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Performance Analysis Of Non-Orthogonal Multiple Access Technique Using Simulink

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ABSTRACT

Non orthogonal multiple access (NOMA) is a novel technology for transmission of the data with similar data-rate for users both at the cell center and the at cell edge. Due to its good cell coverage and large transmission bandwidth enables reliable communication for users located at the cell edge. The signals for the users are transmitted through entire spatial bandwidth by multiplexing in the power domain.

This work presents the Simulink implementation of non-orthogonal multiple access over additive white Gaussian noise channel, Rayleigh and Rician fading channel. The NOMA Transmitter and the receiver blocks with SIC are implemented for two user and three user environments. Multipath fading environment was providing using parameter settings available in the blocks. Performance of the models implemented are analyzed with respect to Bit error rate (BER) v/s E_b/N_o plots comparing using various modulation schemes over various channels. The results are tabulated and analyzed.

Keywords: Non-Orthogonal Multiple Access, Rayleigh Channel, Rician Channel, Successive Interference Cancellation.

1. INTRODUCTION

Among various Non-orthogonal multiple access [8] methods this work is on power domain multiple access. This technique allows the users to utilize complete bandwidth allocated by differentiating users based on power allocated to them [12],[11].

In the figure 1, multiplexing in illustrated graphically in which number of end users is considered to be two in order to have easy understanding. User 1 is allocated with high power and User-2 is allocated with low power, but frequency utilized for communication is same i.e. complete bandwidth. This provides higher data rate and latency thereby increasing Quality of Service [14].

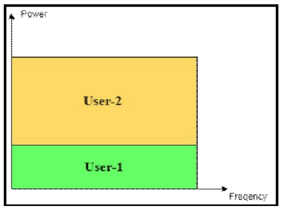

Figure 1 Power domain multiplexing in NOMA

Basic model of the NOMA system is explained with considering the two users as shown in Figure 2. The User-1 is considered near to the base station. The User-2 is located at the cell edge. Since User-1 is nearer to BS power required for transmission is less, but in-case of User-2 requires high power since, it undergoes multipath effects. The power is allocated based on the power allocation co-efficient, which is obtained based on the location of the user. The data intended for two users is transmitted over single channel. Figure 2 depicts ordinary decoding process at User-2 and SIC been implemented at User-1.

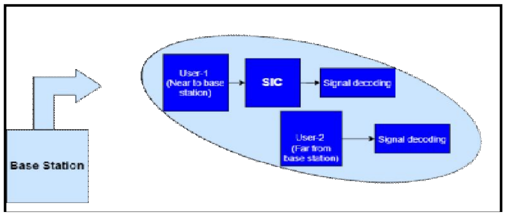

Figure 2 Basic structure of NOMA system

Since User-2 signal is allocated with high power, User-1 signal is treated as noise while retrieving data. But signal at User-1 includes User-2's high power signal which makes decoding a conundrum. Therefore, SIC comes into picture which iterative based solution in which detection and subtraction of User-2's data is done before detecting User-1's signal. This makes job easy of retrieving User-1's data.

This work provides some basic insight to fundamentals of NOMA concepts. NOMA transmitter and receiver model is developed using Simulink. Analysis is done using various modulation techniques over various propagation channels.

2.NOMA CHARACTERIZATION AND MODELING

2.1 Downlink NOMA

In downlink NOMA, at the base station Superposition Coding (SC) is employed and at the User end SIC implemented[6]. Consider data from K channels multiplexed onto single carrier using SC and SIC [2] at User side in decoding data intended for particular User in Figure (3).
In case of downlink at any user farthest user's signal is decoded first since it has been allocated with more power compared to among other users, in this process signals intended for other users is assumed as noise. Therefore, the SNR at k^{th} user is given through equation (1),

$$SNR_k = \frac{P_K\, g_k^2}{N_0 B + \sum_{i=1}^{K-1} P_i g_i^2} \qquad (1)$$

Where, *B* is the bandwidth, g_k is channel attenuation factor for channel between UE_k and BS.
Signal that will be decoded at last user nearer to the BS i.e., UE_1, the SNR at that UE is depicted in equation (2).

$$SNR_1 = \frac{P_1\, g^2{}_1}{N_0 B} \qquad (2)$$

At each user the throughput in terms of bits per second is depicted in equation (3)

$$Throughput\ at\ kth\ user = B * \log_2(1 + \frac{P_k g_k^2}{N + \sum_{i=1}^{k-1} P_i g_i^2}) \qquad (3)$$

Where, B is the bandwidth, g_k is channel attenuation factor for channel between UE_k and BS[10].

