Homework IV

1. Rayleigh Fading

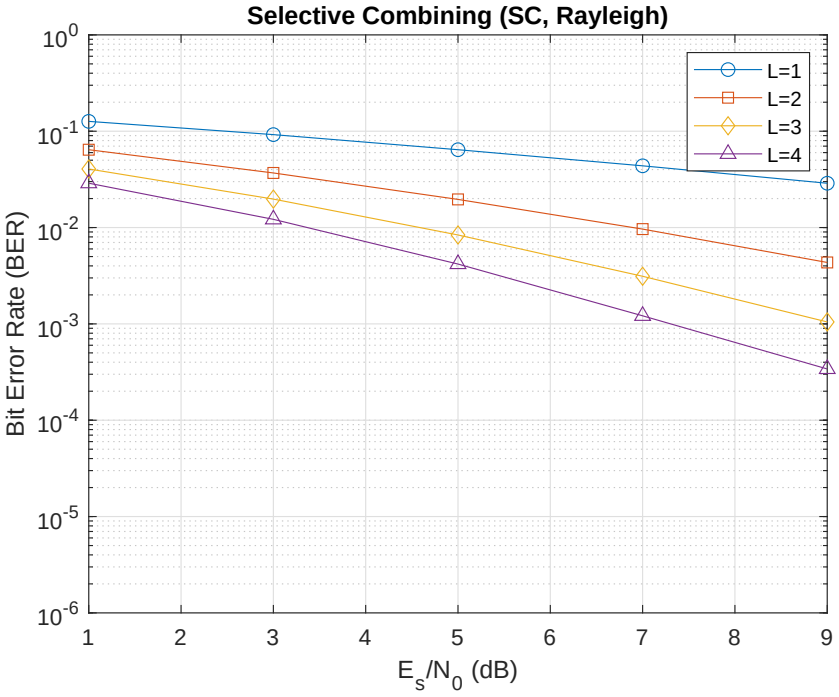
Rayleigh fading is generated by a standard complex gaussian.

$$h \sim \mathcal{CN}(0, 1)$$

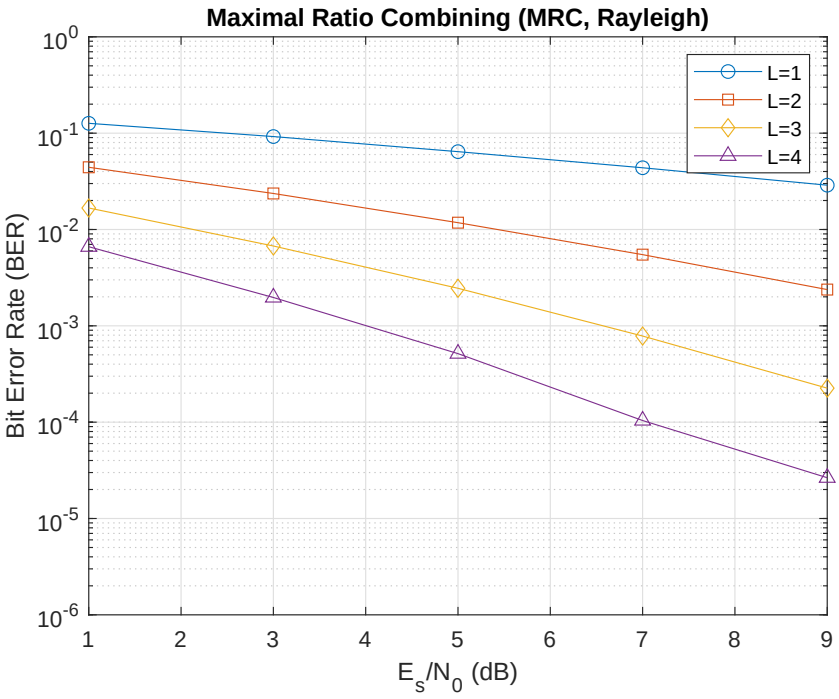
The four combining technique are implemented and the results are shown below:

(a) Selective Combining (SC)

