Simulation assignment 3

Debarnab Mitra
140070037

1. No diversity case

- 10000 random symbols X = (I + jQ) where I , Q take the values 1 or -1 with equal probability are generated. Each complex symbol is QPSK modulated with a carrier frequency of 8000MHz by multiplying X with samples of exp(j2pifct) with a sampling frequency of 2000*10^6 samples per sec with 2000 samples (corresponding to the symbol duration of 1us). (and then taking only the real part.)
- These samples of QPSK modulated symbols are transmitted through the channel where it gets attenuated by the path loss PL and a complex fading coefficient h.
- The received samples for symbol have different noise added. The samples are multiplied by h* (conjugate of h) which is a coherent detection, and we write y as

  y = (|h|^2)*PL*Xi + Ni,

  where Ni is a real Gaussian with variance No/2, No = 10^-13 as given in the question.
- For sufficient statistics only a real noise is added, as (|h|^2)*PL*Xi is real.
- For getting the demodulated value of X, all the samples corresponding to a single symbols are again multiples by the corresponding samples of cos(2pifct) and sin(2pifct) and averaged. These values are then threshold detected against 0 to get the demodulated I and Q symbols for all the 10000 X's.
- From the demodulated symbols, the Pe is calculated.

(a). Pe for this part comes to be 0.0865.

(b). The Pe is calculated for various values of Amplitude of (exp(2pifct)), varied form 0.1mV to 10mV and plotted against Tx SNR (in dB). The Pe comes out to be a decreasing curve with 1/SNR characteristics as shown below.

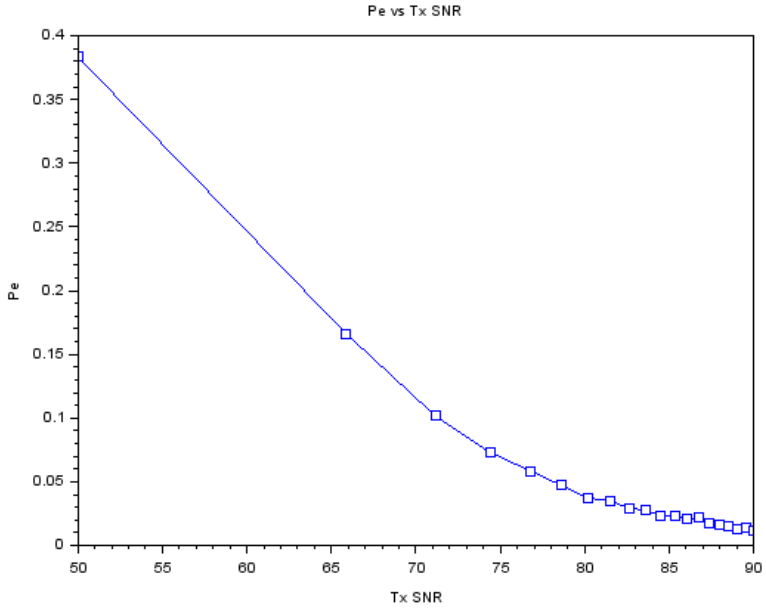

Fig: Prob of error vs Tx SNR (in dB) for no diversity case

(c). The received power is calculated as

Received power (in dB) = Transmitted power in dB – Path loss in dB + 10*log(|h|^2).

This received power is calculated for all the 10000 transmitted symbols and a threshold of -135dBm is applied to calculate the outage probability. Poutage is plotted against Tx SNR in dB (figure below) which is a decreasing curve. It is clear that as amplitude is increases, Tx'ed power increases and hence the outage probability decreases.

