



SNS COLLEGE OF TECHNOLOGY

Coimbatore – 35



An Autonomous Institution

Accredited by NBA – AICTE and Accredited by NAAC – UGC with ‘A++’ Grade

Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

16EC401 / Wireless Communication

IV ECE/ VII SEMESTER

Unit IV - **MULTIPATH MITIGATION TECHNIQUES**

Topic : Error probability in fading channels With diversity reception

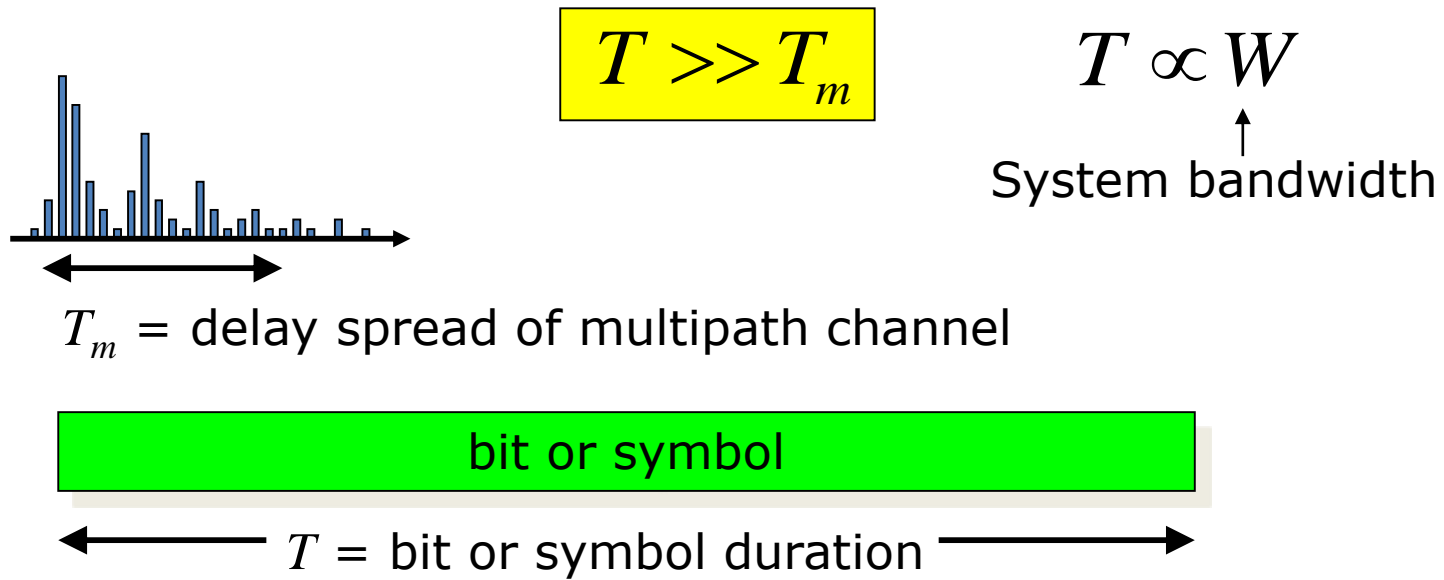


Introduction



Narrowband system:

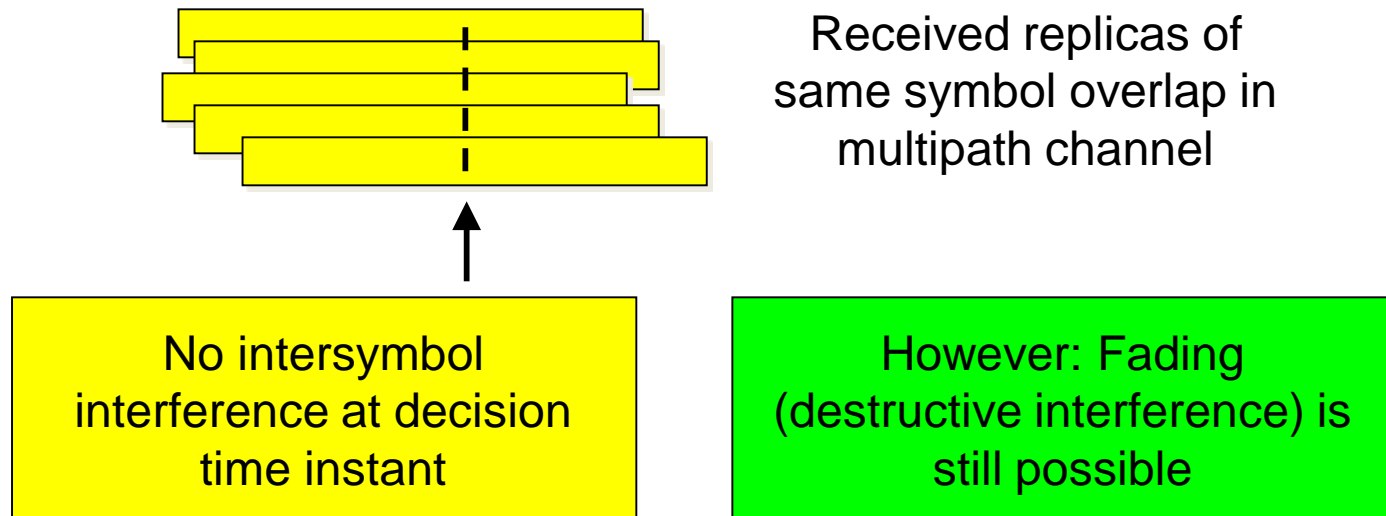
Flat fading channel, single-tap channel model, performance enhancement through diversity





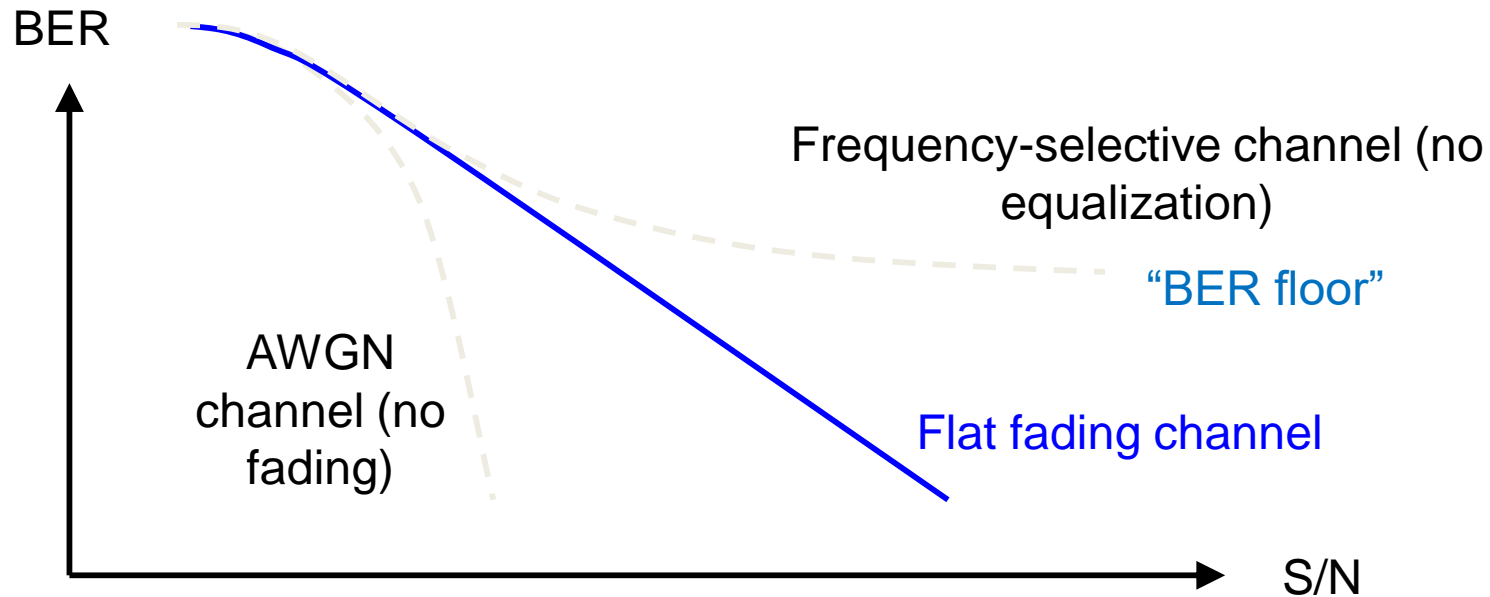
Introduction

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





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 (\Rightarrow 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**:

$$\gamma = a^2 E_b / N_0 \quad \gamma_0 = E \{ a^2 \} \cdot E_b / N_0$$



BER vs. SNR in a flat fading channel

Since

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

using

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

we get

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

Rayleigh distribution

Exponential distribution



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

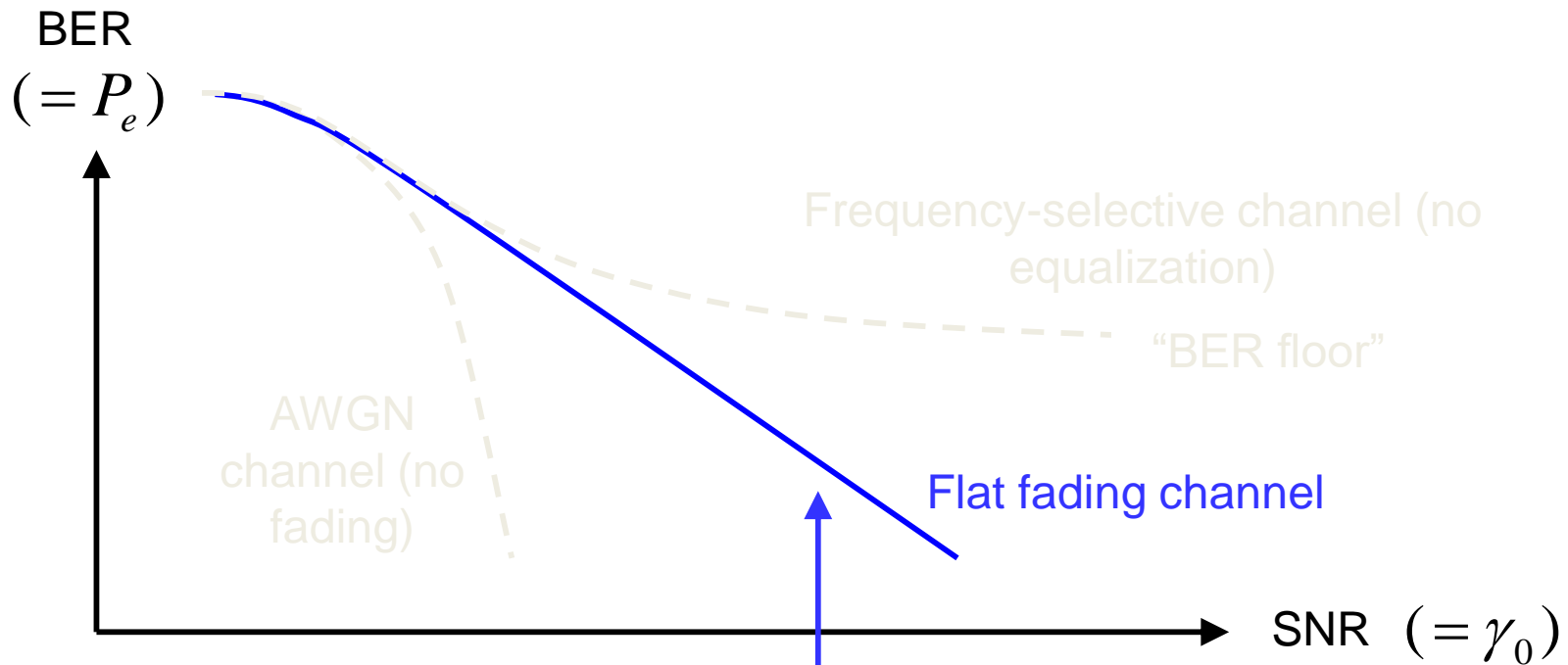
$$\sqrt{1 + x} = 1 + x/2 + \dots$$

which leads to

$$P_e \approx 1/4\gamma_0 \quad \text{for large } \gamma_0.$$



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	$Q(\sqrt{2\gamma})$	$\frac{1}{2}\left(1 - \sqrt{\frac{\gamma_0}{1+\gamma_0}}\right)$	$1/4\gamma_0$
DPSK	$e^{-\gamma}/2$	$1/(2\gamma_0 + 2)$	$1/2\gamma_0$
2-FSK (coh.)	$Q(\sqrt{\gamma})$	$\frac{1}{2}\left(1 - \sqrt{\frac{\gamma_0}{2+\gamma_0}}\right)$	$1/2\gamma_0$
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