Effects of fading on the error performance of BPSK modulation

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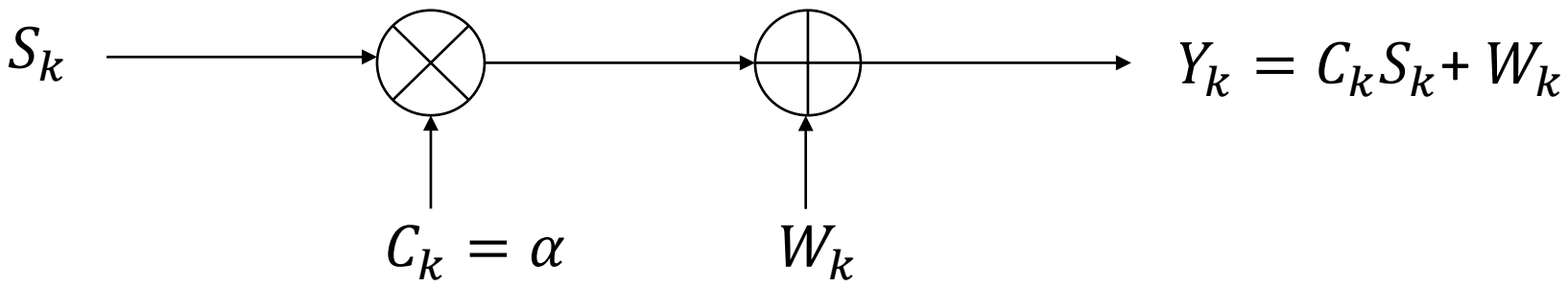
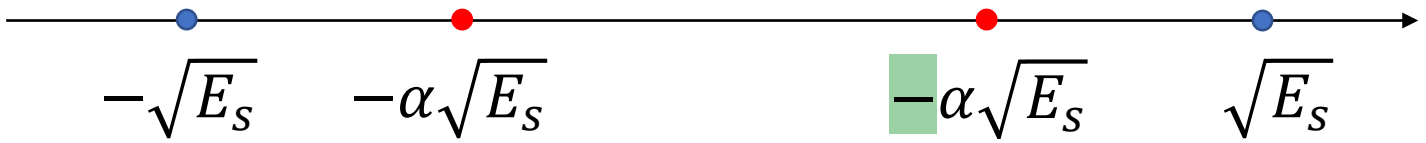
Flat fading (known phase):



Effect on constellation:



Signal energy is random:

$$\Gamma_0 = \frac{E_s}{N_0} A^2,$$

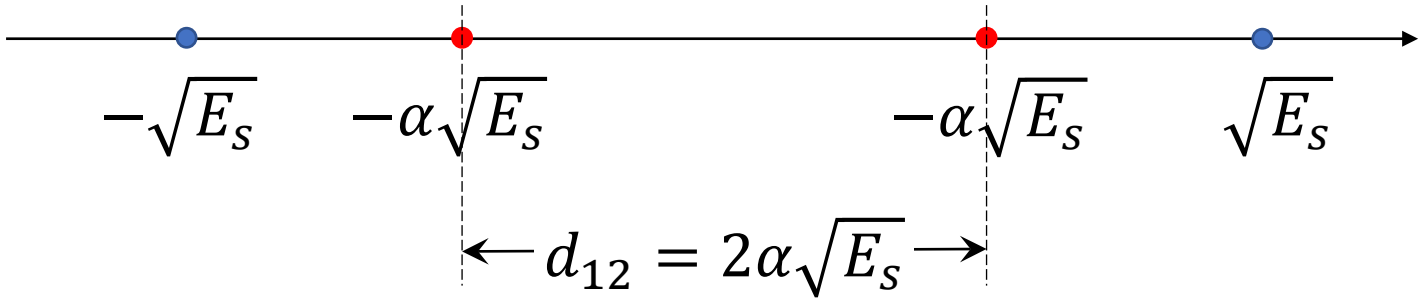
Exponential

$$\gamma_0 = E\{\Gamma_0\} = \frac{E_s}{N_0},$$

if $A = \sqrt{X^2 + Y^2}$, X, Y: Gaussian $N(0;1/2)$

A: Rayleigh, A^2: Exponential

Probability of error is random:



$$P[e|A=\alpha] = Q\left(\sqrt{\alpha^2\, 2\frac{E_s}{N_0}}\right)$$

Average probability of error:

$$P_b = E\{P[e|A]\} = E\left\{Q\left(\sqrt{A^2\, 2\frac{E_s}{N_0}}\right)\right\} = E\left\{Q\left(\sqrt{A^2\, 2\gamma_0}\right)\right\} = \frac{1}{2}\left(1 - \sqrt{\frac{\gamma_0}{1+\gamma_0}}\right)$$

