S-72.227 Digital Communication Systems

Spring 2002 Tutorial#6, 04.03.2002

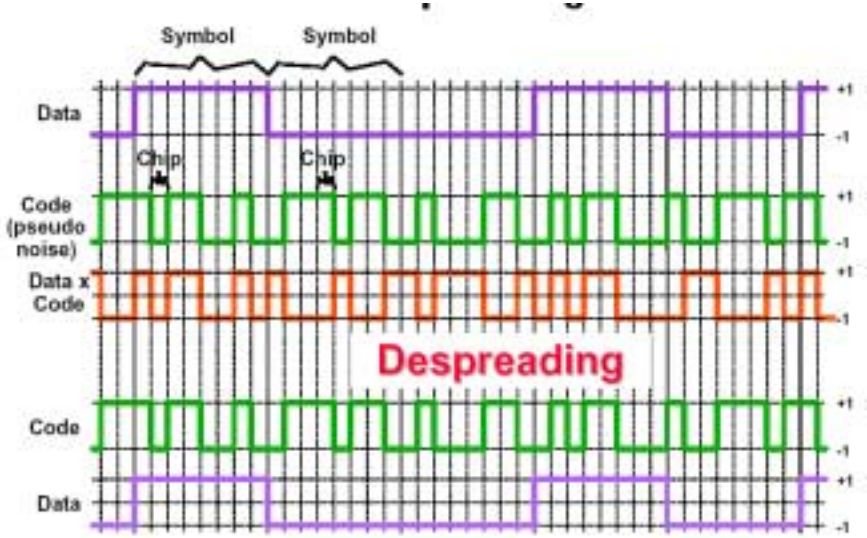
E 6.1

This is not a complte solution, you are encouraged to consult any book about CDMA

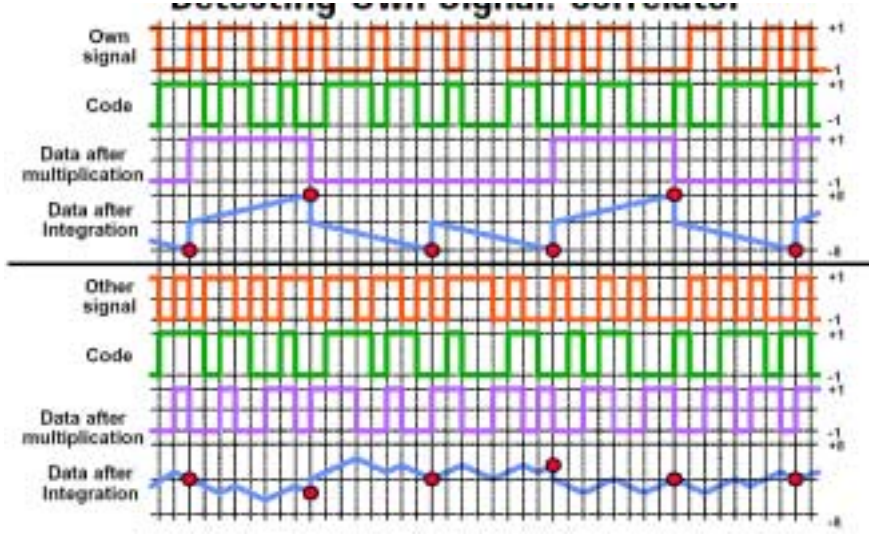
Briefly explain the idea of spreading and despreading in DS-CDMA. How is the desired signal detected correctly using correlation reception? Draw figures to explain the issues. What is processing gain? How does it become an advantage in CDMA receivers?

Answer

Benefits of spreading and despreading in CDMA



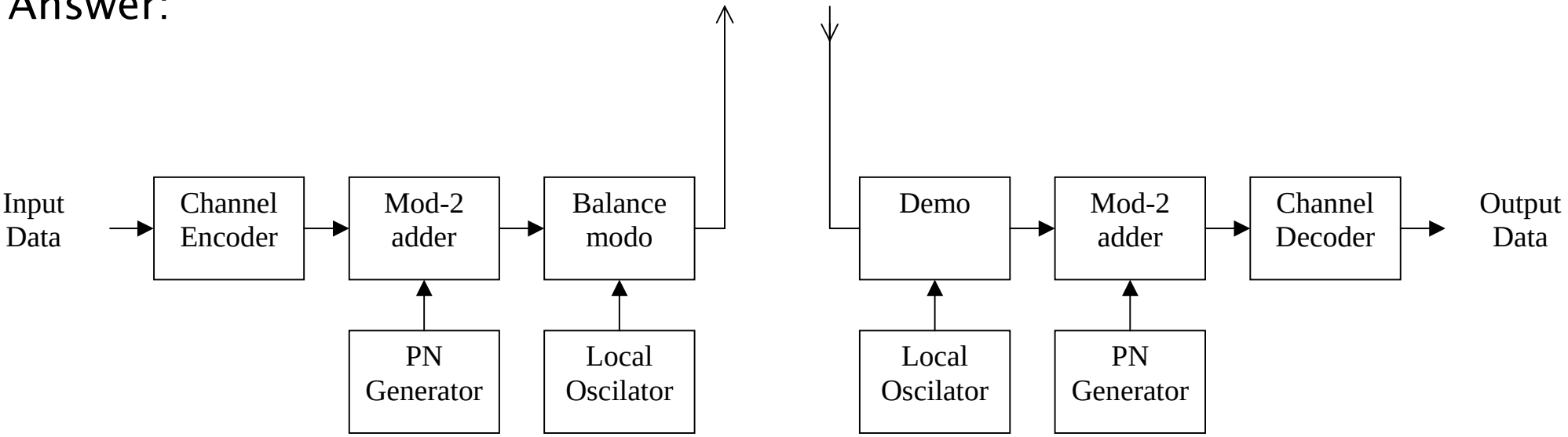
Data after integration in the RAKE receiver