2.2. Uplink NOMA

Contrary to downlink, in uplink SIC is implemented at BS in order to decode the data from K users which is illustrated in the figure (4). SIC at BS operates with a slight difference compared to user end, at BS SIC first decodes the nearest user [2] whose SNR is shown in equation (4).

$$SNR_1 = \frac{Pg^2{}_1}{N_0 B + \sum_{i=2}^{K} Pg^2{}_i} \qquad (4)$$

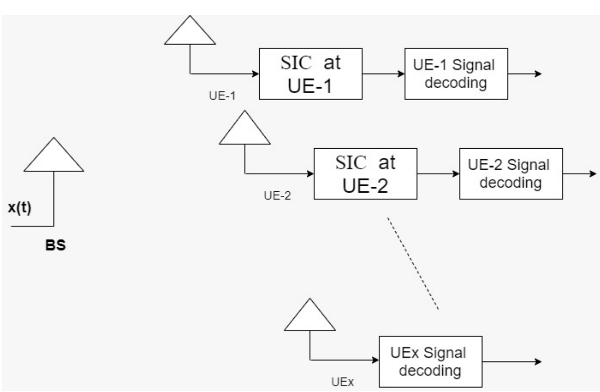

Figure 3 Downlink structure of NOMA

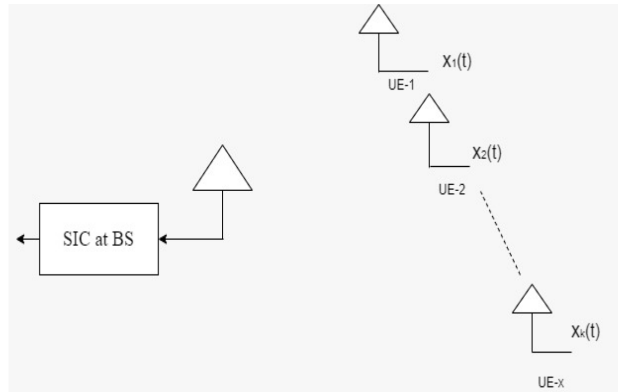

Figure 4 Uplink structure of NOMA

Contrary to downlink the last signal to be decoded will be the signal of farthest user. SNR of which can be written as in equation (5)

$$SNR_K = \frac{Pg^2{}_K}{N_0 B} \qquad (5)$$

Throughput that has to be attained in order to decode each user data is depicted in equation (6)

$$Throughput = B * \log_2(1 + \frac{Pg_k^2}{N + \sum_{i=k+1}^{K} Pg_i^2}) \qquad (6)$$

3.METHODOLOGY AND SYSTEM MODEL

The two basic principles which serve as foundations in implementing NOMA are Super Position Coding and Successive Interference Cancellation [1].

At NOMA transmitter the signals from different sources are multiplexed with different gains in powers [3]. Where power allocated for the User-2 (far user, cell edge) is more compared to power of User-1 (near user, cell center) [7]. At receiver SIC is implemented at the near user since the power allocated is small. The basic model is explained using the figure 2.

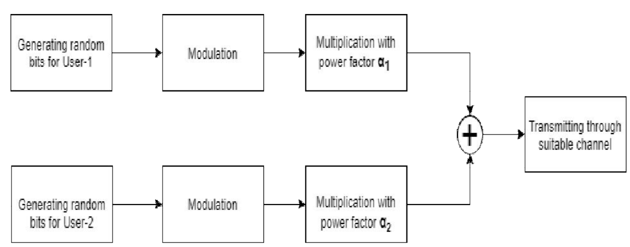

Figure 5 The basic model of NOMA transmitter.

In order to simplify analysis, here the number users under a particular BS are considered to be two. Data from individual users is subjected to encoding and modulation based on the system requirement. After modulation gains to individual user is provided based on power coefficients whose value is decided based on power allocation algorithm and channel state information.

