1. Change input wordlength only

10

[[16. 65.15006704]

[15. 64.90722933]

[14. 64.31690468]

[13. 63.09746168]

[12. 60.89158171]

[11. 57.4899191 ]

[10. 52.84592062]

[ 9. 47.58528788]]

1. Change multuplication output wordlength，stage by stage

**New （100 groups，SNR\_Req: 50)**

[[16. 64.27548951]

[15. 63.92810294]

[14. 63.09875388]

[13. 61.23089281]

[12. 58.37633095]

[11. 54.24151047]

[10. 49.30494017]]

\*\*\*\*\*\*\*\*\* 11

[16, 16, 16, 16, 16, 16]

Average SNR 54.2415104738915

[15, 16, 16, 16, 16, 16]

Average SNR 54.13102822530723

[14, 16, 16, 16, 16, 16]

Average SNR 53.8461741061925

[13, 16, 16, 16, 16, 16]

Average SNR 53.23232839032893

[12, 16, 16, 16, 16, 16]

Average SNR 51.874037572381624

[11, 16, 16, 16, 16, 16]

Average SNR 48.65190056524674

[12, 16, 16, 16, 16, 16]

Average SNR 51.874037572381624

[12, 15, 16, 16, 16, 16]

Average SNR 51.76750470783226

[12, 14, 16, 16, 16, 16]

Average SNR 51.50855791625432

[12, 13, 16, 16, 16, 16]

Average SNR 50.86920571916667

[12, 12, 16, 16, 16, 16]

Average SNR 48.714632103189196

[12, 13, 16, 16, 16, 16]

Average SNR 50.86920571916667

[12, 13, 15, 16, 16, 16]

Average SNR 50.79321665138024

[12, 13, 14, 16, 16, 16]

Average SNR 50.522549130607196

[12, 13, 13, 16, 16, 16]

Average SNR 49.086794232190535

[12, 13, 14, 16, 16, 16]

Average SNR 50.522549130607196

[12, 13, 14, 15, 16, 16]

Average SNR 50.51664870245878

[12, 13, 14, 14, 16, 16]

Average SNR 49.5770589518723

[12, 13, 14, 15, 16, 16]

Average SNR 50.51664870245878

[12, 13, 14, 15, 15, 16]

Average SNR 49.90728562751145

[12, 13, 14, 15, 16, 16]

Average SNR 50.51664870245878

[12, 13, 14, 15, 16, 15]

Average SNR 49.90728562751145

[[16, 16, 16, 16, 16, 16], [15, 16, 16, 16, 16, 16], [14, 16, 16, 16, 16, 16], [13, 16, 16, 16, 16, 16], [12, 16, 16, 16, 16, 16], [11, 16, 16, 16, 16, 16], [12, 16, 16, 16, 16, 16], [12, 15, 16, 16, 16, 16], [12, 14, 16, 16, 16, 16], [12, 13, 16, 16, 16, 16], [12, 12, 16, 16, 16, 16], [12, 13, 16, 16, 16, 16], [12, 13, 15, 16, 16, 16], [12, 13, 14, 16, 16, 16], [12, 13, 13, 16, 16, 16], [12, 13, 14, 16, 16, 16], [12, 13, 14, 15, 16, 16], [12, 13, 14, 14, 16, 16], [12, 13, 14, 15, 16, 16], [12, 13, 14, 15, 15, 16], [12, 13, 14, 15, 16, 16], [12, 13, 14, 15, 16, 15]]

[54.2415104738915, 54.13102822530723, 53.8461741061925, 53.23232839032893, 51.874037572381624, 48.65190056524674, 51.874037572381624, 51.76750470783226, 51.50855791625432, 50.86920571916667, 48.714632103189196, 50.86920571916667, 50.79321665138024, 50.522549130607196, 49.086794232190535, 50.522549130607196, 50.51664870245878, 49.5770589518723, 50.51664870245878, 49.90728562751145, 50.51664870245878, 49.90728562751145]