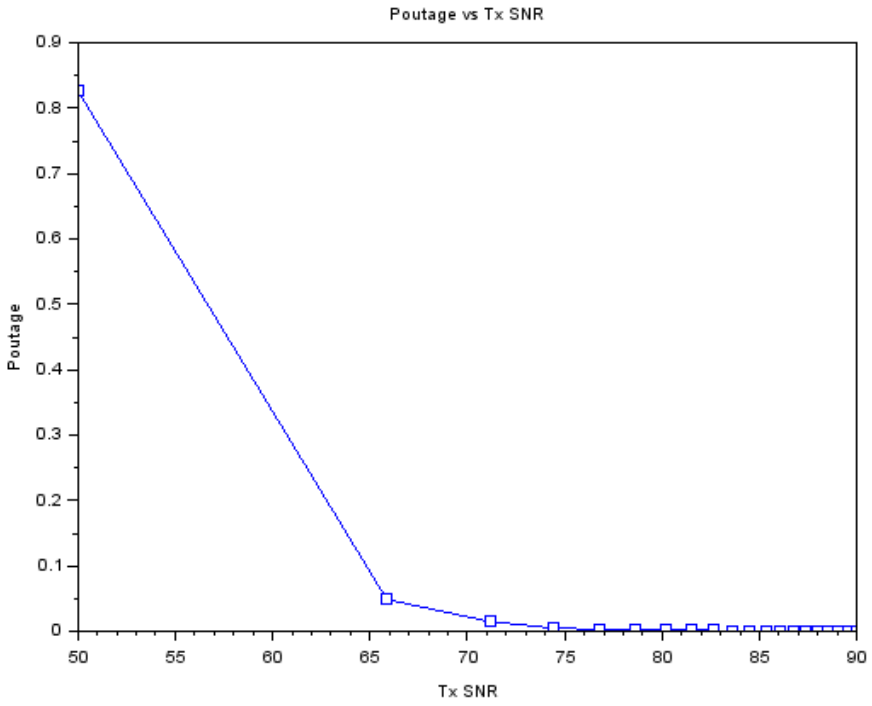

Fig: Prob of outage vs Tx SNR (in dB) for no diversity case

2. Antenna Diversity

(a) Probability of error

In this part, for each symbol, three different values of Y is computed (by method similar to part 1) with different fading coefficients. That value of y is taken for demodulation which has the maximum received SNR. The graph of Pe vs Tx SNR is plotted below, which is again a decreasing curve. It can be clearly seen that Pe in the antenna diversity case is lower that than the no diversity case.

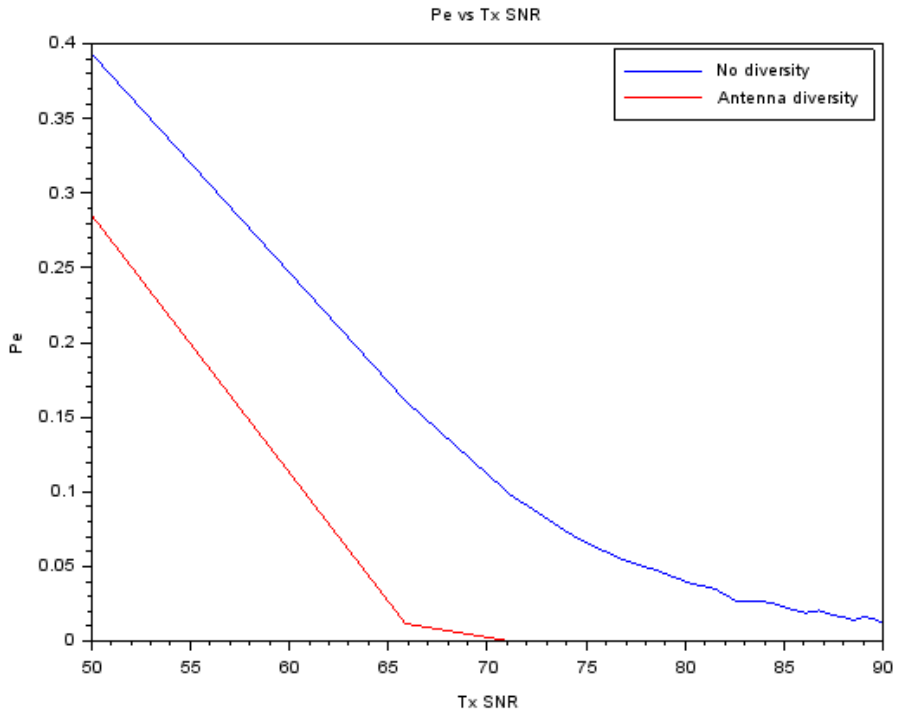

Fig: Prob of error vs TX SNR(dB)

(b) Probability of outage

As in this part we are taking only that value of the received signal which has the maximum received SNR, the probability of outage is lower than the no diversity case. It can be clearly seen in the figure below.