Let 'x' be the signal transmitted by the base station. 's_1' and 's_2' be the information signals of the User-1 and User-2 respectively. 'α_1' and 'α_2' be the power allocation factor

(power coefficients). 'P' is the total power. 'p_1' and 'p_2' be the power allocated the signals of User-1 and User-2 respectively [15].
The power allocated to the User-1 and User-2 is given by equation (7) and equation (8),

$$p_1 = \alpha_1 P \quad (7)$$
$$p_2 = \alpha_2 P \quad (8)$$

The signals transmitted from the base station is given by equation (9)[5],

$$x = \sqrt{p_1}s_1 + \sqrt{p_2}s_2 \quad (9)$$

The received signal will be,

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \end{bmatrix} \quad (10)$$

$$y_i = h_i x + n \quad (11)$$

Here, y_i is the signal received at i^{th} user, h_i is channel fading Coefficient matrix and n is Additive White Gaussian Noise.

$$y_i = h_i\left(\sqrt{p_1}s_1 + \sqrt{p_2}x_2\right) + n \quad (12)$$

Assuming the SIC is ideal then UE1 signal detection is be expressed as [3],

$$\widehat{s_1} = \left\langle \frac{y_1 - \sqrt{p_2}s_2}{\sqrt{p_1}} \right\rangle \quad (13)$$

Similarly estimated symbol at UE2 is [3],

$$\widehat{s_2} = \left\langle \frac{y_2}{\sqrt{p_2}} \right\rangle \quad (14)$$

In the above implementation, the number of users considered were two, if there are *i*number of users in total and assuming perfect SIC, then the user a's signal detection at receiver can be expressed as[4]

$$s_a = \left[\frac{y_a - \left(\sum_{i=a+1}^{N} s_i\sqrt{p_i}\right)}{\sqrt{p_a}} \right] \quad (15)$$

Where, $i \epsilon$ [1, 2... N], $\langle . \rangle$ denotes decoding and demodulation of signal.

Since implementing SIC the user end, the desired signal for particular 'a' user can be denoted as[4]

$$y_a = \{h_a \times s_a\sqrt{p_a}\} + \left[h_a \times \left(\sum_{i=a+1}^{N} s_i\sqrt{p_i}\right)\right] + n \quad (16)$$

4.IMPLEMENTATION

Simulink is a graphical programming, developed by the MATLAB. This work proposes a developed Simulink model for the NOMA transmitter and receiver with AWGN, Rayleigh and Rician channel[13] utilizing modulation techniques like BPSK, QPSK and QAM[9]. In Simulink implementation series of binary bits (0 and 1) are considered as data on which signal processing operations are performed.

Power allocation coefficients to individual user are assigned manually based on assumption of near and far user.

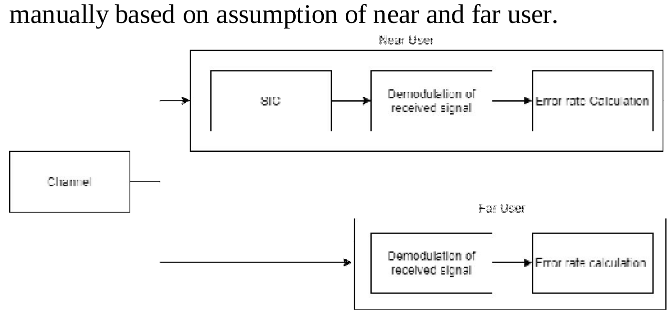

Figure 6 Basic model of NOMA receiver

4.1AWGN Channel

Figure (7) and figure (8) depicts NOMA model for AWGN channel in three user environments.

4.2Rayleigh/ Rician Fading Channel

In order to have multipath effects in the simulation environment, average path gain for UE-1 and UE-2 is fixed to 0dB and -2dB respectively. In case of three user environment, UE-1, UE-2 and UE-3 are given -2dB, -1dB and 0dB as average gain respectively. In case of rician channel, rician factor (k) is of value 3. NOMA receiver incorporates zero forcing equalizer blocks after SIC in order to nullify channel effects. Implemented models are depicted in figure (9) and figure (10).

