POINT TO MULTIPOINT COMMUNICATION WITH DS/SSMA AND MPSK

Xianming Zhao, Honglin Zhao,Tingxian Zhou

ABSTRACT

It is always desirable to transmit several data signals simultaneously. This paper discusses how one transmitter can transmit several data signals to several receivers at the same time in a Point to Multipoint communication system . Two novel schemes are proposed. One is communication with Multiple Phase Shift Keying(MPSK,e.g.8PSK),another is communication with Direct-Sequence Spread-Spectrum Multiple-Access(DS/SSMA). Their models are presented and their operations are illustrated. It is proved theoretically that the communication properties of DS/SSMA are better than those of another.

KEY WORDS

Point to multipoint communication, DS/SSMA, MPSK

INTRODUCTION

The demand for communication in morden information society is getting higher and hihger. According to practical needs, various communication systems were produced, but how to improve the effectivemess and reliability of communication is always a basic project and problem of communication.

According to the topological structure of various communication systems, they can be classified as net structure(multi-points to multi-points), star structure(point to multi-points) and line structure(point to point). In net structure and star structure communiation system, the effective scheme to implement real time communications among multi-points is multiple-access technology, such as traditional TDMA, FDMA and advanced CDMA scheme. Star structure(point to multi-points) is in fact a special form of net structure(multi-points to multipoints), so some special problems in application of Multiple Access technology in point to multi-points communication of star topology should be considered, such as how the base station can use only one transmitter to transmit multirouting data information at the same time.

This paper suggests that, in point to multi-points communication system, multiple phase and multivalue modulation i.e. MPSK or MQAM may be used to implement point to multi-points communication. Besides these, this paper gives a point to multi-points communication scheme with DS/SSMA. The communication performances of these two schemes are analyzed and compared.

POINT TO MULTIPOINT COMMUNICATION SCHEME WITH MPSK

A block diagram of the proposed point to multi-points system model with MPSK is shown in Figure 1.

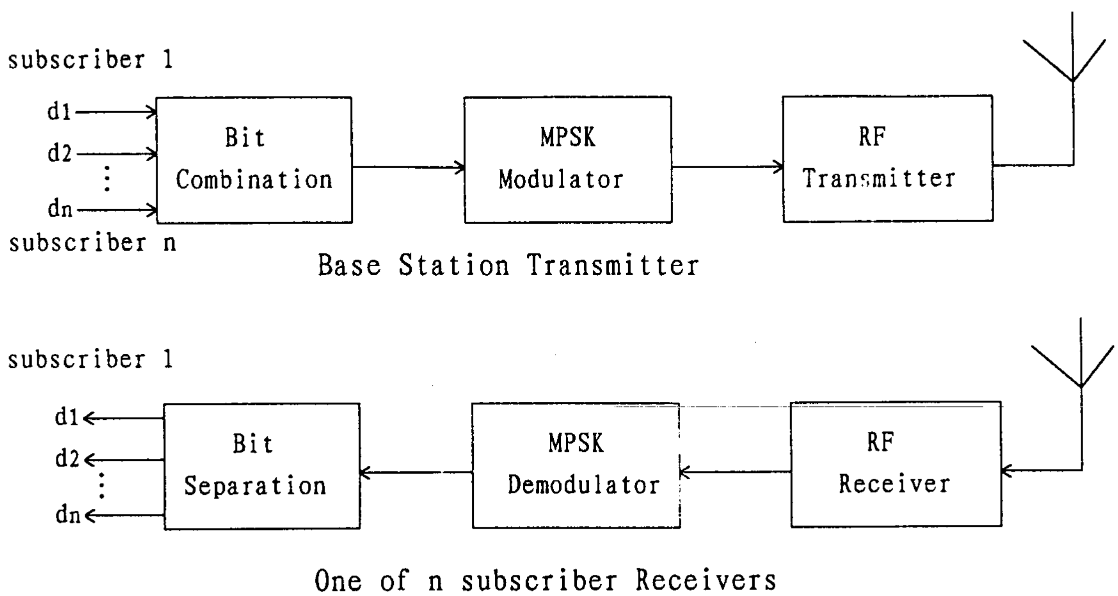

Figure 1. System Model With MPSK

A. The Principle of Operation

In this system, base station transmits data to n subscribers at the same time. The symbols s1,s2,...,sn respectively represent data sequences transmitted to n subscribers, which are information bit strings represented by logical levels of 1 and 0.