####### 11

####### [12, 13, 14, 15, 16, 16]

[16, 16, 16, 16, 16, 16]

Average\_SNR 50.51664870245878

[15, 16, 16, 16, 16, 16]

Average\_SNR 50.43119015857147

[14, 16, 16, 16, 16, 16]

Average\_SNR 50.36096356014412

[13, 16, 16, 16, 16, 16]

Average\_SNR 50.115984034639474

[12, 16, 16, 16, 16, 16]

Average\_SNR 49.65114704649568

[13, 16, 16, 16, 16, 16]

Average\_SNR 50.115984034639474

[13, 15, 16, 16, 16, 16]

Average\_SNR 50.05589691188164

[13, 14, 16, 16, 16, 16]

Average\_SNR 49.987218426559686

[13, 15, 16, 16, 16, 16]

Average\_SNR 50.05589691188164

[13, 15, 15, 16, 16, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 16, 16]

Average\_SNR 50.01122674769678

[13, 15, 13, 16, 16, 16]

Average\_SNR 49.92605499028676

[13, 15, 14, 16, 16, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 15, 16, 16]

Average\_SNR 49.959968854166625

[13, 15, 14, 16, 16, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 15, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 14, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 13, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 12, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 11, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 10, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 9, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 8, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 7, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 6, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 5, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 4, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 3, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 1, 16]

Average\_SNR 3.012791174008981

[13, 15, 14, 16, 2, 16]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 15]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 14]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 13]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 12]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 11]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 10]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 9]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 8]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 7]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 6]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 5]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 4]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 3]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 2]

Average\_SNR 50.01122674769678

[13, 15, 14, 16, 2, 1]

Average\_SNR 2.9907805579391407

[[16, 16, 16, 16, 16, 16], [15, 16, 16, 16, 16, 16], [14, 16, 16, 16, 16, 16], [13, 16, 16, 16, 16, 16], [12, 16, 16, 16, 16, 16], [13, 16, 16, 16, 16, 16], [13, 15, 16, 16, 16, 16], [13, 14, 16, 16, 16, 16], [13, 15, 16, 16, 16, 16], [13, 15, 15, 16, 16, 16], [13, 15, 14, 16, 16, 16], [13, 15, 13, 16, 16, 16], [13, 15, 14, 16, 16, 16], [13, 15, 14, 15, 16, 16], [13, 15, 14, 16, 16, 16], [13, 15, 14, 16, 15, 16], [13, 15, 14, 16, 14, 16], [13, 15, 14, 16, 13, 16], [13, 15, 14, 16, 12, 16], [13, 15, 14, 16, 11, 16], [13, 15, 14, 16, 10, 16], [13, 15, 14, 16, 9, 16], [13, 15, 14, 16, 8, 16], [13, 15, 14, 16, 7, 16], [13, 15, 14, 16, 6, 16], [13, 15, 14, 16, 5, 16], [13, 15, 14, 16, 4, 16], [13, 15, 14, 16, 3, 16], [13, 15, 14, 16, 2, 16], [13, 15, 14, 16, 1, 16], [13, 15, 14, 16, 2, 16], [13, 15, 14, 16, 2, 15], [13, 15, 14, 16, 2, 14], [13, 15, 14, 16, 2, 13], [13, 15, 14, 16, 2, 12], [13, 15, 14, 16, 2, 11], [13, 15, 14, 16, 2, 10], [13, 15, 14, 16, 2, 9], [13, 15, 14, 16, 2, 8], [13, 15, 14, 16, 2, 7], [13, 15, 14, 16, 2, 6], [13, 15, 14, 16, 2, 5], [13, 15, 14, 16, 2, 4], [13, 15, 14, 16, 2, 3], [13, 15, 14, 16, 2, 2], [13, 15, 14, 16, 2, 1]]

