SNS COLLEGE OF TECHNOLOGY

Coimbatore – 35

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

19ECT311 / Wireless Communication

IV ECE/ VII SEMESTER

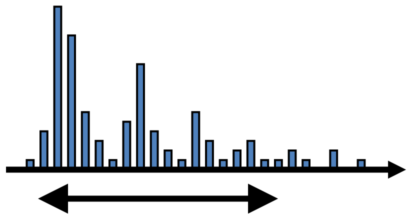
Unit IV - **MULTIPATH MITIGATION TECHNIQUES**

Topic : Error probability in fading channels With diversity reception

Introduction

Narrowband system:

Flat fading channel, single-tap channel model, performance enhancement through diversity



$$T >> T_m$$

$$T \propto W$$

↑ System bandwidth

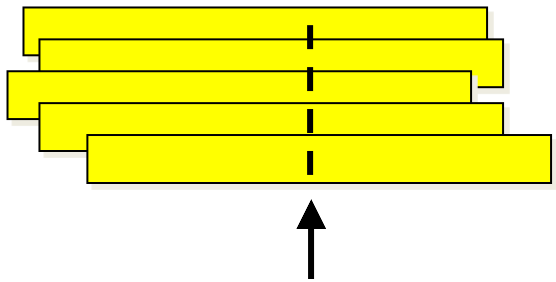
T_m = delay spread of multipath channel

bit or symbol

← T = bit or symbol duration →

Introduction

Adjacent symbols (bits) do not affect the decision process (there is no intersymbol interference).