With n input bits, there are $2^n = M$ combinations and M symbols will be produced. Multiple Psk modulator maps M symbols into M phase states of carrier. Carrier signal with some phase state is transmitted(RF channel) to multiple subscribers through some RF frequency (RF channel).

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But some communication performances of this scheme in some situation are not perfect.

B. Performance analysis

In communication system, performances which are comparatively important are receiver output signal-to-noise ratio and bit error rate.

At receiver end, when phases detected out of waveform received are different with phase bound pre-determined, errors will be produced, the bound is $\pm p / M$, as shown in Figure 2. It can be testified that the error probability of bit groups(named as symbol error probability P_s) is [1]

$$P_s = \frac{M-1}{M} - \frac{1}{2}\mathrm{erf}\left[\left(\sin\frac{p}{M}\right)\sqrt{\frac{E_s}{N_0}}\right] - \frac{1}{\sqrt{p}}\int_0^{(\sin p/M)\sqrt{E_s/N_0}} e^{-y^2}\,\mathrm{erf}\left(y\cot\frac{p}{M}\right)dy \qquad (1)$$

where E_s is symbol energy, $E_s = (\log_2 M)E_b$, E_b is bit energy,and

$$\mathrm{erf}(\bullet) = 1 - \mathrm{erfc}(\bullet)$$

here $\mathrm{erfc}(\bullet)$ is complemetary error function,

$$\mathrm{erfc}(x) = \frac{2}{\sqrt{p}}\int_x^{\infty} e^{-y^2}dy$$

Define Q function as

$$Q(x) = \frac{1}{\sqrt{2p}}\int_x^{\infty} e^{-y^2/2}dy$$

therefore, $\mathrm{erfc}(x) = 2Q(\sqrt{2}x)$,when $P_s < 10^{-3}$, $M > 2$,

$$P_s \approx \mathrm{erfc}\left[\left(\sin\frac{p}{M}\right)\sqrt{\frac{E_s}{N_0}}\right] \qquad (2)$$

and aproximately bit error probability is

$$P_b \approx \frac{P_s}{\log_2 M}$$

Output signal-to-noise ratio is

$$(C / N)_o \approx (\log_2 M)\bullet \frac{2E_b}{N_0}\left(\sin\frac{p}{M}\right) \quad (3)$$

Figure 3. shows the symbol error probability P_s versus $E_s/N_0 = (E_b/N_0)/\log_2 M$ function graph of 2, 4, 8 and 16 phases PSK

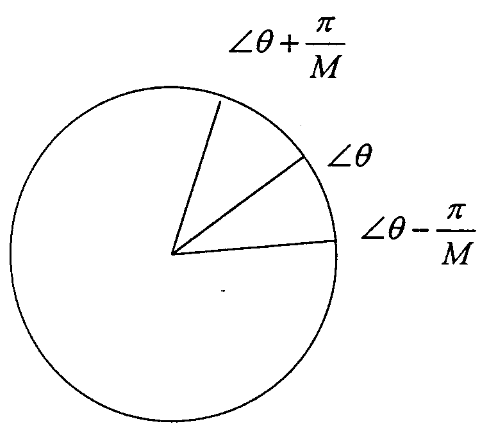

Figure 2. MPSK Coherent Detection Zone

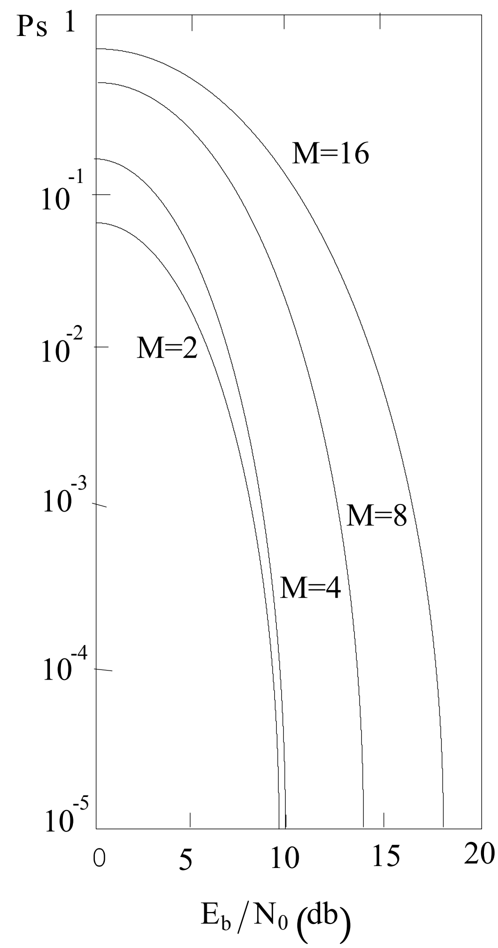

Figure 3. MPSK Symbol Error Probability

From formula (2), (3) and Figure 3., it is shown that if the number of phases increases, performance will decrease, so the scheme of multiple-access with MPSK is suitable for the situation where subscribers (address) are relatively few.