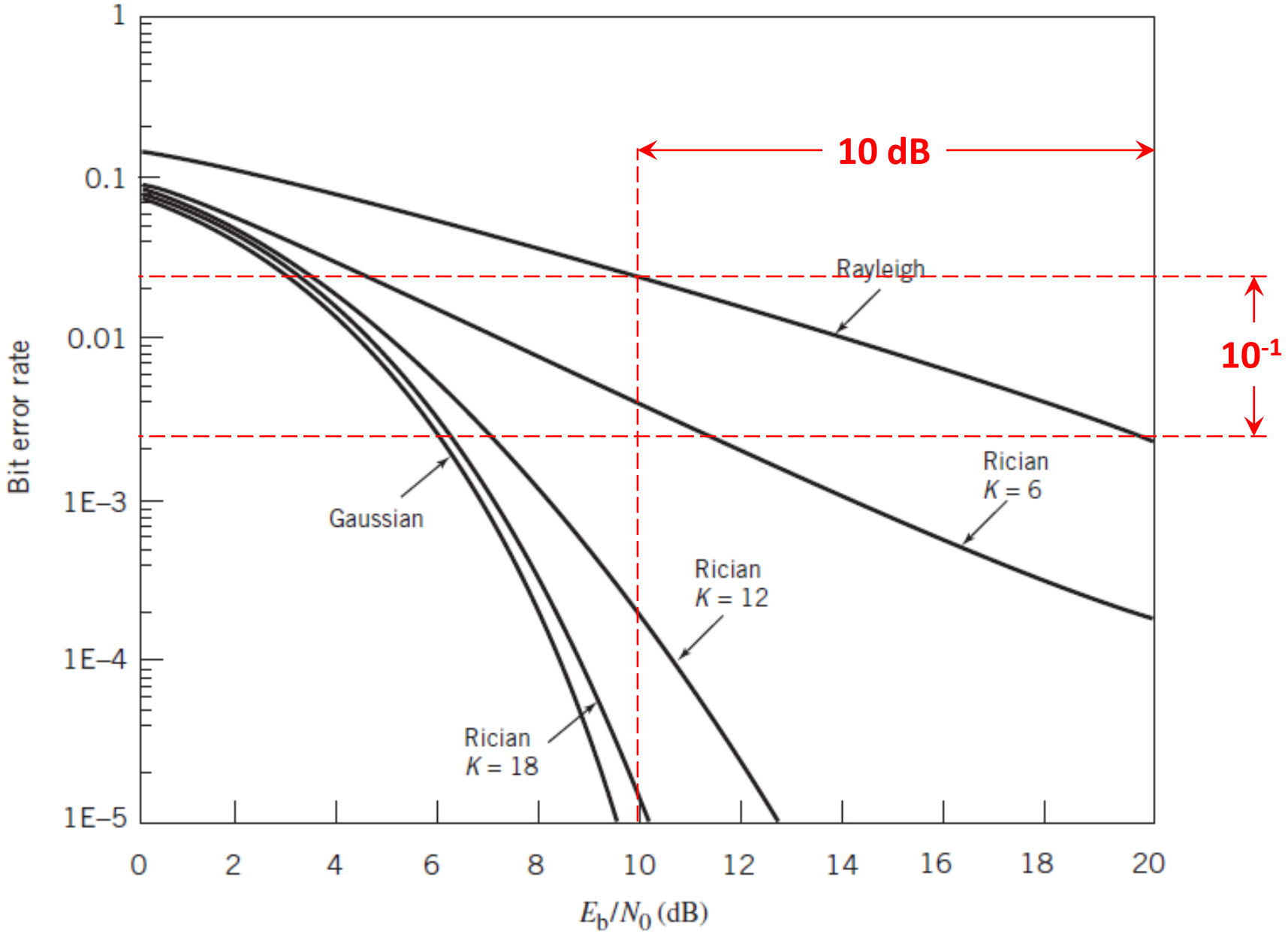


Figure 9.17 Comparison of performance of coherently detected binary PSK over different fading channels.

Diversity order

Define the “slope” of the linear BER characteristic as follows:

$$S = \frac{10 \log_{10}\left(P_{b,2} / P_{b,1}\right)}{\left[E_s/N_0\right]_2 (dB) - \left[E_s/N_0\right]_2 (dB)}$$

For BPSK (or any other modulation format, why?) we have $S = -1$

The negative of the slope is known as the **diversity order** $D = -S$ of a (mobile) wireless communication system

All digital modulation formats offer a diversity order equal to one