

Example: using the high SNR approximation, find the BER for $L = 2$ antennas at $SNR_{dB} = 20 \text{ dB}$.

$$SNR_{dB} = 20 \text{ dB}$$
$$\Rightarrow 10 \log_{10} SNR = 20$$

$$\Rightarrow \log_{10} \text{SNR} = 2$$

$$\Rightarrow \text{SNR} = 10^2 = 100.$$

Approx BER with L antennas,

$$= {}^{2L-1}C_L \left(\frac{1}{2 \text{SNR}} \right)^L$$

$$L = 2$$

$$\text{BER} = {}^3C_2 \cdot \left(\frac{1}{2 \text{SNR}} \right)^2 = \frac{3}{4} \frac{1}{\text{SNR}^2}$$

$$BER = \frac{3}{4} \cdot \frac{1}{SNR^2}$$

↓

$$SNR = 100$$

$$BER = \frac{3}{4} \cdot \frac{1}{100^2}$$

$$= 0.75 \times 10^{-4}$$

$$= 7.5 \times 10^{-5}$$

very close to exact value
 $= 7.2564 \times 10^{-5}$

Example: Using formula for approximate BER, calculate SNR required to achieve BER $= 10^{-6}$ in a wireless system with $L = 2$ antennas.

For $L = 2$

$$\text{BER} = \frac{3}{4} \cdot \frac{1}{\text{SNR}^2}$$

$$10^{-6} = \frac{3}{4} \cdot \frac{1}{\text{SNR}^2}$$

$$\text{SNR}^2 = \frac{3}{4} \cdot 10^6$$

$$\text{SNR} = \sqrt{0.75 \times 10^6}$$
$$= 866.0254$$

$$10\log_{10} \text{SNR} = 10\log_{10} 866.0254$$

$$= 29.37 \text{ dB}$$

Required for $\text{BER} = 10^{-6}$
with $L = 2$ antennas.

Recall for an AWGN or
wireline system for
 $BER = 10^{-6}$, SNR is

$$SNR = 14.19 \text{ dB}$$

↓
wireline
AWGN

For a wireless system with
 $L = 1$ antenna, across
Rayleigh Fading channel, for
 $BER = 10^{-6}$, SNR is

$$SNR = 56.98 \text{ dB} \\ \approx 57 \text{ dB}$$

When number of antennas
increases from $L=1$ to $L=2$

SNR required decreases from

57 dB to 29.37 dB

For same noise power,
required transmit power P
decreased by.

$$57 - 29.37 = 27.63 \text{ dB}$$

Increasing antennas leads
to a significant decrease
in BER.

→ This is the advantage
of DIVERSITY.

Diversity is used in
several 3G/4G systems
such as,

WCDMA }
HSDPA } 3G

LTE }
WiMAX } 4G