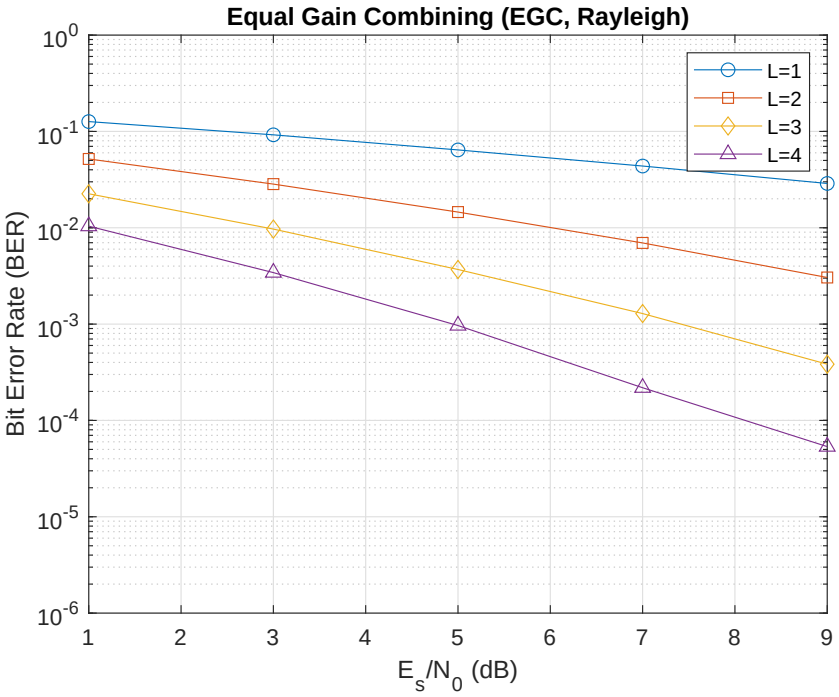
Choose the strongest branch as the combining result.



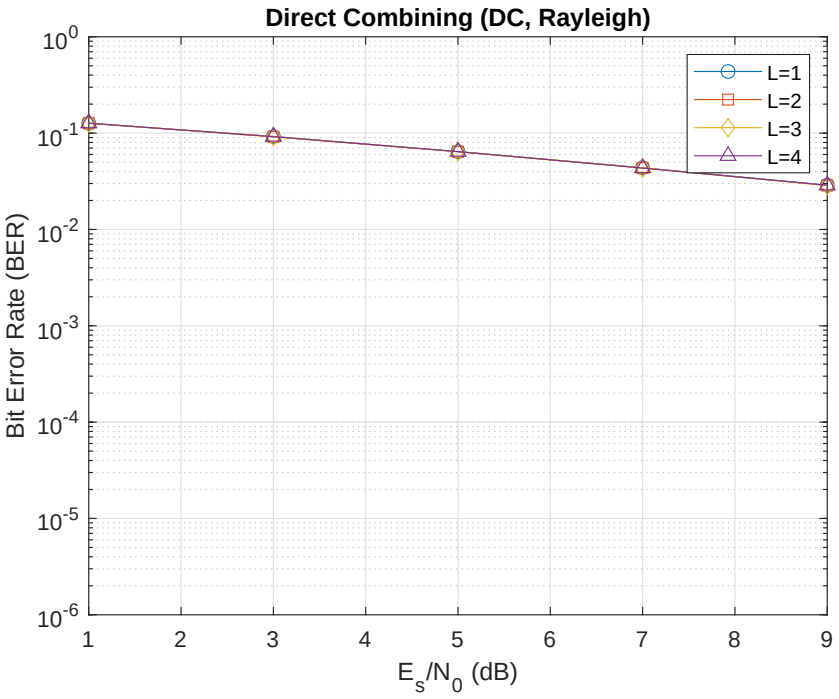
(b) **Maximal Ratio Combinig (MRC)**
Weight each branch according to the corresponding channel gain.



(c) **Equal Gain Combinig (MRC)**
Weight each branch with same gain.



(d) **Direct Combinig (MRC)**
Combine each branch directly and then compensate phase.



