POLYTECHNIC UNIVERSITY
EL501: WIRELESS PERSONAL COMMUNICATIONS

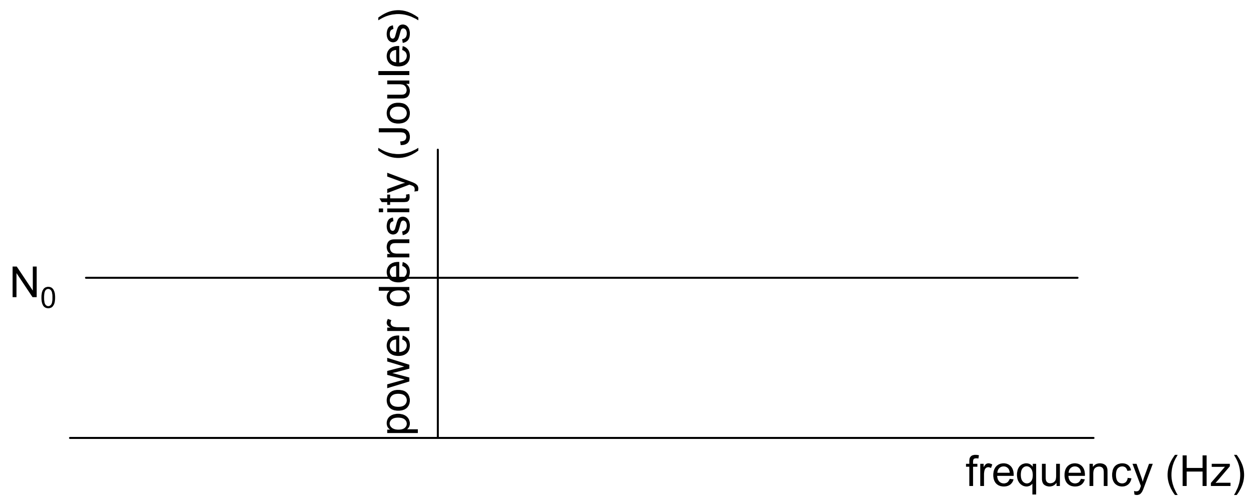
CAPACITY OF PRACTICAL CDMA SYSTEMS

Digital communication in white gaussian noise

ERROR RATE DEPENDS ON E_b/N_0

E_b JOULES IS THE ENERGY PER BIT

N_0 WATTS/Hz = N_0 JOULES IS THE POWER SPECTRAL DENSITY OF WHITE NOISE



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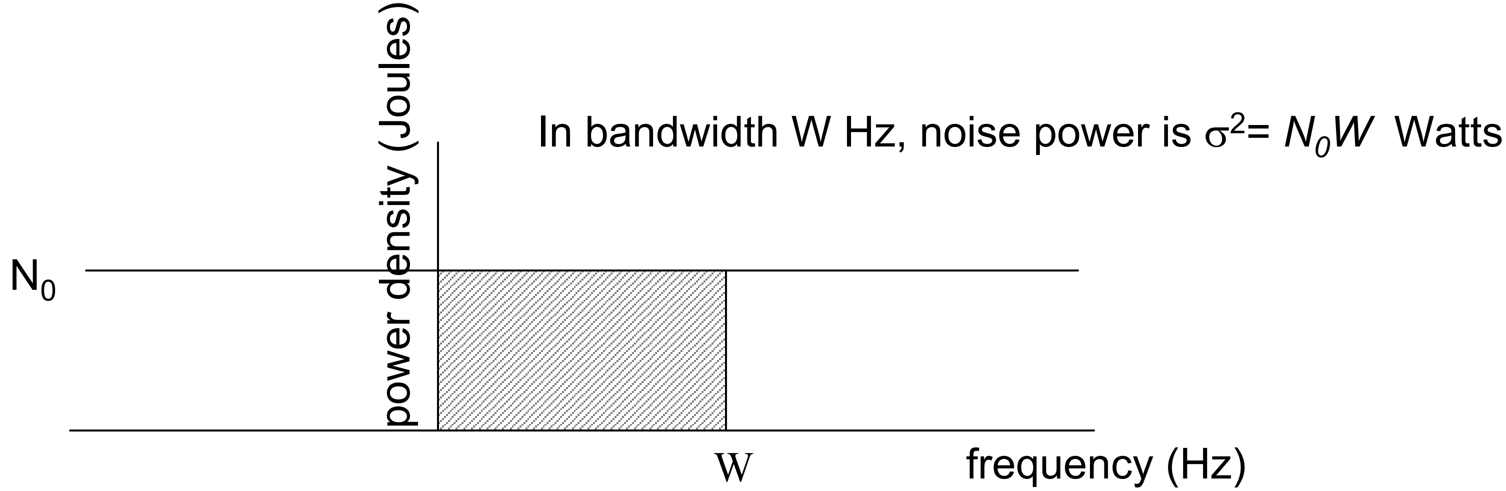
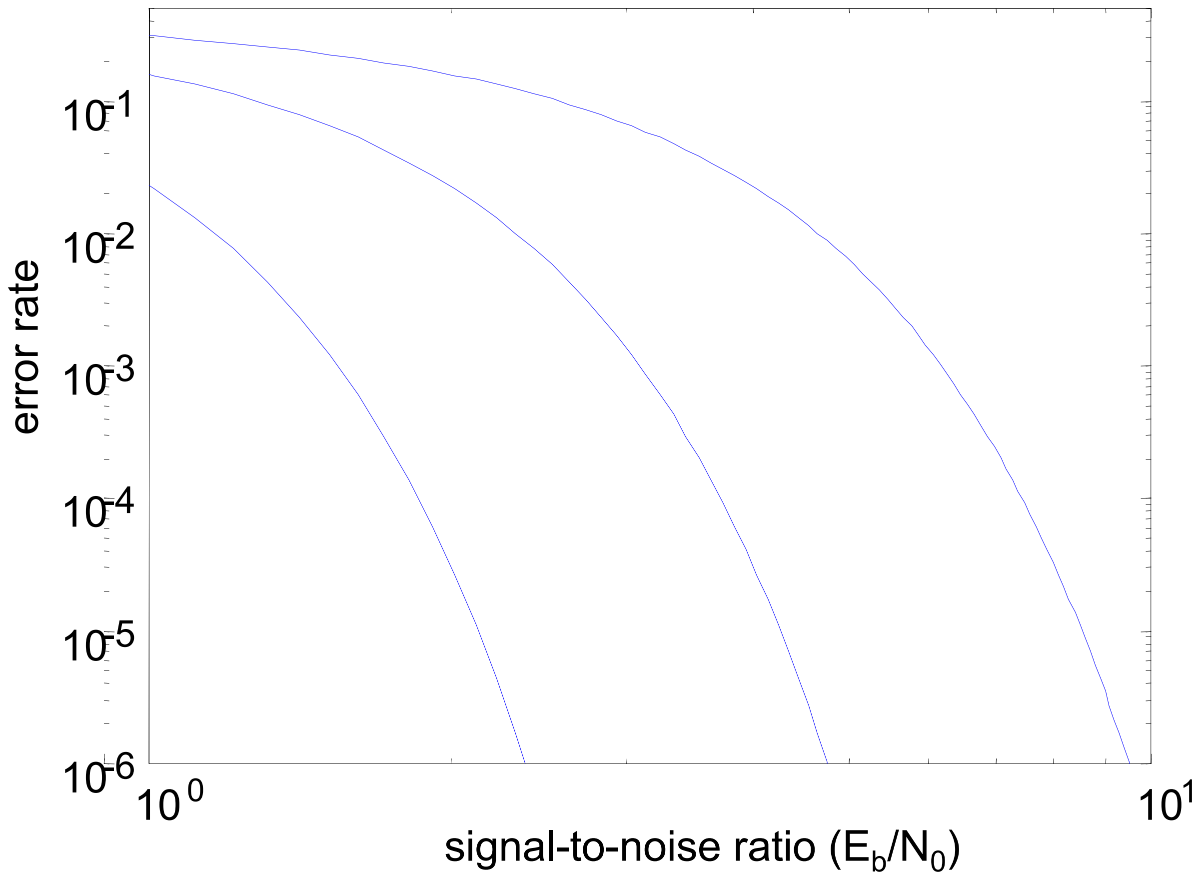