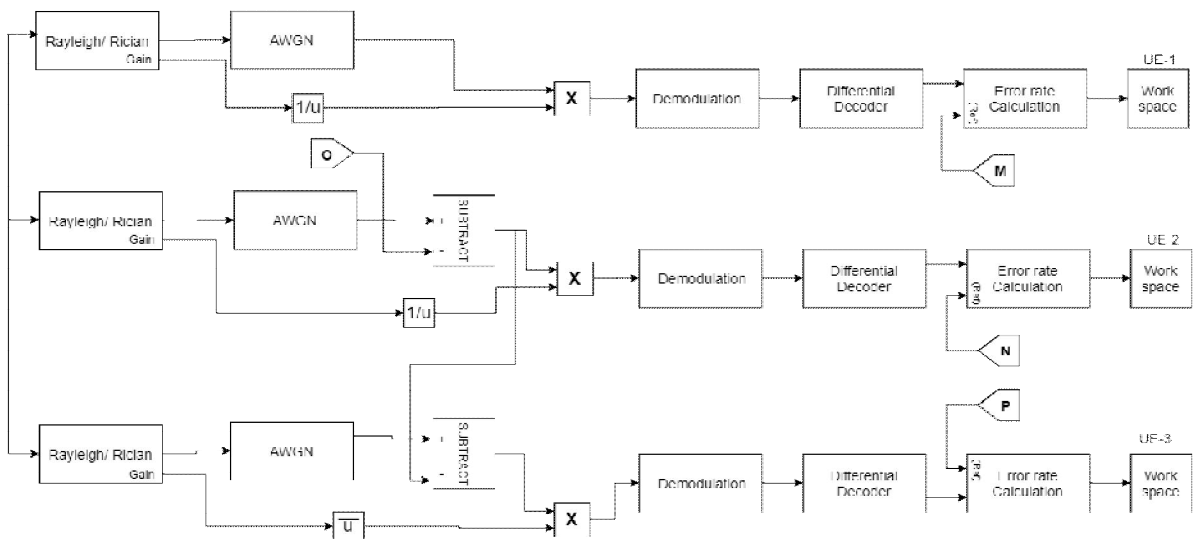

Figure 7 NOMA Receiver for Three Users in AWGN channel

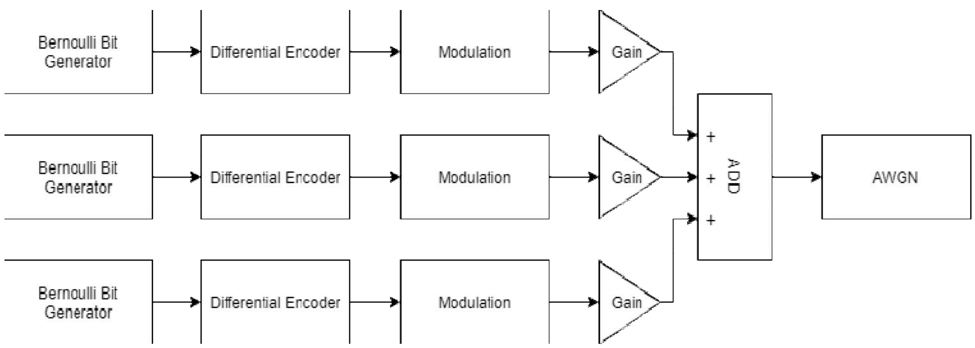

Figure 8 NOMA Transmitter for Three Users in AWGN Channel

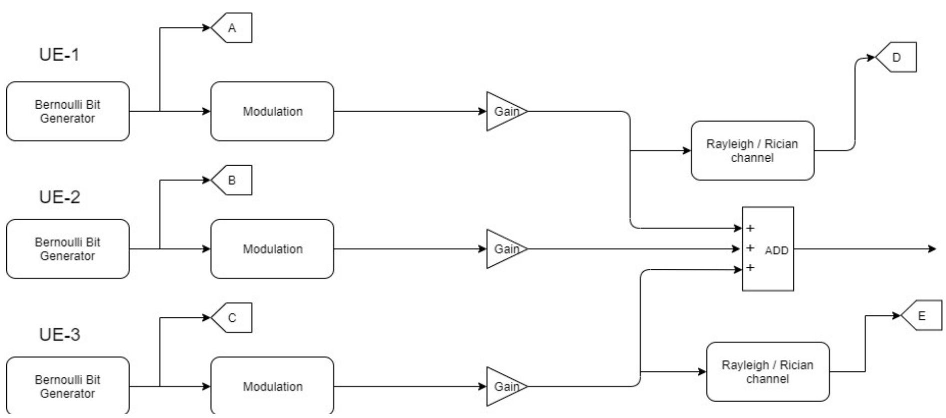

Figure 9 NOMA Transmitter for Three Users in Rayleigh/Rician Channel

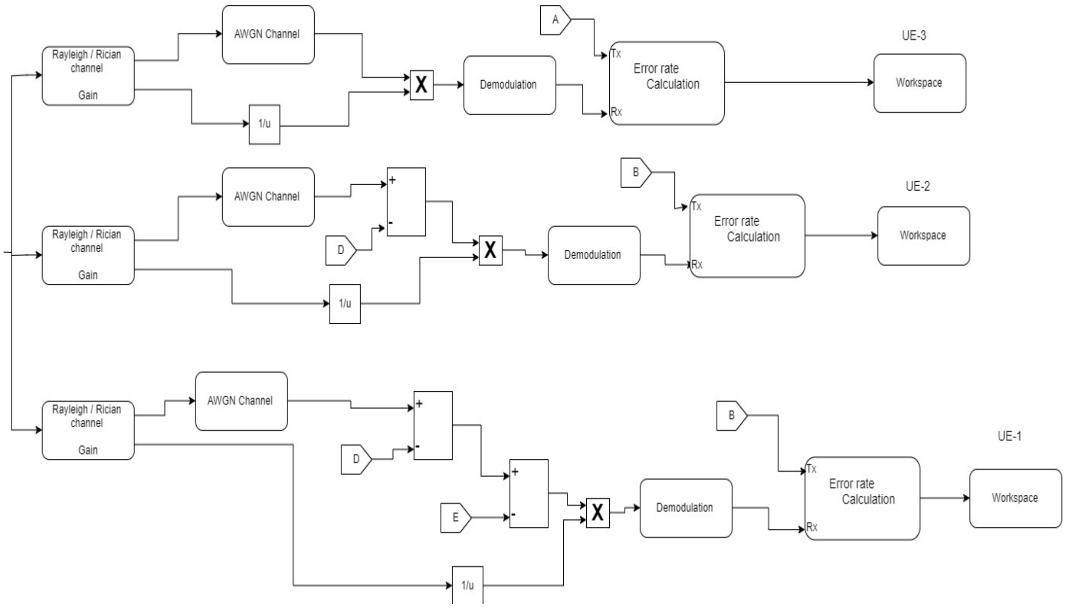

Figure 10 NOMA Receivers for Three Users in Rayleigh/Rician Channel.

5. SIMULATION RESULTS AND DISCUSSION

Using relevant tools in Simulink the results for developed models were obtained in the form of BER v/s E_b/N_o plots. Modulation techniques considered were BPSK, QPSK and 16-QAM. The model was analyzed over range power factors for both User-1 and User-2. The power factors for two user environment (UE-1, UE-2) were (0.1, 0.9), (0.2, 0.8), (0.3, 0.7) and (0.4, 0.6) respectively over all propagation channels. In-case of three user environment (UE-3, UE-2, UE-1) are (0.1, 0.3, 0.6) respectively.Analysis is performed over propagation channels like AWGN, Rayleigh and Rician channels. The results of BER obtained are tabulated in tables (1), (2), (3) and (4).In all the channels, we can observe that performance of BPSK and QPSK are almost similar. In a view to achieve least BER 16-QAM turns out to be least appreciable.

6. CONCLUSION

This work enlightened the basics of NOMA, its differentiation based on implementation i.e. either on BS or user end and proves to be most reliable technology to be implemented future new radio type. Simulation analysis was done using Simulink software. Through the results conclusion drawn is, BPSK and QPSK are most reliable modulation schemes for NOMA technique over any channel, if goal of the system design is to have least BER. As users increases in order to have efficient reception data the power coefficient difference between the users should be high.