Similarly, according to the same principle, MQAM but not MPSK can also be applied to carry on poin to multi-points communication.

POINT TO MULTIPOINT COMMUNICATION WITH DS/SSMA

A. The Principle of Operation

The system model with DS/SSMA is shown in Figure 5.

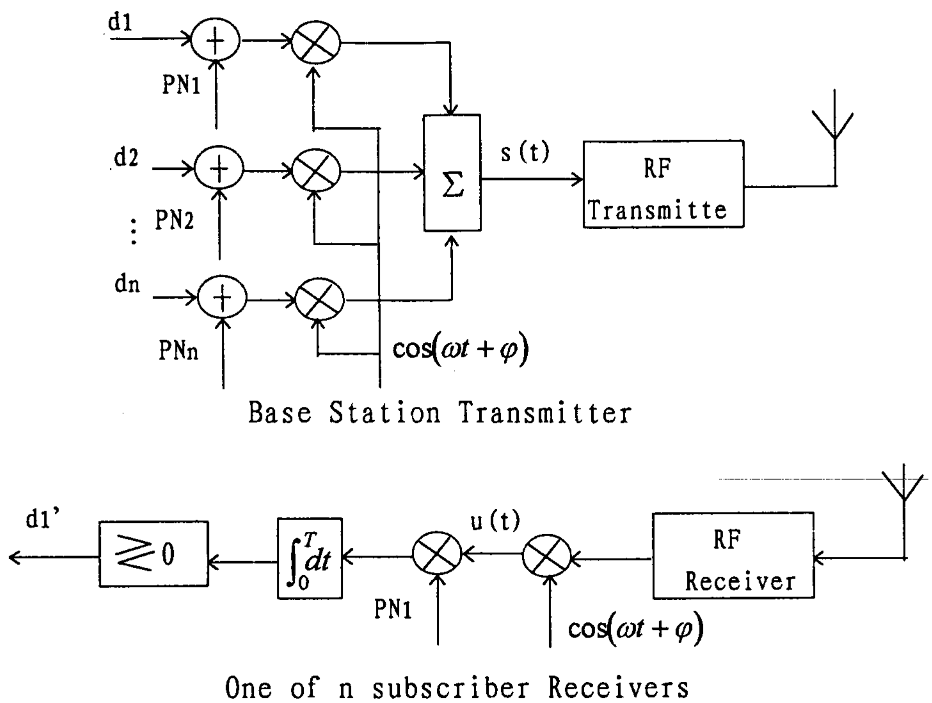

Figure 4. System model with DS/SSMA

At base station, data sequences d1(t),d2(t),...dn(t) of n subscribers, are modulated (spectrum spreaded) by n pseudo-random sequences(m-sequence, balanced Gold sequence and orthogonal pseudo-random sequence) PN1(t), PN2(t),..., PNn(t) to produce n wideband signals d1(t)PN1(t),...,dn(t)PNn(t).

Then these wideband signals are respectively modulated by same carrier $\cos(wt + f)$ (IF signal, such as 10.7MHz), and the n modulated signals are added (an added circuit made up by integrated arithmetic amplifier can finish it) to produce one signal

$$S(t) = \sum_{i=1}^{n} d_i(t)PN_i(t)\cos(wt + f) \qquad (4)$$

which is transmitted by RF transmitter through a certain carrier frequency(channel)to multiple subscribers.

At every subscriber's receive-end, without loss of generality, only subscriber 1 is considered, RF receiver outputs IF signal R(t)=S(t)+n(t) by frequency downconversion, where the n(t) is White Gaussion noise whose average value is “0” and dual-side power spectral density is N0/2. Then the IF signal is demodulated by carrier to produce signal

$$U(t) = [\sum_{i=1}^{n} d(t)_i \, PN_i(t)] + n(t)\cos(wt + f) \tag{5}$$

After the signal u(t) is demodulated(despreaded) by local pseude-radom sequence, we obtain the output

$$\begin{aligned} V_0 &= \int_0^T u(t)PN_1(t)dt = \int_0^T d_1(t)PN_1(t)PN_1(t)dt + \int_0^T d_2(t)PN_2(t)PN_1(t)dt \\ &+\cdots+\int_0^T d_n(t)PN_n(t)PN_1(t)dt + \int_0^T n(t)PN_1(t)\cos(wt+f)dt \\ &= T \cdot d_1(t) + N(t) \end{aligned} \tag{6}$$

where d1(t) is information data modulated with PN1(t) and could be demodulated out correctly. According to the same principle, the other subscriber’s data information can be demodulated out. In short, at every subscriber’s receive-end, using ordinary spread-spectrum receiver without any modification, we can demodulate out the corresponding data information.

