1. 上行长度为512，功率因子0.2，preamble = 26

* **CSI==16**
* **许道峰模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.1947 | 0.1408 | 0.08966 | 0.04722 | 0.01852 | 0.005058 | 0.0008219 | 7.6e-5 | 3.45e-6 | 6.6e-8 |
| 下行MSE | 0.2674 | 0.2063 | 0.1459 | 0.09231 | 0.05412 | 0.03345 | 0.02371 | 0.01914 | 0.0166 | 0.01505 |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.25 | 0.1831 | 0.1169 | 0.0614 | 0.02445 | 0.00677 | 0.001099 | 8.5e-5 | 3.8e-6 | 1.55e-7 |
| 下行MSE | 0.4775 | 0.3648 | 0.2536 | 0.1579 | 0.09099 | 0.05318 | 0.03484 | 0.02581 | 0.02063 | 0.01759 |

* **DL模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.19547 | 0.14186 | 0.09023 | 0.04764 | 0.01914 | 0.00530 | 0.0009411 | 9.2333984375e-05 | 4.58984375e-06 | 9.765625e-08 |
| 下行MSE | 0.25252 | 0.18251 | 0.1250 | 0.0780 | 0.0438 | 0.023879 | 0.013611 | 0.008710 | 0.00615 | 0.00470 |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.239570 | 0.173877 | 0.110577 | 0.0583341 | 0.023555 | 0.006713574 | 0.001235986 | 0.00013320 | 8.9355e-06 | 2.9296875e-07 |
| 下行MSE | 0.31955 | 0.2265 | 0.15322 | 0.0950 | 0.053833 | 0.02982 | 0.018136 | 0.0123391 | 0.0093106 | 0.0075236 |

* **图像对比**
  + - BER——512x16



* + - MSE——512x16

****

* **CSI==32**
* **许道峰模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.1965 | 0.1438 | 0.09342 | 0.05026 | 0.02087 | 0.005928 | 0.001041 | 0.0001084 | 8.7e-6 | 2.3e-6 |
| 下行MSE | 0.4239 | 0.3462 | 0.2645 | 0.1834 | 0.1199 | 0.08034 | 0.0609 | 0.05203 | 0.04742 | 0.04467 |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.2835 | 0.2125 | 0.1395 | 0.07644 | 0.03191 | 0.008786 | 0.001541 | 0.0001611 | 1.24e-5 | 2.4e-6 |
| 下行MSE | 0.7644 | 0.6479 | 0.5009 | 0.3459 | 0.2168 | 0.1333 | 0.09088 | 0.06991 | 0.05855 | 0.05154 |

* **DL模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.197135 | 0.144427 | 0.093533 | 0.05030 | 0.020635 | 0.0058876 | 0.0010173 | 0.00010659 | 没测 | 没测 |
| 下行MSE | 0.39486 | 0.3100554 | 0.225608 | 0.14859606 | 0.09007 | 0.053246 | 0.033369 | 0.02324 | 没测 | 没测 |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.2707541015625 | 0.20097216796875 | 0.129644140625 | 0.06978896484375 | 0.02823759765625 | 0.00769853515625 | 0.001365234375 | 0.0001453125 | 1.30859375e-05 | 7.8125e-06 |
| 下行MSE | 0.5525103 | 0.41291803 | 0.29316726 | 0.19090451 | 0.11293535 | 0.06642032 | 0.04344486 | 0.0314698 | 0.025527526 | 0.02194169 |

* **图像对比**
  + - BER——512x32



* + - MSE——512x32



* **CSI==64**
* **许道峰模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.1997 | 0.1499 | 0.1011 | 0.05933 | 0.02826 | 0.01036 | 0.002894 | 0.0006564 | 0.0001279 | 2.97e-5 |
| 下行MSE | 0.6009 | 0.5294 | 0.4422 | 0.3447 | 0.2557 | 0.19 | 0.1523 | 0.1332 | 0.1238 | 0.1188 |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.3229 | 0.2541 | 0.1786 | 0.1076 | 0.05175 | 0.01914 | 0.005852 | 0.001818 | 0.00077 | 0.0004728 |
| 下行MSE | 1.025 | 0.9675 | 0.848 | 0.6766 | 0.4829 | 0.3333 | 0.2377 | 0.1856 | 0.1574 | 0.1407 |

