Lab Handout # 3
BER Performance over Multiple Receiving Antennas

Design LAB II(Software)

Instructor: D. RAWAL, N. SHARMA
Dept. of ECE, The LNMIIT, Jaipur

Time : 3:00 Hour Maximum Marks : 10

Instructions and information for students

- This Lab Handout consists of 2 pages. Please check that you have a complete copy.
- Simulate in matlab or any other Software.

Objective:

1) Analyze and Simulate BER performance of BPSK/QPSK signal over Multiple receiving antenna system.

Itroduction:

1) **BER performance over Wireless channel using Multiple receiving antenna.**
   a) A BPSK modulated signal with power P is transmitted over wireless channel accompanied by AWGN noise. The user equipment is equipped with multiple receiving antennas let's say L (Here L =2). The received signal at respective antenna is given by

$$Y_1 = \sqrt{P} \cdot h_1 \cdot X + n_1$$
$$Y_2 = \sqrt{P} \cdot h_2 \cdot X + n_2$$

   where X is BPSK signal and n_1 and n_2 are gaussian noise $\mathbf{N}(\mu, \sigma^2)$.

   b) The BER performance expression(Asymptotic or tangential) of multiple receiving antenna system for BPSK transmitted signal over Wireless channel is given by

$$\binom{2L-1}{L}\left(\frac{1}{2SNR}\right)^L$$

   Where SNR_{linear} is signal to noise ration in linear scale.

1) **Simulating Multiple Rx. antenna system**
   a) Generate a random binary sequence of 10000 values. Lets call it 'X' sequence.
   b) Transmit the above sequence over wireless channel links, which are reperesented as an attenuation/amplification factors h_1, h_2.
   c) Generate Gaussian noise(randn function) and vary the snr(signal to noise ratio) from 0 to 24 in step of 4 dB (or noise variance from 1 to 0.001), lets call it n_1 and n_2 noise sequences. Use

$$SNR_{dB} = 10 \cdot log10(SNR_{linear})$$

   d) The received signal at user equipment (UE) is given by (for ease of understanding let's take $P = 1$)

$$Y_1 = h_1 \cdot X + n_1$$
$$Y_2 = h_2 \cdot X + n_2$$

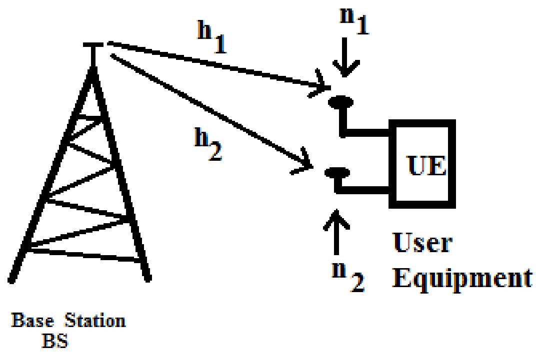

Fig. 1. Signal Reception using multiple Receive antennas

Which can be represented in vecor form as

$$\bar{Y} = \bar{h}X + \bar{n}$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} h_1 \\ h_2 \end{bmatrix} X + \begin{bmatrix} n_1 \\ n_2 \end{bmatrix}$$

e) At the receiver, the signal can be decoded as
   - Multiply the received signal by a vector$[\frac{h_1^*}{|\bar{h}|^2}, \frac{h_2^*}{|\bar{h}|^2}]$ and divide it by norm $|h|^2$, call it Dec_1.

$$\begin{bmatrix} \frac{h_1^*}{|\bar{h}|^2} & , & \frac{h_2^*}{|\bar{h}|^2} \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} \frac{h_1^*}{|\bar{h}|^2} & , & \frac{h_2^*}{|\bar{h}|^2} \end{bmatrix} \begin{bmatrix} h_1 \\ h_2 \end{bmatrix} X + \begin{bmatrix} \frac{h_1^*}{|\bar{h}|^2} & , & \frac{h_2^*}{|\bar{h}|^2} \end{bmatrix} \begin{bmatrix} n_1 \\ n_2 \end{bmatrix}$$

$$Dec_1 = X + \frac{h_1^* \cdot n_1 + h_2^* \cdot n_2}{|h|^2}$$

   - Apply thresholding(compare greaterthan/less than zero) on Dec_1 and Generate $\hat{X}$.

f) Find out the total error 'e' between input 'X' and recovered sequence '$\hat{X}$'.
g) Plot your conclusion.
h) plot theroretical expression curve and verify.

2) **BER of QPSK Over Multiple receiving antennna system**
   a) Repeat all the above steps for QPSK signal.
3) **Observations and Results**.
   a) Plot BER Vs SNR for BPSK over $L = 2$ receiving antenna system.(m-file) [2]
   b) Make a generalized code for any number of receiving antenna. [2]
   c) Match tangential theoretical expression with above BER result. [2]
   d) Plot BER Vs SNR for QPSK over Wireless Channel(m-file). [2]
   e) Make a generalised simulink model of the above. [2]

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