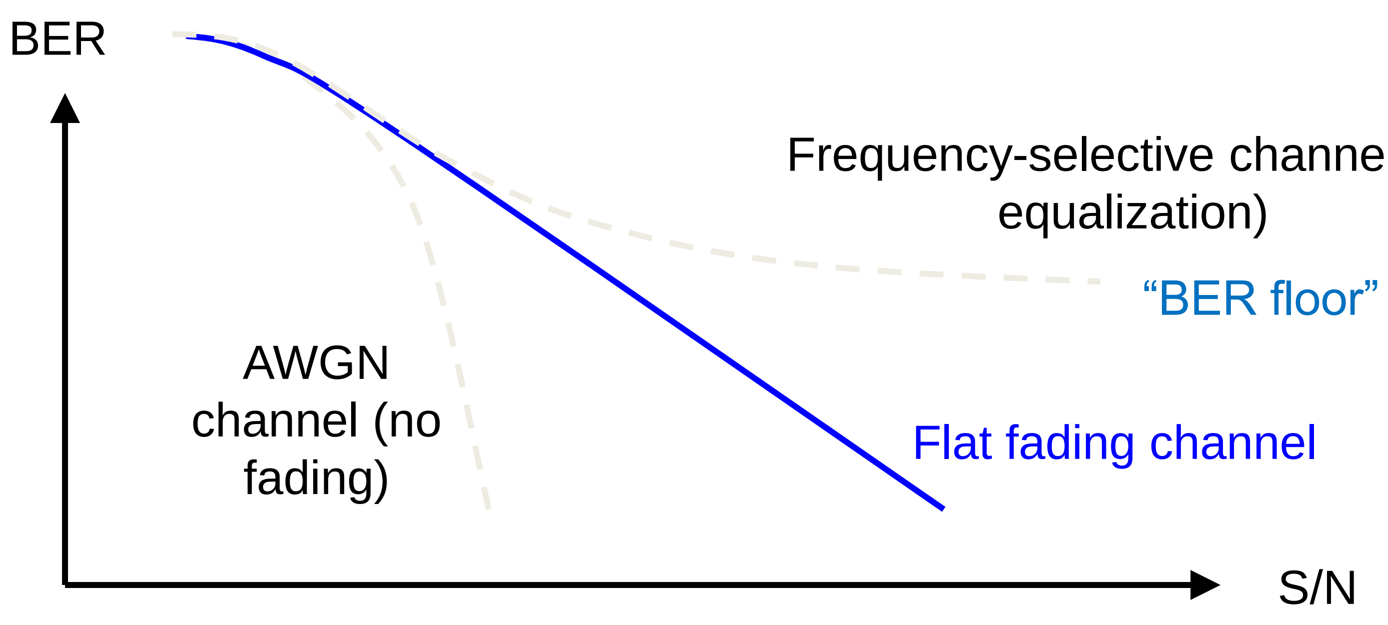


Received replicas of same symbol overlap in multipath channel

No intersymbol interference at decision time instant

However: Fading (destructive interference) is still possible

Narrowband system: BER performance



BER vs. SNR in a flat fading channel

In a flat fading channel (or narrowband system), the CIR (channel impulse response) reduces to a single impulse scaled by a time-varying complex coefficient.

The received (equivalent lowpass) signal is of the form

$$r(t) = a(t)e^{j\phi(t)}s(t) + n(t)$$

We assume that the phase changes "slowly" and can be perfectly tracked

=> important for coherent detection

Activity

- Imagine folding a paper in half once
- Then take the result and fold it in half again; and so on
- How many times can you do that?

BER vs. SNR in a flat fading channel

We assume:

The time-variant complex channel coefficient changes slowly (=> constant during a symbol interval)

The channel coefficient magnitude (= attenuation factor) a is a Rayleigh distributed random variable

Coherent detection of a binary PSK signal (assuming ideal phase synchronization)

Let us define instantaneous SNR and average SNR:

$$\gamma = a^2 E_b / N_0 \qquad \gamma_0 = E\left\{a^2\right\} \cdot E_b / N_0$$

BER vs. SNR in a flat fading channel

Since

$$p(a) = \frac{2a}{E\{a^2\}} e^{-a^2/E\{a^2\}} \qquad a \geq 0,$$

Rayleigh distribution

using

$$p(\gamma) = \frac{p(a)}{|d\gamma/da|}$$

Exponential distribution

we get

$$p(\gamma) = \frac{1}{\gamma_0} e^{-\gamma/\gamma_0} \qquad \gamma \geq 0.$$

BER vs. SNR in a flat fading channel

The average bit error probability is

$$P_e = \int_0^\infty P_e(\gamma)\, p(\gamma)\, d\gamma$$

Important formula for obtaining statistical average

where the bit error probability for a certain value of a is

$$P_e(\gamma) = Q\left(\sqrt{2a^2 E_b / N_0}\right) = Q\left(\sqrt{2\gamma}\right).$$

2-PSK

We thus get

$$P_e = \int_0^\infty Q\left(\sqrt{2\gamma}\right)\frac{1}{\gamma_0} e^{-\gamma/\gamma_0} d\gamma = \frac{1}{2}\left(1 - \sqrt{\frac{\gamma_0}{1+\gamma_0}}\right).$$

BER vs. SNR

Approximation for large values of average SNR is obtained in the following way. First, we write

$$P_e = \frac{1}{2}\left(1 - \sqrt{\frac{\gamma_0}{1+\gamma_0}}\right) = \frac{1}{2}\left(1 - \sqrt{1 + \frac{-1}{1+\gamma_0}}\right)$$