* **DL模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.2009466 | 0.149838 | 0.1005289 | 0.058574804 | 0.0280092 | 0.01078647 | 0.0035344 | 0.00132070 | 0.000743164 | 0.00057915 |
| 下行MSE | 0.646674 | 0.504236 | 0.381025 | 0.274796 | 0.1880 | 0.12726 | 0.088913 | 0.06632 | 0.053133 | 0.0456288 |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.31062451171875 | 0.2392220703125 | 0.16244560546875 | 0.0930462890625 | 0.043634375 | 0.0173044921875 | 0.00694130859375 | 0.0036765625 | 0.00279208984375 | 0.002525390625 |
| 下行MSE | 0.80344415 | 0.6791795 | 0.5602511 | 0.41769797 | 0.28676978 | 0.20592265 | 0.16480906 | 0.14416228 | 0.13258202 | 0.12622486 |

* + - H由LS估计，模型改变

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.31118193359375 | 0.24000751953125 | 0.1622283203125 | 0.09209111328125 | 0.04118427734375 | 0.01516025390625 | 0.0052287109375 | 0.0024193359375 |  |  |
| 下行MSE | 0.8051857 | 0.67113394 | 0.5380899 | 0.38666523, | 0.2551535 | 0.17770422 | 0.1373383 | 0.11662818 |  |  |

* **图像对比**
  + - BER——512x64



* + - MSE——512x64

****

* **估计BER与MSE总图**





1. 上行长度为512，功率因子0.15，preamble = 26

* **CSI==16**
* **许道峰模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.1873 | 0.1337 | 0.08344 | 0.04222 | 0.01616 | 0.004169 | 0.0006542 | 5.45e-5 |  |  |
| 下行MSE | 0.3372 | 0.2633 | 0.1897 | 0.1224 | 0.07548 | 0.04929 | 0.03719 | 0.0314 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.2425 | 0.1752 | 0.1103 | 0.05569 | 0.02161 | 0.005588 | 0.0008747 | 7.2e-5 |  |  |
| 下行MSE | 0.5527 | 0.4333 | 0.3083 | 0.1971 | 0.1179 | 0.07256 | 0.0502 | 0.03926 |  |  |

* **DL模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.18854 | 0.134304 | 0.084027587 | 0.043037 | 0.016752 | 0.004465 | 0.0007381 | 7.40234375e-05 |  |  |
| 下行MSE | 0.30590 | 0.23044 | 0.159918 | 0.099505 | 0.055951 | 0.030695 | 0.018083 | 0.012084 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.23083818359375 | 0.16512412109375 | 0.1032427734375 | 0.0527853515625 | 0.020678125 | 0.0057134765625 | 0.00101474609375 | 9.873046875e-05 |  |  |
| 下行MSE | 0.38548112 | 0.28249314 | 0.19327705 | 0.11835137 | 0.0669385 | 0.03773779 | 0.023766603 | 0.01642785 |  |  |

* **图像对比**
  + - BER——512x16



* + - MSE——512x16

****

* **CSI==32**
* **许道峰模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.1881 | 0.136 | 0.08573 | 0.04537 | 0.01793 | 0.004922 | 0.0008598 | 8.88e-5 |  |  |
| 下行MSE | 0.5044 | 0.4233 | 0.3308 | 0.2378 | 0.1633 | 0.1172 | 0.09396 | 0.08316 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.2771 | 0.2048 | 0.1323 | 0.06991 | 0.02778 | 0.007502 | 0.001265 | 0.0001206 |  |  |
| 下行MSE | 0.8423 | 0.7326 | 0.5821 | 0.4135 | 0.2682 | 0.1763 | 0.1277 | 0.1039 |  |  |