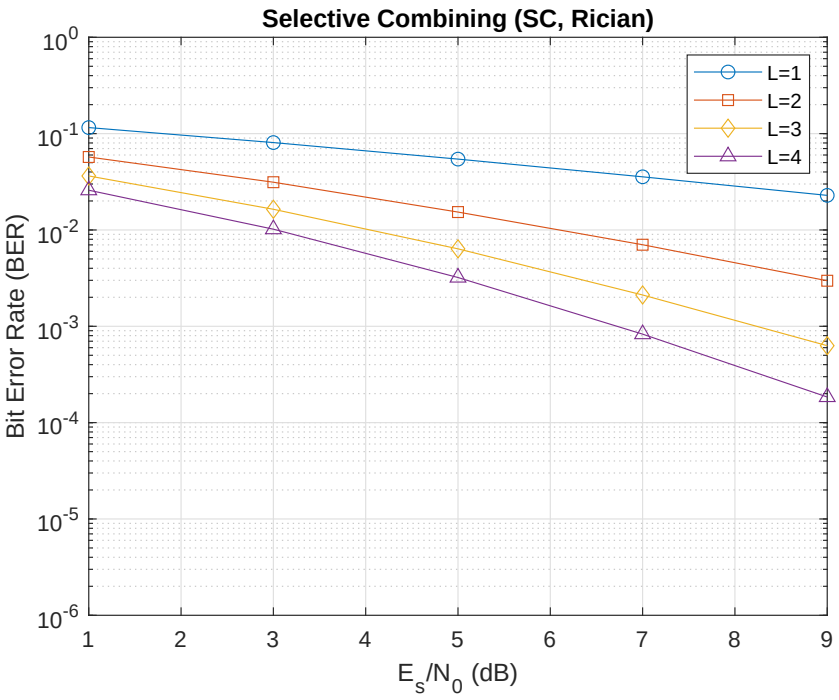
2. Rician Fading

Rician fading with K-factor is generated through

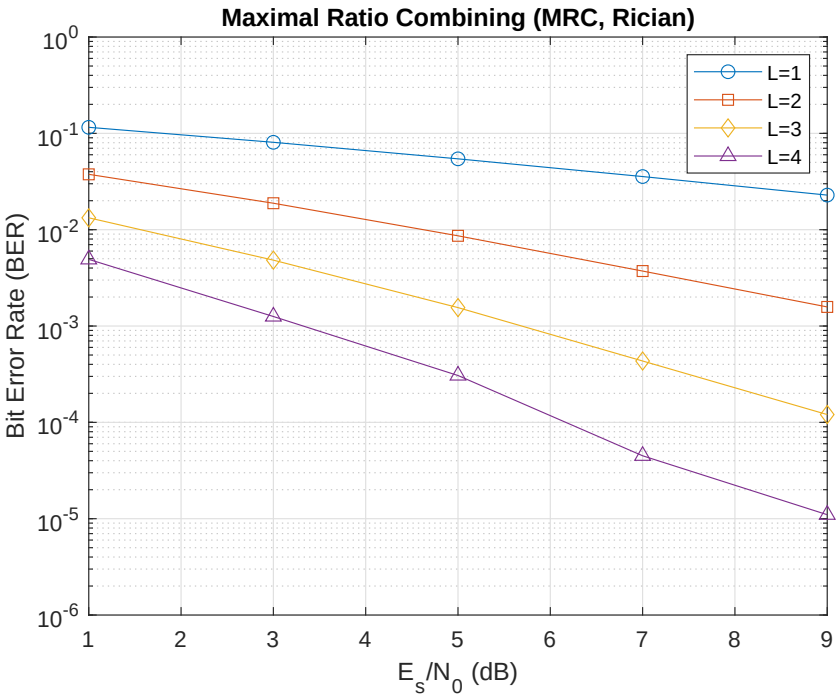
$$\sqrt{\frac{K}{K+1}} \cdot s + \sqrt{\frac{1}{K+1}} \cdot N$$

where s is the direct path power, which set to be 1 and $N \sim \mathcal{CN}(0,1)$. The implementation of those combining schemes are same as that in (a). The results are shown below:

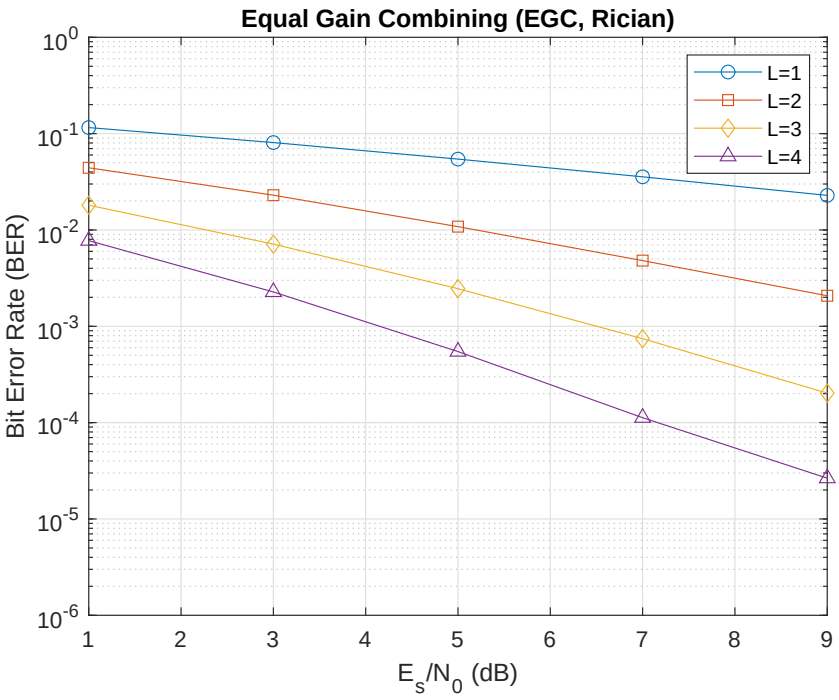
(a) **Selective Combining (SC)**



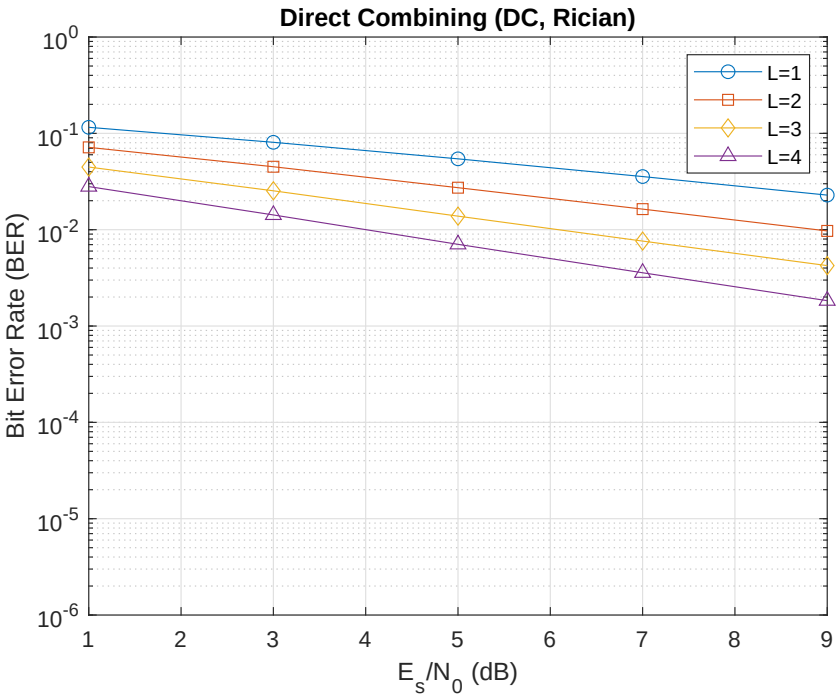
(b) **Maximal Ratio Combinig (MRC)**



(c) **Equal Gain Combinig (MRC)**



(d) **Direct Combinig (MRC)**



3. Comparison

(a) **Comparison of different combining**

In SC, the receiver chooses the strongest path as the combined result. With more paths available, the signal has a higher probability of benefiting from favorable fading conditions, leading to a lower BER.

In MRC, the receiver weights each path according to its channel gain. This approach achieves the same performance as Maximum Likelihood (ML) detection, which is the optimal detection strategy.

In EGC, the receiver weights each path equally. The performance of EGC lies between that of MRC and SC.

In DC, the receiver combines all paths directly, which may result in phase cancellation. Consequently, the performance of DC is the poorest among the four combining schemes.

In conclusion, the diversity gain order of the four combining techniques is MRC > EGC > SC > DC.

(b) **Comparison of different fading**

It can be seen that BER is lower under Rician fading. This is because there is line-of-sight (LOS) under Rician fading, which provides a stable signal. On the other hand, by comparing the BER curves of $L = 1$ and $L = 4$ under different fading conditions, it can be seen that there is more diversity gain under Rayleigh fading. The reason is that, without LOS, each path is more independent, which increases the diversity gain.