B. Performance Analysis

In normal DS/SSMA communication model, RF signal power is P. When transmitting one route data, i.e., only one subscriber’s data, its signal-to-noise ratio and symbol error rate of receiver are respectively as follows [3]

$$(C/N)_0 = 2E_b/N_0 \qquad P_b = Q(\sqrt{2E_b/N_0}) \tag{7}$$

It can be proved that the signal-to-noise ratio and bit error rate of DS/SSMA system with n subscribers are

$$(C/N)_0 \approx \frac{n-1}{3N} + \frac{N_0}{2E_b} \qquad P_b \approx Q(\sqrt{\frac{n-1}{3N} + \frac{N_0}{2E_b}}) \tag{8}$$

where N is the length of PN code. [2]

The bit error rates of different communication model are respectively given in Figure 5,and 6. Figure 5. show the symbol error rates of several communication schemes at different transmission power. The bit error rates are shown in Figure 4. It is derived from Figure 5. and Figure 6 that with few subscribers, i.e., the number of multipoints is few, the performances of the two methods are similar, as the munber of subscribers increases, the performances of MPSK scheme evidently drop. Because it demands higher signal-to-noise ratio, this scheme is not applicable to the radio communication system and mobile communication system with powerful noise.

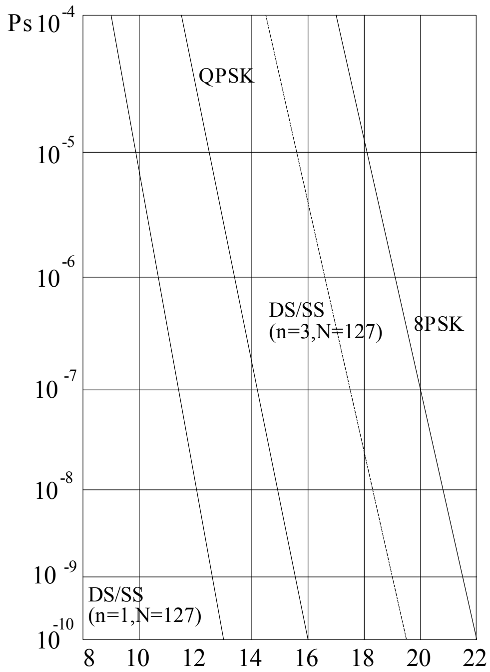

Figure 5. P_s of Different Systems

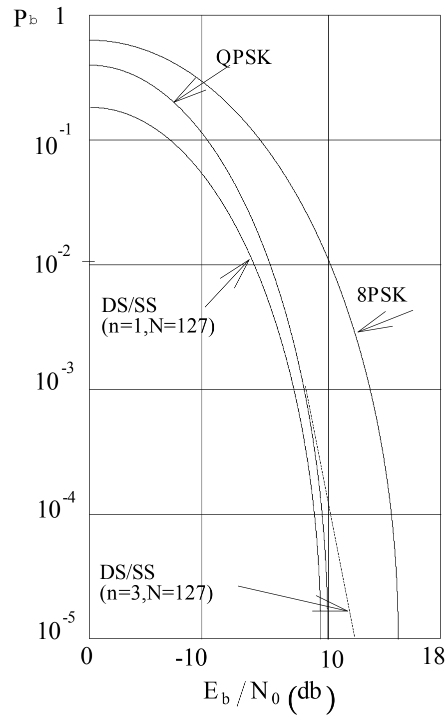

Figure 6 P_b of Different Systems

CONCLUSION

This paper proposes two special communication schemes used in point to multipoint communication system. Both solve the problem of distributing data to multiple subscribers with one transmitter at the same time. The two schemes are both suitable for the case of fewer subscribers and easy to be realized. Especially, the scheme using DS/SSMA can be used more widespreadly and is attractive, for it has characteristic of powerful anti-interference and well secrecy.

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