present, multiple mobile targets will be remote controlled in many remote control and telemetry system, in which multiple access technology will be applied.
This paper proposes a communication scheme to remote control multiple mobile targets using Coded-Division Multiple Access(CDMA) technique. It's feasibility ,advantage and shortcoming are analyzed. Moreover, the key techniques of Direct-Sequence Spread Spectrum(DS/SS) system, i.e. the correlation detection and delay lock-on techniques, are studied and stimulated on the experimental model. The results of theoretical analysis show that the CDMA system has the peculiar advantage over the conventional multiple access system, such as FDMA and TDMA.

KEY WORDS

Spread spectrum communication, Delay lock loop, Point to multipoint communication, CDMA

INTRODUCTION

With the development of military and civil technology ,in more and more fields, point to point telemetry and remote control system have not been able to meet specific requirement, hence multiple targets remote control came into being. In this paper, the system of several mobile targets being controlled by a center is introduced. The control of several targets is related to the question of multi-access. Thanks to the unique merits of spread-spectrum CDMA comparing to that of traditional CDMA. Here, CDMA technique is employed. The model of given system is first described, then the key technique in spread-spectrum CDMA systemthe scheme of PN acquisition and synchronizing track is analyzed. The performance of CDMA system is also considered. At the end, the feasibility of this technique applied in given system is concluded.

DESCRIPTION OF SYSTEM MODEL

Figure 1 depicts the given system. In this system, three mobile targets are remote controlled by a center. In the center, three groups of information being sent to three mobile targets are modulated by spread-spectrum technique with m sequence of P=127, then PSK modulation is carried out. After linear adding together, the comprehensive modulated signal is sent to the channel shown by the solid line drawn in the figure. At the target end, likewise telemetry information is modulated by spread-spectrum technique with m sequence of P=127, then PSK modulation is carried out. Thereafter, processed signal is sent to channel machine, just shown by the dotted line depicted in the figure. The received signal in the center is the sum of three signals from three targets, which assumes spatial adding feature. Thus, a DS/SS CDMA multi-access system is constructed. The m sequences adopted here are selected through computation and they possess good correlation performance. Due to DS technique, 20 dB processing gain is acquired, so the antiinterference property of this system is improved.

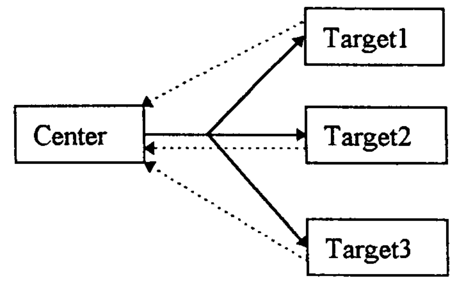

Figure 1 System Model

THE SCHEME OF PN SYNCHRONIZATION AND ANALYSIS

At the receiver end, local PN must synchronize with sending PN, so as to perform despread and demodulation. In order to implement PN synchronization, two questions of PN acquisition and tracking are introduced, and they are the most important questions in spread-spectrum communication.

A.The scheme of PN acquisition and analysis

Search strategy is employed in this system, while coherent detection is dual-pause time system. The block diagram is given in figure 2. It has two integral periods. One is for rapid search of code state, and integral time is τ_{D1}(comparatively less);The other is for further estimation of PN synchronization, and its time constant is τ_{D2}. Through analysis,we can see that the former provides certain false-alarm protection,while other protection is distributed to the latter,and the latter can assure higher detection probability and less false-alarm probability. The acquisition time of the latter is smaller than that of the former.