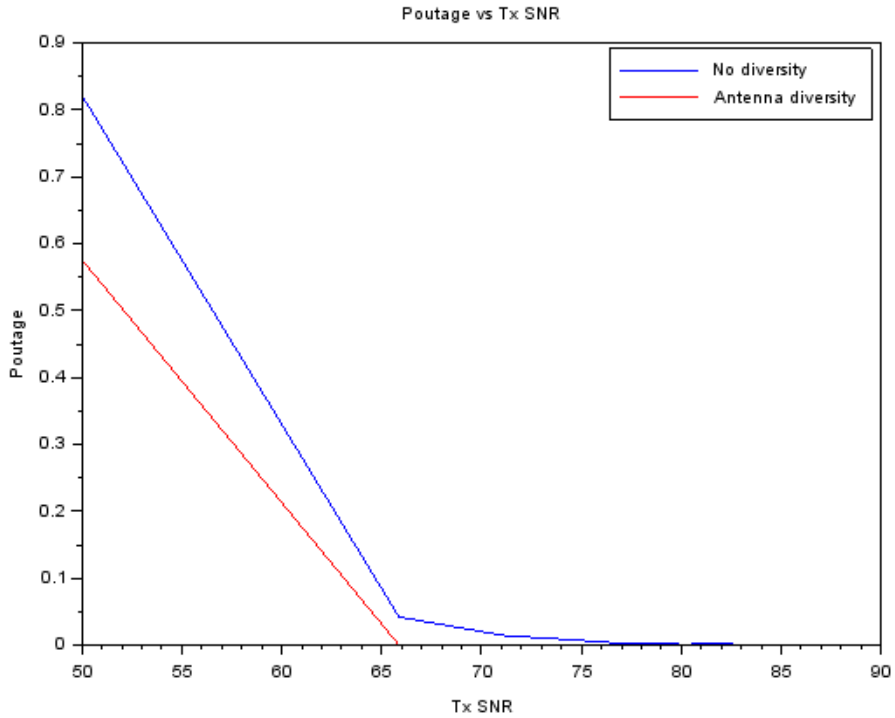

Fig: Prob of outage vs Tx SNR (in dB)

3. Time diversity

(a) Probability of error

Here a similar procedure is followed as in part 2. However, here for each of the three received y (for a symbol), the demodulated I,Q is found out and then a majority detector is used. The probability of error is this case is less than the no diversity case but is more than the antenna diversity as can be seen in the figure below.