* **DL模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.188779 | 0.1363050 | 0.086480 | 0.0447611 | 0.017414 | 0.004462 | 0.0007008 | 5.9423828125e-05 |  |  |
| 下行MSE | 0.482118 | 0.3833 | 0.2805 | 0.18334 | 0.10919 | 0.06344 | 0.039331 | 0.026811 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.26138203125 | 0.1902244140625 | 0.1208798828125 | 0.0626037109375 | 0.02442197265625 | 0.006683203125 | 0.001257421875 | 0.0001890625 |  |  |
| 下行MSE | 0.6458207 | 0.5049578 | 0.36728802 | 0.23672226 | 0.14047903 | 0.08652562 | 0.059430245 | 0.045800854 |  |  |

* **图像对比**
  + - BER——512x32



* + - MSE——512x32



* **CSI==64**
* **许道峰模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.1904 | 0.1396 | 0.09187 | 0.05203 | 0.02364 | 0.008487 | 0.002274 | 0.0005281 |  |  |
| 下行MSE | 0.6778 | 0.6102 | 0.5202 | 0.4193 | 0.3243 | 0.2566 | 0.216 | 0.196 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.3167 | 0.2466 | 0.1683 | 0.09778 | 0.04415 | 0.01541 | 0.00433 | 0.001175 | 0.0004165 | 0.0002358 |
| 下行MSE | 1.071 | 1.025 | 0.9175 | 0.7467 | 0.5511 | 0.3971 | 0.3011 | 0.2486 | 0.2192 | 0.2021 |

* **DL模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.1916754 | 0.1404381 | 0.091569 | 0.050312 | 0.02156181 | 0.006648 | 0.001480 | 0.000368 |  |  |
| 下行MSE | 0.772649 | 0.64436 | 0.49768 | 0.345491 | 0.216396 | 0.126959 | 0.0743511 | 0.0446577 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.29786865234375 | 0.22557431640625 | 0.14934853515625 | 0.0828146484375 | 0.03717333984375 | 0.0138556640625 | 0.00497314453125 | 0.002211328125 |  |  |
| 下行MSE | 0.9089497 | 0.809227 | 0.68728185 | 0.51861876 | 0.36154976 | 0.2648115 | 0.21509092 | 0.18846753 |  |  |

* **图像对比**
  + - BER——512x64



* + - MSE——512x64

****

* **估计BER与MSE总图**





1. 上行长度为512，功率因子0.1，preamble = 26

* **CSI==16**
* **许道峰模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.1798 | 0.1267 | 0.07735 | 0.03807 | 0.01417 | 0.003433 | 0.0005106 | 4.05e-5 |  |  |
| 下行MSE | 0.4432 | 0.3589 | 0.2671 | 0.1813 | 0.1199 | 0.08483 | 0.06823 | 0.06031 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.2363 | 0.1679 | 0.1023 | 0.05064 | 0.01911 | 0.0048204 | 0.000715 | 6.5e-5 |  |  |
| 下行MSE | 0.6624 | 0.5407 | 0.4014 | 0.2687 | 0.1702 | 0.1131 | 0.08448 | 0.07017 |  |  |

* **DL模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.1807730 | 0.1274021 | 0.0781672 | 0.0385651 | 0.014443 | 0.0036520 | 0.0005659 | 4.8291015625e-05 |  |  |
| 下行MSE | 0.41486 | 0.320147 | 0.22410 | 0.13817 | 0.07758 | 0.042321 | 0.024866 | 0.016355 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.22358876953125 | 0.15673115234375 | 0.09612314453125 | 0.04748115234375 | 0.01802939453125 | 0.0045884765625 | 0.00075478515625 | 7.890625e-05 |  |  |
| 下行MSE | 0.5123259 | 0.38121727 | 0.26463103 | 0.16070278 | 0.09250472 | 0.05354659 | 0.035571847 | 0.02607294 |  |  |