[50.51664870245878, 50.43119015857147, 50.36096356014412, 50.115984034639474, 49.65114704649568, 50.115984034639474, 50.05589691188164, 49.987218426559686, 50.05589691188164, 50.01122674769678, 50.01122674769678, 49.92605499028676, 50.01122674769678, 49.959968854166625, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 3.012791174008981, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 50.01122674769678, 2.9907805579391407]

**55dB**

**[[16. 64.27548951]**

**[15. 63.92810294]**

**[14. 63.09875388]**

**[13. 61.23089281]**

**[12. 58.37633095]**

**[11. 54.24151047]]**

**\*\*\*\*\*\*\*\*\* 12**

**[16, 16, 16, 16, 16, 16]**

**Average SNR 58.37633094913679**

**[15, 16, 16, 16, 16, 16]**

**Average SNR 58.223503797181884**

**[14, 16, 16, 16, 16, 16]**

**Average SNR 57.71034546837506**

**[13, 16, 16, 16, 16, 16]**

**Average SNR 56.58781496393996**

**[12, 16, 16, 16, 16, 16]**

**Average SNR 53.799049965168926**

**[13, 16, 16, 16, 16, 16]**

**Average SNR 56.58781496393996**

**[13, 15, 16, 16, 16, 16]**

**Average SNR 56.4101733564076**

**[13, 14, 16, 16, 16, 16]**

**Average SNR 55.86818964103161**

**[13, 13, 16, 16, 16, 16]**

**Average SNR 54.03336955071004**

**[13, 14, 16, 16, 16, 16]**

**Average SNR 55.86818964103161**

**[13, 14, 15, 16, 16, 16]**

**Average SNR 55.7097453726971**

**[13, 14, 14, 16, 16, 16]**

**Average SNR 54.66683810037882**

**[13, 14, 15, 16, 16, 16]**

**Average SNR 55.7097453726971**

**[13, 14, 15, 15, 16, 16]**

**Average SNR 55.35058175273652**

**[13, 14, 15, 14, 16, 16]**

**Average SNR 53.42312017923118**

**[13, 14, 15, 15, 16, 16]**

**Average SNR 55.35058175273652**

**[13, 14, 15, 15, 15, 16]**

**Average SNR 54.21937470780365**

**[13, 14, 15, 15, 16, 16]**

**Average SNR 55.35058175273652**

**[13, 14, 15, 15, 16, 15]**

**Average SNR 54.21937470780365**

**[[16, 16, 16, 16, 16, 16], [15, 16, 16, 16, 16, 16], [14, 16, 16, 16, 16, 16], [13, 16, 16, 16, 16, 16], [12, 16, 16, 16, 16, 16], [13, 16, 16, 16, 16, 16], [13, 15, 16, 16, 16, 16], [13, 14, 16, 16, 16, 16], [13, 13, 16, 16, 16, 16], [13, 14, 16, 16, 16, 16], [13, 14, 15, 16, 16, 16], [13, 14, 14, 16, 16, 16], [13, 14, 15, 16, 16, 16], [13, 14, 15, 15, 16, 16], [13, 14, 15, 14, 16, 16], [13, 14, 15, 15, 16, 16], [13, 14, 15, 15, 15, 16], [13, 14, 15, 15, 16, 16], [13, 14, 15, 15, 16, 15]]**

**[58.37633094913679, 58.223503797181884, 57.71034546837506, 56.58781496393996, 53.799049965168926, 56.58781496393996, 56.4101733564076, 55.86818964103161, 54.03336955071004, 55.86818964103161, 55.7097453726971, 54.66683810037882, 55.7097453726971, 55.35058175273652, 53.42312017923118, 55.35058175273652, 54.21937470780365, 55.35058175273652, 54.21937470780365]**