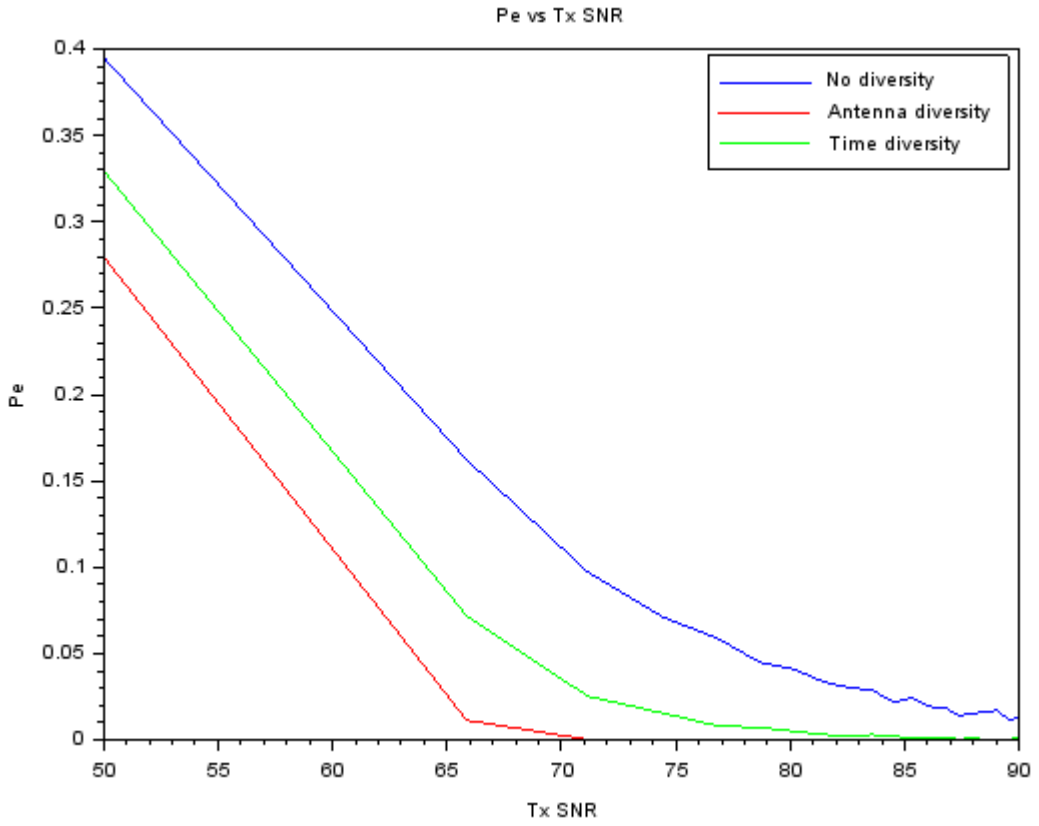

Fig: Prob of error vs TX SNR(dB)

(b) Probability of outage

Here, if 2 or 3 of the 3 repeated symbols are in outage, the symbol (which is sent 3 times) is taken to be in outage. The outage probability in this case is less than the no diversity case which is the diversity gain, but is less than the antenna diversity case, as here, even two antennas are in outage, the symbol is considered to be in outage, but in antenna diversity case, the max SNR antenna has to be in outage for the symbol to be considered in outage. This can be seen in the figure below.

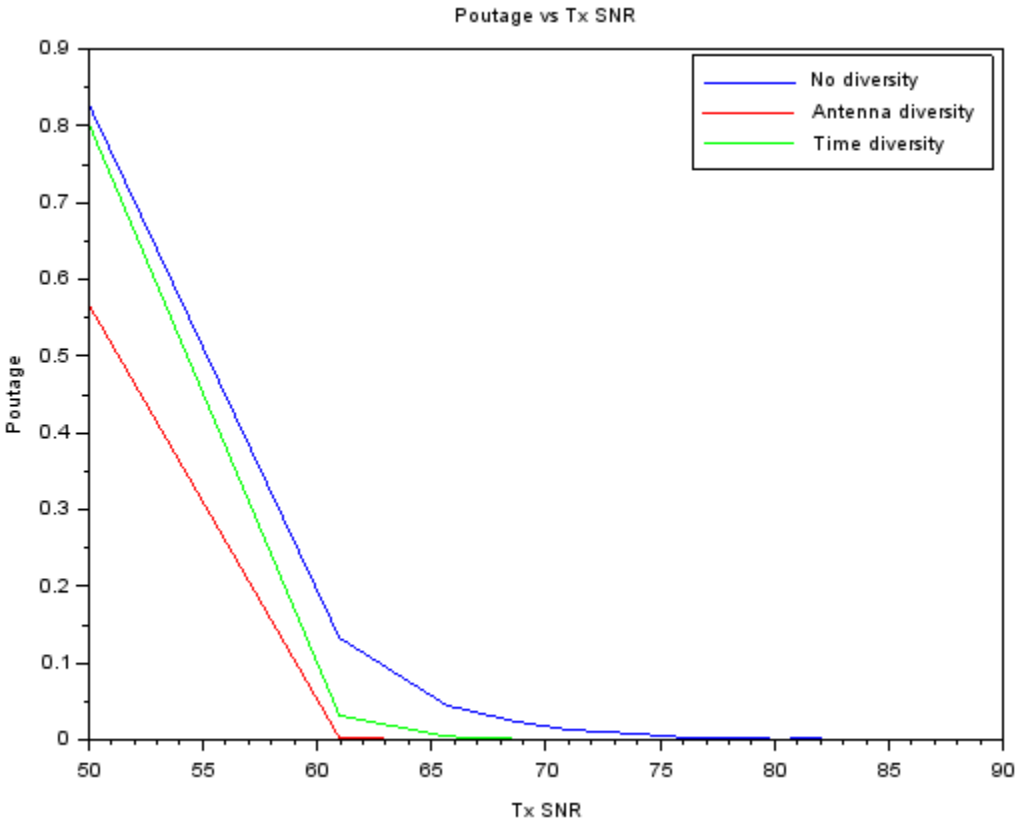

Fig: Poutage vs Tx SNR

The antenna diversity scheme is the best scheme among 2 and 3 as it gives the least BER and outage probability. However it uses more resource (3 Rx antennas) which may be costly. Thus there is a tradeoff between cost and system performance in scheme 2 and 3.