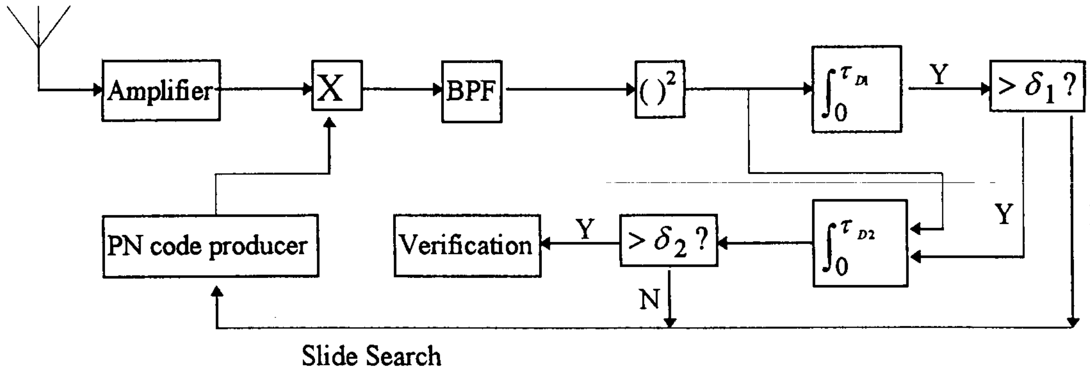

Figure 2 Block Diagram of Acquisition Circuit

B.The scheme of synchronization tracking and analysis

Single Δ-value tracking loop is applied here, as shown in figure 3. If not taking into account the influence of filtering upon PN waveform, the input signal can be expressed as follows:

$$S(t) = \sqrt{P_s}C(t+T)Cos[w_0 t + f(t)] \qquad (1)$$

Through computation, we can gain:

$$X(t) = \sqrt{P_s}[R(T-T1-\Delta/2) - R(T-T1+\Delta/2)] + n_s + n_n \qquad (2)$$

where $R(T-T1-\Delta/2)$ correlation parameter.

T-T1steady delay between input and local PN code.

P_s average power of input signal.

$C(t+T)$ the sending address code.

n_s white Gaussian noise in both upper and lower branches.

n_n multiplying noise of local PN and input interference in both upper and lower branches.

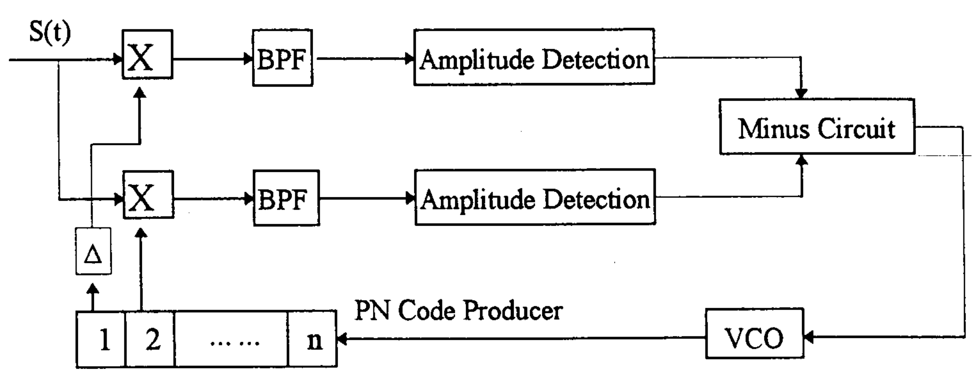

Figure 3 Block Diagram of Delay Lock Loop

Thus, we can conclude that $R(T-T1-\Delta/2)-R(T-T1+\Delta/2)$ is the error function, furthermore, we can draw the error curve in figure 4.

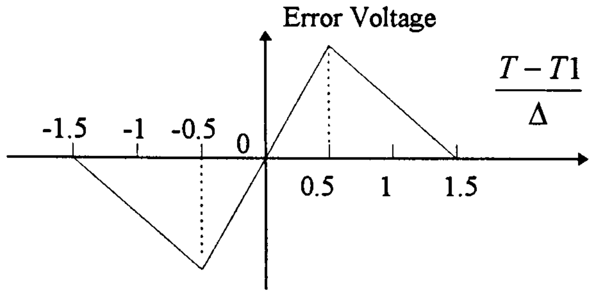

Figure 4 Error Function Curve

Through this figure, when $|(T-T1)/\Delta|$<1/2, local PN code can follow outer sequence with linear change and keep tracking; when $R(\Delta/2)-R(-\Delta/2)=0$,the receiver synchronizes with the sender completely; when $|(T-T1)/\Delta|$>1/2, the loop is out of lock.

Above analysis shows that acquisition circuit implement the rapid search of sender PN code by using local PN code, so as to adjust the phase-error between local PN and sending PN to $|(T-T1)/\Delta|$<1/2. Then delay-lock loop starts to work, the lock state is kept by controlling VCO with error signal. Experiments have proved that the scheme can perform despreading quite well.