E 6.2

Outline the transmitter and receiver structure for DS-CDMA systems! Explain briefly the functions of different blocks.

Answer:



Direct Sequence Transmitter with BPSK

Direct Sequence Receiver with BPSK

E 6.3

This question is adopted to explain the near-far problem in WCDMA

Investigate the SIR of WCDMA system with two users. The users are at distances $d = [\ \ 20 \quad 55\ \ ]\ m$. Attenuation in the channel is approximated as d^{-atten} where $atten = 4$.

a) calculate the SIR for both users when no power control is applied and transmitted powers are $P_{tr} = [\ 0.1 \quad 0.1\ ]\ W$.

b) what are the transmitted powers when to assume an optimal power control and the SIR target for both users is 10 dB. (the transmitted powers should be in the intervals $-50 \leq P \leq 20\ dBm$.)

Assume that the other user interference is scaled by the spreading gain. The chip rate is 3.84 $\frac{Mchip}{s}$ and bitrate for both users is same 15 $\frac{kbit}{s}$.

Answer:

a) Since we do not have any power control the exercise illustrates the near far problem in CDMA system.

In CDMA the SIR is function of spreading gain $\frac{W}{R}$ and received power and interfering power ratio at receiver. The received power P_r is related to the transmitted power P_{tr} by the propagation loss (in our exercise it is d^{-4}): $P_r = P_{tr} d_1^{-atten}$.

The signal to interference ratio for the first user can be expressed as:

$$SIR_1 = \frac{W}{R_1} \frac{P_{r1}}{P_{r2} + N_0} = \frac{W}{R_1} \frac{P_{tr1} d^{-4}}{P_{tr2} d^{-4} + N_0} \tag{1}$$

W spread signal bandwidth,
R_1 transmitted data rate,
P_{r1}, P_{r2} received powers for the first and second users accordingly,
P_{tr1}, P_{tr2} transmitted powers for the first and second users accordingly,
N_0 noise power.
By inserting into the equation for first user we get the following equation

$$SIR_1 = \frac{3.84 \times 10^6}{15 \times 10^3} \frac{0.1 \times 20^{-4}}{0.1 \times 55^{-4} + N_0} \Rightarrow 52.04 \ dB$$

and for the second user

$$SIR_2 = \frac{3.84 \times 10^6}{15 \times 10^3} \frac{0.1 \times 55^{-4}}{0.1 \times 20^{-4} + N_0} \Rightarrow -3.87 \ dB$$

and above. For example in UMTS the transmitted power in uplink should be between -50 ... 20 dBm.

By transmitting its own signal users generate interference to each other. In order to find the transmitted power with power control we have to solve a system of equations containing both user powers.

From the 1 we can express the transmitted power for both users:

$$P_{tr1} = \frac{R_1}{W} \frac{SIR_{d1} \times \left(P_{tr2} d_2^{-4} + N_0\right)}{d_1^{-4}}$$

$$P_{tr2} = \frac{R_2}{W} \frac{SIR_{d1} \times \left(P_{tr1} d_1^{-4} + N_0\right)}{d_2^{-4}}$$

constrained by

$$-50\ dBm\ \leq P_{tr1}, P_{tr2} \leq 20\ dBm$$

The constraints are due to the limits for possible signal powers.
By solving these equations for our parameters we get

$$\begin{aligned} P_{tr1} &= -50\ dBm \\ P_{tr2} &= -36\ dBm. \end{aligned}$$

And

$$\begin{aligned} CIR_1 &= 38.6\ dB \\ CIR_2 &= 10\ \ dB. \end{aligned}$$

Homework-6 Deadline 08 April 2002 at 10.00

Homework return box is located at Otakaari 5, 2nd floor, near the E-wing. You can also return the answers to the assistant just before the class.

1. Draw RAKE receiver structure and explain the functions of different blocks.
2. Why CDMA systems can use RAKE receiver?
3. What is co-phasing? How is it done in RAKE receiver?

Limit your answer in maximum of three pages.