Universidad de Alcalá

Lesson 6
Bandpass digital transmission

1 Problemas básicos

Este primer bloque de problemas son problemas extraídos de la bibliografía de la asignatura, y consisten en algunos cálculos básicos que es necesario dominar.

Problem 6.1

[Sklar2001] Calculate the expected value of the number of error bits during a day for the coherent BPSK receiver described below, under continuous operation. The data rate is $5000 bits/s$. The input digital signals are $s_1(t) = A \cdot cos(\omega_p t)$ and $s_2(t) = -A \cdot cos(\omega_p t)$, where $A = 1mV$, and the unilateral noise power spectral density is $N_0 = 10^{-11} W/Hz$.

RESULTS FOR PROBLEM

    2338 bits

Problem 6.2

[Sklar2001] A coherent BPSK system operating continuously produces errors at an average rate of 100 errors per day. The data rate is $1000 bits/s$. The unilateral noise power spectral density is $N_0 = 10^{-10} W/Hz$.

   a) If the system is ergodic, which is the average error probability?

   b) If the average received power is adjusted to 10^{-6} W, would this value be enough to keep the error probability calculated in a)?

RESULTS FOR PROBLEM

   a) $1.16 \cdot 10^{-6}$

   b) No

Problem 6.3

[Haykin2001] The signal component of a coherent PSK system is defined by the expression

$$s(t) = A_c k sen(\omega_p t) \pm A_c \sqrt{1 - k^2} cos(\omega_p t)$$

where $0 \leq t < T_b$, and the plus sign corresponds to the 1 symbol, and the minus sign corresponds to the 0 one. The first term on the right hand side of the equation represents a carrier component, included to improve the synchronization between transmitter and receiver. Solve this:

a) Plot the constellation of the signals described; what can be said about this diagram?

b) Show that, in presence of zero-mean additive white Gaussian noise with power spectral density $N_0/2$, the average error probability is

$$P_e = Q\left(\sqrt{\frac{2E_b}{N_0}(1-k^2)}\right)$$

with $E_b = \frac{1}{2}A_c^2 T_b$

c) Assume that 10% of the transmitted power is located in the carrier component. Determine the value of E_b/N_0 required to obtain an error probability of 10^{-4}.

d) Compare this E_b/N_0 value with the one required in a conventional PSK system with the same error probability.

RESULTS FOR PROBLEM

a) PSK constellation

b) Demonstration

c) $\frac{E_b}{N_0} = 8.02$

d) $\frac{E_b}{N_0} = 7.22$

Problem 6.4

[Haykin2001] We want to compare two data transmission bandpass systems. One of them employs 16-PSK, the other, 16-QAM. Both systems have to provide an average symbol error probability of 10^{-3}. Compare the signal-to-noise requirements of said systems.

RESULTS FOR PROBLEM

$\Delta\left(\frac{E_s}{N_0}\right) = 3.68dB$

Problem 6.5

[Sklar2001] If the performance criterion of a system is the bit error probability, which one of the following modulation schemes would be chosen to operate in an AWGN channel? Show the calculations.

a) Coherent binary orthogonal FSK with $E_b/N_0 = 13dB$.

b) Coherent binary PSK with $E_b/N_0 = 8dB$.

RESULTS FOR PROBLEM

Coherent binary orthogonal FSK

2 Problemas adicionales

Estos problemas son algo más elaborados que los anteriores, en muchos casos extraídos de exámenes antiguos.

References

[Haykin2001] Simon Haykin. Communication Systems, 4th Ed. John Wiley and Sons, 2001.

[Sklar2001] Bernard Sklar. Digital Communications, 2nd Ed. Prentice Hall, 2001.