* **图像对比**
  + - BER——512x16



* + - MSE——512x16

****

* **CSI==32**
* **许道峰模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.1796 | 0.1271 | 0.07878 | 0.04011 | 0.01531 | 0.004036 | 0.0006672 | 6.71e-05 |  |  |
| 下行MSE | 0.6161 | 0.53510 | 0.4359 | 0.3311 | 0.2437 | 0.1892 | 0.1612 | 0.1481 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.2697 | 0.1966 | 0.1236 | 0.06361 | 0.02433 | 0.006338 | 0.001018 | 9.8e-5 |  |  |
| 下行MSE | 0.9288 | 0.8374 | 0.6903 | 0.51514 | 0.3577 | 0.254 | 0.199 | 0.1714 |  |  |

* **DL模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.181086 | 0.128288 | 0.07896 | 0.03939 | 0.014460 | 0.003425 | 0.000470 | 3.134765625e-05 |  |  |
| 下行MSE | 0.61980 | 0.50363 | 0.37245 | 0.243443 | 0.14439 | 0.0832 | 0.05109 | 0.034126 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.2525435546875 | 0.18120693359375 | 0.112264453125 | 0.05573095703125 | 0.02092109375 | 0.0054537109375 | 0.00089638671875 | 0.0001037109375 |  |  |
| 下行MSE | 0.7964336 | 0.64209425 | 0.47752416 | 0.3117109 | 0.19044864 | 0.1231102 | 0.08893324 | 0.07140158 |  |  |

* **图像对比**
  + - BER——512x32



* + - MSE——512x32



* **CSI==64**
* **许道峰模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.1813 | 0.1299 | 0.08203 | 0.04418 | 0.01904 | 0.006321 | 0.001634 | 0.0003404 |  |  |
| 下行MSE | 0.7665 | 0.7087 | 0.6257 | 0.5265 | 0.4329 | 0.3646 | 0.3255 | 0.3055 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.31 | 0.2363 | 0.1574 | 0.08701 | 0.03755 | 0.01164 | 0.002921 | 0.0006177 |  |  |
| 下行MSE | 1.102 | 1.072 | 0.9816 | 0.8262 | 0.6447 | 0.4946 | 0.4048 | 0.3538 |  |  |

* **DL模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.18212 | 0.13069 | 0.082229 | 0.043062 | 0.01712 | 0.004600 | 0.000828 | 0.0001133 |  |  |
| 下行MSE | 0.9351635 | 0.79858 | 0.628127 | 0.439402 | 0.27413 | 0.16098 | 0.094726 | 0.056156 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.28805244140625 | 0.2135626953125 | 0.1376962890625 | 0.0737595703125 | 0.03115654296875 | 0.0104806640625 | 0.00292939453125 | 0.0008552734375 |  |  |
| 下行MSE | 1.0110173 | 0.9399698 | 0.8171567 | 0.6395152 | 0.4653944 | 0.35694325 | 0.29922956 | 0.2694387 |  |  |

* **图像对比**
  + - BER——512x64



* + - MSE——512x64

****

* **估计BER与MSE总图**





1. 上行长度为512，功率因子0.05，preamble = 26

* **CSI==16**
* **许道峰模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.1722 | 0.1184 | 0.07139 | 0.03401 | 0.01199 | 0.002915 | 0.0004413 | 3.4e-5 |  |  |
| 下行MSE | 0.6255 | 0.5413 | 0.4361 | 0.3305 | 0.2443 | 0.1947 | 0.1698 | 0.1576 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.2291 | 0.1588 | 0.09549 | 0.04597 | 0.01661 | 0.003971 | 0.0005681 | 4.2e-5 |  |  |
| 下行MSE | 0.8223 | 0.7175 | 0.5791 | 0.4261 | 0.3036 | 0.228 | 0.1892 | 0.1695 |  |  |