**####### 12**

**####### [13, 14, 15, 15, 16, 16]**

**[16, 16, 16, 16, 16, 16]**

**Average\_SNR 55.35058175273652**

**[15, 16, 16, 16, 16, 16]**

**Average\_SNR 55.24408686998234**

**[14, 16, 16, 16, 16, 16]**

**Average\_SNR 55.166642738037154**

**[13, 16, 16, 16, 16, 16]**

**Average\_SNR 54.72612707805957**

**[14, 16, 16, 16, 16, 16]**

**Average\_SNR 55.166642738037154**

**[14, 15, 16, 16, 16, 16]**

**Average\_SNR 55.088651223677005**

**[14, 14, 16, 16, 16, 16]**

**Average\_SNR 54.983595296238**

**[14, 15, 16, 16, 16, 16]**

**Average\_SNR 55.088651223677005**

**[14, 15, 15, 16, 16, 16]**

**Average\_SNR 55.00123977632971**

**[14, 15, 14, 16, 16, 16]**

**Average\_SNR 55.00123977632971**

**[14, 15, 13, 16, 16, 16]**

**Average\_SNR 54.84966073173259**

**[14, 15, 14, 16, 16, 16]**

**Average\_SNR 55.00123977632971**

**[14, 15, 14, 15, 16, 16]**

**Average\_SNR 54.89089215544695**

**[14, 15, 14, 16, 16, 16]**

**Average\_SNR 55.00123977632971**

**[14, 15, 14, 16, 15, 16]**

**Average\_SNR 55.00123977632971**

**[14, 15, 14, 16, 14, 16]**

**Average\_SNR 55.00123977632971**

**[14, 15, 14, 16, 13, 16]**

**Average\_SNR 55.00123977632971**

**[14, 15, 14, 16, 12, 16]**

**Average\_SNR 55.00123977632971**

**[14, 15, 14, 16, 11, 16]**

**Average\_SNR 55.00123977632971**

**[14, 15, 14, 16, 10, 16]**

**40dB**

[[16. 64.27548951]

[15. 63.92810294]

[14. 63.09875388]

[13. 61.23089281]

[12. 58.37633095]

[11. 54.24151047]

[10. 49.30494017]

[ 9. 43.82012356]

[ 8. 38.1535808 ]]

\*\*\*\*\*\*\*\*\* 9

[16, 16, 16, 16, 16, 16]

Average SNR 43.82012355690257

[15, 16, 16, 16, 16, 16]

Average SNR 43.79961881205531

[14, 16, 16, 16, 16, 16]

Average SNR 43.71794756804428

[13, 16, 16, 16, 16, 16]

Average SNR 43.54531172321699

[12, 16, 16, 16, 16, 16]

Average SNR 43.19016120352565

[11, 16, 16, 16, 16, 16]

Average SNR 42.4078992773091

[10, 16, 16, 16, 16, 16]

Average SNR 40.77692787284117

[9, 16, 16, 16, 16, 16]

Average SNR 37.128041744694784

[10, 16, 16, 16, 16, 16]

Average SNR 40.77692787284117

[10, 15, 16, 16, 16, 16]

Average SNR 40.75075158572329

[10, 14, 16, 16, 16, 16]

Average SNR 40.68125741652359

[10, 13, 16, 16, 16, 16]

Average SNR 40.54364099944078

[10, 12, 16, 16, 16, 16]

Average SNR 40.20509419477086

[10, 11, 16, 16, 16, 16]

Average SNR 39.47268099940834

[10, 12, 16, 16, 16, 16]

Average SNR 40.20509419477086

[10, 12, 15, 16, 16, 16]

Average SNR 40.18670673803145

[10, 12, 14, 16, 16, 16]

Average SNR 40.11909261962781

[10, 12, 13, 16, 16, 16]

Average SNR 39.934193119474735

[10, 12, 14, 16, 16, 16]

Average SNR 40.11909261962781

[10, 12, 14, 15, 16, 16]

Average SNR 40.12213072982765

[10, 12, 14, 14, 16, 16]