Examples of error rate curves



SNR analysis

$$E_b = \int_0^T s^2(t)dt$$ Joules

If *s(t)* is a constant envelope signal with received power level P_r Watts, bit rate= R b/s, bit duration $=T=1/R$ seconds

$E_b=P_rT=P_r/R$ Joules,

$\sigma^2 = N_0W$ Watts

$N_0=\sigma^2/W$ Joules

$$E_b / N_0 = \frac{W}{R}\frac{P_r}{\sigma^2}$$

Extend the analysis to CDMA

K SIMULTANEOUS TRANSMISSIONS

K-1 TRANSMISSIONS CAUSE INTERFERENCE *I Watts*

NOISE + INTERFERENCE POWER IS $\sigma^2 + I$ *Watts*

$$E_b / N_0 = \frac{W}{R} \frac{P_r}{\sigma^2 + I}$$

IF ALL *K* SIGNALS ARRIVE WITH POWER P_r *Watts*, THEN

$I = (K-1)P_r$ *Watts*

CDMA capacity

$$E_b / N_0 = \frac{W}{R} \frac{P_r}{\sigma^2 + (K-1)P_r}$$

$$= \frac{W}{R} \frac{1}{(K-1) + \sigma^2 / P_r}$$

IF WE REQUIRE $E_b/N_0 \geq (E_b/N_0)_{req}$, THEN

$$K \leq \frac{W}{R} \frac{1}{(E_b / N_0)_{req}} + 1 - \frac{\sigma^2}{P_r}$$

CDMA capacity

$$K \le \frac{W}{R}\frac{1}{(E_b/N_0)_{req}} + 1$$

INTERFERENCE LIMITED
$\sigma^2/P_r \approx 0$

$$K \le \frac{W}{R}\frac{1}{(E_b/N_0)_{req}}$$

NOISE POWER & SIGNAL POWER APPROXIMATELY THE SAME
$\sigma^2 \approx P_r$

$$K \le \frac{G}{(E_b/N_0)_{req}}$$

MODEM HAS 1 b/s/Hz, THEN
$W=R_c$ CHIPS PER SECOND
$W/R=R_C/R=G$, PROCESSING GAIN

Other properties of practical CDMA systems

•speech activity detection	increase by F_{speech}
•directional antennas	increase by $F_{sectors}$
•interference from other cells	decrease by F_{cells}
•unequal received signal powers	decrease by F_{power}

$$C = \frac{W}{R} \frac{1}{(E_b / N_0)_{req}} \frac{F_{sectors} F_{speech}}{F_{power} F_{cells}}$$

IS-95 CDMA

- $W/R = 1.2288/9600 = 128$
- $4\ (6\ dB) < E_b/N_0 < 5\ \ (7\ dB)$
- $2 < F_{speech} < 3$
- $F_{sectors} \approx 2.4$
- $F_{cells} \approx 1.6$
- $1.05 < F_{power} < 3.3$

23 < conversations/base station < 137