* **DL模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.172908 | 0.1200823 | 0.0719867 | 0.03435961 | 0.012339 | 0.0028858 | 0.0004208 | 3.10546875e-05 |  |  |
| 下行MSE | 0.6474175 | 0.51735365 | 0.3778 | 0.237380 | 0.13557 | 0.07480 | 0.04466 | 0.028548 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.2154861328125 | 0.14958427734375 | 0.08873232421875 | 0.0429537109375 | 0.01550615234375 | 0.0038724609375 | 0.00058291015625 | 5.244140625e-05 |  |  |
| 下行MSE | 0.72713983 | 0.5777151 | 0.41697302 | 0.2720628 | 0.16599037 | 0.109470874 | 0.081065595 | 0.066237524 |  |  |

* **图像对比**
  + - BER——512x16



* + - MSE——512x16



* **CSI==32**
* **许道峰模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.1707 | 0.1181 | 0.07066 | 0.03434 | 0.0124 | 0.003073 | 0.0004799 | 4.605e-05 |  |  |
| 下行MSE | 0.7716 | 0.7086 | 0.6195 | 0.5156 | 0.4237 | 0.3636 | 0.3324 | 0.3172 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.2622 | 0.1884 | 0.1142 | 0.05609 | 0.02041 | 0.004927 | 0.0007544 | 6.78e-5 |  |  |
| 下行MSE | 1.011 | 0.9526 | 0.8372 | 0.6811 | 0.5323 | 0.4273 | 0.3709 | 0.3411 |  |  |

* **DL模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.172449 | 0.119562 | 0.071657 | 0.0341407 | 0.01170 | 0.00257749 | 0.0003083 | 2.0263671875e-05 |  |  |
| 下行MSE | 0.87508 | 0.73801 | 0.57153 | 0.386708 | 0.23332 | 0.13708 | 0.08465 | 0.05571 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.24243525390625 | 0.1705501953125 | 0.10272412109375 | 0.04943193359375 | 0.01751962890625 | 0.00423193359375 | 0.00062421875 | 5.625e-05 |  |  |
| 下行MSE | 0.9845392 | 0.85791177 | 0.6800573 | 0.4783969 | 0.31894743 | 0.22743446 | 0.18082656 | 0.15652457 |  |  |

* **图像对比**
  + - BER——512x32



* + - MSE——512x32



* **CSI==64**
* **许道峰模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.1713 | 0.1181 | 0.07153 | 0.03538 | 0.01367 | 0.003845 | 0.0007652 | 0.0001185 |  |  |
| 下行MSE | 0.8735 | 0.8336 | 0.7725 | 0.694 | 0.6188 | 0.5636 | 0.5323 | 0.5168 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.3032 | 0.2275 | 0.1469 | 0.0756 | 0.02913 | 0.007773 | 0.001473 | 0.0001966 |  |  |
| 下行MSE | 1.093 | 1.08 | 1.024 | 0.9116 | 0.7745 | 0.6611 | 0.5928 | 0.5551 |  |  |

* **DL模型**
  + - H精确

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.17203408203125 | 0.11933291015625 | 0.07203974609375 | 0.03554453125 | 0.01346240234375 | 0.0035849609375 | 0.00063125 | 7.998046875e-05 |  |  |
| 下行MSE | 0.9079402 | 0.8215456 | 0.6988634 | 0.5457253 | 0.40533248 | 0.30387303 | 0.2431174 | 0.20691687 |  |  |

* + - H由LS估计

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 信噪比/dB | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 上行BER | 0.27940546875 | 0.20327451171875 | 0.12645966796875 | 0.0636478515625 | 0.02436904296875 | 0.00674541015625 | 0.00136650390625 | 0.00021484375 |  |  |
| 下行MSE | 1.0629121 | 1.0222447 | 0.93784356 | 0.79477024 | 0.64276034 | 0.537081 | 0.47936973 | 0.44855404 |  |  |

* **图像对比**
  + - BER——512x64



* + - MSE——512x64



* **估计BER与MSE总图**