Average SNR 39.94676407162079

[10, 12, 14, 15, 16, 16]

Average SNR 40.12213072982765

[10, 12, 14, 15, 15, 16]

Average SNR 39.98895120091957

[10, 12, 14, 15, 16, 16]

Average SNR 40.12213072982765

[10, 12, 14, 15, 16, 15]

Average SNR 39.98895120091957

[[16, 16, 16, 16, 16, 16], [15, 16, 16, 16, 16, 16], [14, 16, 16, 16, 16, 16], [13, 16, 16, 16, 16, 16], [12, 16, 16, 16, 16, 16], [11, 16, 16, 16, 16, 16], [10, 16, 16, 16, 16, 16], [9, 16, 16, 16, 16, 16], [10, 16, 16, 16, 16, 16], [10, 15, 16, 16, 16, 16], [10, 14, 16, 16, 16, 16], [10, 13, 16, 16, 16, 16], [10, 12, 16, 16, 16, 16], [10, 11, 16, 16, 16, 16], [10, 12, 16, 16, 16, 16], [10, 12, 15, 16, 16, 16], [10, 12, 14, 16, 16, 16], [10, 12, 13, 16, 16, 16], [10, 12, 14, 16, 16, 16], [10, 12, 14, 15, 16, 16], [10, 12, 14, 14, 16, 16], [10, 12, 14, 15, 16, 16], [10, 12, 14, 15, 15, 16], [10, 12, 14, 15, 16, 16], [10, 12, 14, 15, 16, 15]]

[43.82012355690257, 43.79961881205531, 43.71794756804428, 43.54531172321699, 43.19016120352565, 42.4078992773091, 40.77692787284117, 37.128041744694784, 40.77692787284117, 40.75075158572329, 40.68125741652359, 40.54364099944078, 40.20509419477086, 39.47268099940834, 40.20509419477086, 40.18670673803145, 40.11909261962781, 39.934193119474735, 40.11909261962781, 40.12213072982765, 39.94676407162079, 40.12213072982765, 39.98895120091957, 40.12213072982765, 39.98895120091957]

####### 9

####### [10, 12, 14, 15, 16, 16]

[16, 16, 16, 16, 16, 16]

Average\_SNR 40.12213072982765

[15, 16, 16, 16, 16, 16]

Average\_SNR 40.09447879102008

[14, 16, 16, 16, 16, 16]

Average\_SNR 40.082451440415674

[13, 16, 16, 16, 16, 16]

Average\_SNR 40.007278099684285

[12, 16, 16, 16, 16, 16]

Average\_SNR 39.89885786234455

[13, 16, 16, 16, 16, 16]

Average\_SNR 40.007278099684285

[13, 15, 16, 16, 16, 16]

Average\_SNR 39.991234528789676

[13, 16, 16, 16, 16, 16]

Average\_SNR 40.007278099684285

[13, 16, 15, 16, 16, 16]

Average\_SNR 39.9921020811568

[13, 16, 16, 16, 16, 16]

Average\_SNR 40.007278099684285

[13, 16, 16, 15, 16, 16]

Average\_SNR 39.99167408732935

[[16, 16, 16, 16, 16, 16], [15, 16, 16, 16, 16, 16], [14, 16, 16, 16, 16, 16], [13, 16, 16, 16, 16, 16], [12, 16, 16, 16, 16, 16], [13, 16, 16, 16, 16, 16], [13, 15, 16, 16, 16, 16], [13, 16, 16, 16, 16, 16], [13, 16, 15, 16, 16, 16], [13, 16, 16, 16, 16, 16], [13, 16, 16, 15, 16, 16]]

[40.12213072982765, 40.09447879102008, 40.082451440415674, 40.007278099684285, 39.89885786234455, 40.007278099684285, 39.991234528789676, 40.007278099684285, 39.9921020811568, 40.007278099684285, 39.99167408732935]