MULTI-ACCESS PERFORMANCE ANALYSIS

We assume there are M stations working at the same time, and the number i station's signal is

$$X(t) = C_i(t-t_i)A_i\mathrm{Cos}[w_0 t + f_i(t)] \qquad (3)$$

where $C_i(t-t_i)$ — is PN sequence.

In order to detect the number i station's signal, through relational detection of local sequence with received signal, we obtain

$$E(t) = A_i\mathrm{Cos}[w_0 t + f_i(t)] + \sum_{k=0,k\neq i}^{M-1} C_k(t-t_k)A_k\mathrm{Cos}[w_0 t + f_k(t)] + n(t)C_i(t-t_i) \qquad (4)$$

$\sum_{k=0,k\neq i}^{M-1} C_k(t-t_k)A_k\mathrm{Cos}[w_0 t + f_k(t)]$ — is mutual interference which can be regarded as white noise.

$n(t)C_i(t-t_i)$ is white noise process.

Therefore, through a band filter whose bandwidth is information bandwidth B_m,the mutual interference power is approximated by

$$N = \frac{B_m}{B_c} \sum_{k=0,k\neq i}^{M-1} P_k + N_0 B_m \qquad (5)$$

where B_c is spread-spectrum bandwidth.

P_k is the number k station's power.

Hence the information demodulator's output signal-to-noise ratio is

$$P/N = P_0 \Big/ \left(\frac{B_m}{B_c} \sum_{k=0,k\neq i}^{M-1} P_k + N_0 B_m\right) \qquad (6)$$

when $P_0 = P_1 = \cdots = P_{M-1}$, $P/N = P_0 \Big/ \left(\frac{M-1}{B_c} P_0 + N_0\right) B_m$

In fact, the mutual interference is major interference, therefore we think $\frac{M-1}{B_c} P_0 >> N_0$, $M >> 1$. Thus, above formula can be simplified to be

$$P/N = \frac{B_c}{B_m} \frac{1}{M} \qquad (7)$$

We can see through analysis that the spread-spectrum code speed rate is higher, $\frac{B_c}{B_m}$ is bigger and the signal-to-noise is higher. At certain communication quality, $\frac{B_c}{B_m}$ is bigger, the umber of address to communicate simultaneously is more. therefore if heightening the gain of spread-spectrum process, the umber of address can increase.

Premising $P_0 = P_1 = \cdots = P_{M-1}$,when communicating with M addresses simultaneously under the same transmitting quality, the receive power demanded by every address to the receive power only one address is computed as formula

$$P'/P = 1 \Big/ \left[1 - \frac{M-1}{G_p}\left(\frac{E_b}{N_0}\right)\right] \qquad (8)$$

where P is the receive power demanded by only one address.

P' is the receive power demanded by every address when communicating with M addresses simultaneously.

$\frac{E_b}{N_0}$ is normalized signal-to-noise.

when P=127 ($G_p \cong 20\text{dB}$),according to diverse demand of E_b/N_0 ,the relation between the P'/P and the umber of address M is given in table 1.

Table 1 The relation of P' and P

M / P'/P / E_b/N_0	3	5	7	10
7	0.36	0.74	1.17	1.90
8	0.45	0.96	1.54	2.58
9	0.58	1.26	2.07	3.64
10	0.74	1.64	2.79	5.35

We can obtain through analysis of table 1: the multi-access interference in CDMA is very serious. Quite a few power is consumed on the multi-access interference. When the umber of address exceed a certain bound, the power requirement increase sharply, which worsen the situation of communication. But to this system proposed in this paper, the umber of address is fewer, therefore the problem of multi-access interference in CDMA is not serious.

SUMMARY

The application of CDMA often isn't attractive only from the capacity point of view, but CDMA technique cut down spectrum density, has powerful antiinterference property, provide secrecy of information, and can resist the multipath effect in mobile communication. It is convenience for CDMA to structure diverse communication network, and the address can change at the occasion demands. Therefore, the CDMA technique is very suitable for the system in which umber of mobile targets is few, and the high reliability (e.g. powerful antiinterference) is demanded.

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