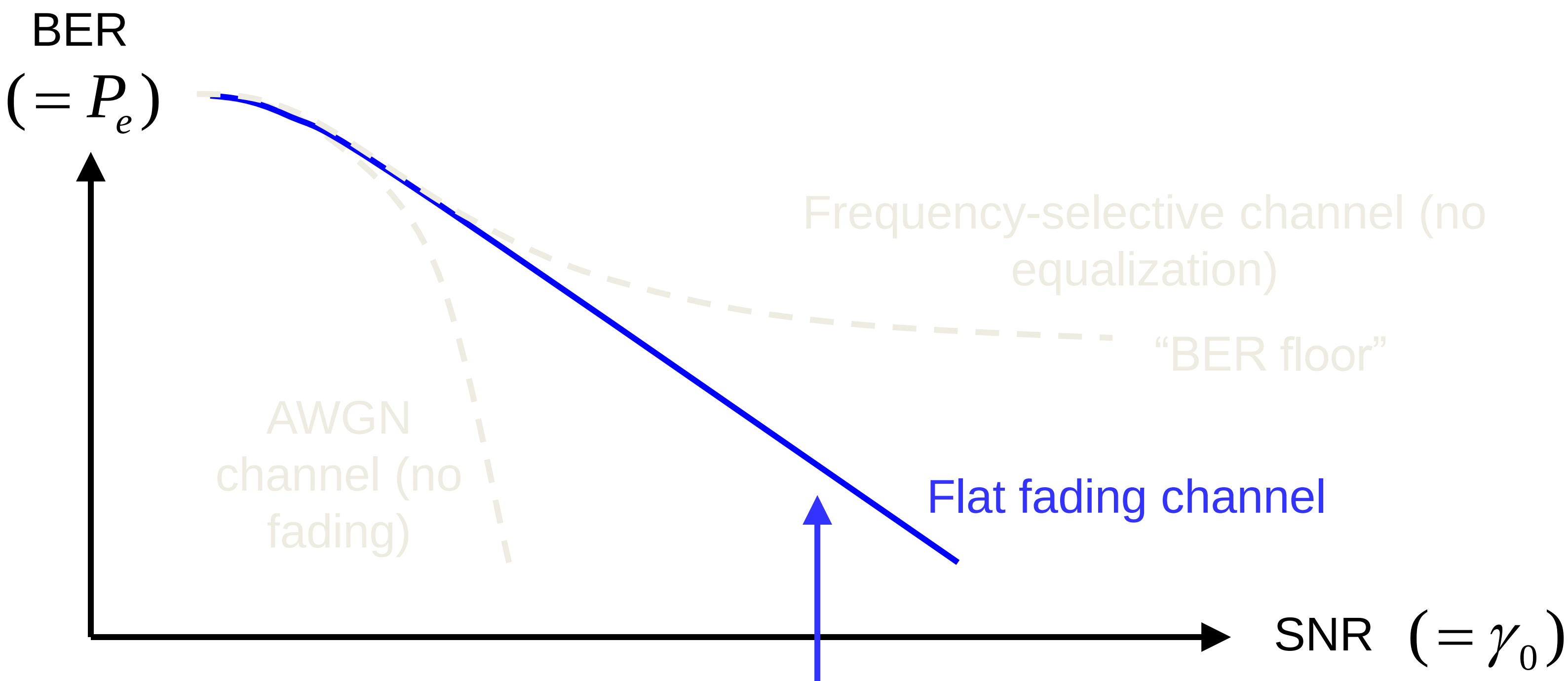
Then, we use

$$\sqrt{1+x} = 1 + x/2 + \text{K}$$

which leads to

$$P_e \approx 1/4\gamma_0$$ for large γ_0.

BER vs. SNR



$P_e \approx 1/4\gamma_0$ means a straight line in log/log scale

Summary

Modulation	$P_e(\gamma)$	P_e	P_e (for large γ_0)
2-PSK	$Q\left(\sqrt{2\gamma}\right)$	$\frac{1}{2}\left(1-\sqrt{\frac{\gamma_0}{1+\gamma_0}}\right)$	$1/4\gamma_0$
DPSK	$e^{-\gamma}/2$	$1/(2\gamma_0+2)$	$1/2\gamma_0$
2-FSK (coh.)	$Q\left(\sqrt{\gamma}\right)$	$\frac{1}{2}\left(1-\sqrt{\frac{\gamma_0}{2+\gamma_0}}\right)$	$1/2\gamma_0$
2-FSK (non-c.)	$e^{-\gamma/2}/2$	$1/(\gamma_0+2)$	$1/\gamma_0$

Assessment

- **What are the modes of adaptive equalizer?**
  a) Training mode
  b) Tracking mode
  c) Both of the mentioned
  d) None of the mentioned

- **The ISI and adjacent channel interference is removed by**
  a) Cancelling filter
  b) Port processing equalizer
  c) Both of the mentioned
  d) None of the mentioned

THANK YOU