Table 1: BER values for two user environment over AWGN channel

		POWER FACTOR		E_bN_0 (in dB)										
				0	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**
AWGN	BPSK	UE1	0.1	0.495755	0.4911751	0.4850751	0.4760752	0.4612854	0.4407856	0.4097859	0.3629764	0.302577	0.2255777	0.1463985
			0.2	0.4741553	0.4588654	0.4391356	0.4085059	0.3622864	0.301957	0.2276877	0.1421986	0.0741593	0.0252597	0.00478
			0.3	0.4462955	0.4147659	0.3743163	0.3186268	0.2478775	0.1652783	0.0886391	0.0348197	0.0079399	0.00072	4.00E-05
			0.4	0.4074459	0.3619064	0.300777	0.2270077	0.1442586	0.0720993	0.0255597	0.00464	0.00038	0	0
		UE2	0.9	0.1863081	0.1103989	0.0477795	0.0140599	0.00216	0.00018	0	0	0	0	0
			0.8	0.2366776	0.1613384	0.098279	0.0476195	0.0167198	0.00358	0.00034	0	0	0	0
			0.7	0.299277	0.2371676	0.1761382	0.1230788	0.0744793	0.0366596	0.0119199	0.00242	0.0002	0	0
			0.6	0.3605864	0.3165768	0.2846172	0.2456875	0.2104379	0.1689383	0.1219588	0.0758992	0.0369796	0.0125799	0.00234
	QPSK	UE1	0.1	0.4921902	0.4905902	0.4850503	0.4767705	0.4617708	0.4415512	0.4082018	0.3638727	0.3035039	0.2257755	0.1439571
			0.2	0.4747505	0.4602108	0.4393612	0.4075118	0.3660327	0.302184	0.2240555	0.1430571	0.0722986	0.0238395	0.0044199
			0.3	0.4462326	0.4176727	0.3751016	0.3172442	0.2460169	0.1631296	0.0867173	0.0327824	0.0073975	0.00077	2.50E-05
			0.4	0.4075018	0.3606928	0.301154	0.2243555	0.1426371	0.0733585	0.0244595	0.0046199	0.0003	2.00E-05	0
		UE2	0.9	0.1872363	0.1066579	0.047579	0.0139997	0.0027399	0.00014	0	0	0	0	0
			0.8	0.2388152	0.1633167	0.0959781	0.0450791	0.0172197	0.0033199	0.00044	4.00E-05	0	0	0
			0.7	0.299354	0.2381552	0.1749465	0.1231175	0.0725985	0.0363793	0.0115798	0.00246	0.00024	0	0
			0.6	0.3571529	0.3194036	0.2830943	0.2438851	0.2097458	0.1670367	0.1206176	0.0742785	0.0377992	0.0115198	0.0022
	16-QAM	POWER FACTOR		E_bN_0 (in dB)										
				0	**3**	**6**	**9**	**12**	**15**	**18**	**21**	**24**	**27**	**30**
		UE1	0.1	0.50129	0.49819	0.49991	0.50183	0.49867	0.4969901	0.4958501	0.50093	0.4933301	0.4732705	0.399392
			0.2	0.50147	0.4951301	0.50119	0.49827	0.4963901	0.50229	0.4910702	0.4712706	0.4048719	0.2681146	0.1131977
			0.3	0.50019	0.50193	0.50195	0.4971701	0.49791	0.4906302	0.4676506	0.3837123	0.2458751	0.0899582	0.0131197
			0.4	0.5028499	0.4955501	0.50065	0.50223	0.4945501	0.4748905	0.4034719	0.2700746	0.1106378	0.0177596	0.00076
		UE2	0.9	0.49753	0.49755	0.4866103	0.4464111	0.3424332	0.1908762	0.0611988	0.0085998	0.00028	0	0
			0.8	0.49807	0.50049	0.4897302	0.4536709	0.3657527	0.2343153	0.1075578	0.0330393	0.0042399	8.00E-05	0
			0.7	0.4967701	0.49807	0.4929901	0.4661707	0.3921522	0.2933941	0.1845963	0.099758	0.0390792	0.0061999	0.0002
			0.6	0.49897	0.5031699	0.4958701	0.4795104	0.4243115	0.3531529	0.2872743	0.2292554	0.1684766	0.1045579	0.0373593

Table 2: BER values for two user environment over Rayleigh fading channel

		POWER FACTOR		E_bN_0 (in dB)										
				0	**3**	**6**	**9**	**12**	**15**	**18**	**21**	**24**	**27**	**30**
RAYLEIGH	**BPSK**	**UE1**	**0.1**	0.5021659	0.4971676	0.4778407	0.4208597	0.3805398	0.3078974	0.20993	0.1466178	0.0919693	0.0546485	0.0273242
			0.2	0.4701766	0.4391869	0.3865378	0.311896	0.221926	0.1419527	0.0906365	0.0593136	0.0279907	0.0099967	0.0073309
			0.3	0.4191936	0.3678774	0.2899034	0.1886038	0.1326225	0.0866378	0.0453182	0.023992	0.0126624	0.0046651	0.0019993
			0.4	0.3785405	0.3018994	0.2152616	0.1359547	0.0913029	0.0533156	0.0346551	0.0113296	0.0046651	0.0019993	0.0013329
		UE2	**0.9**	0.2019327	0.1246251	0.0739753	0.041986	0.0226591	0.0079973	0.0046651	0.0019993	0	0	0
			0.8	0.2252582	0.1599467	0.1059647	0.0699767	0.0313229	0.0166611	0.0079973	0.0039987	0	0	0
			0.7	0.2885705	0.2005998	0.137954	0.0946351	0.0593136	0.0353216	0.0206598	0.0093302	0.0033322	0.0019993	0.0006664
			0.6	0.3678774	0.2992336	0.2559147	0.1946018	0.1312896	0.0846385	0.0619793	0.0233256	0.0133289	0.0093302	0.0013329
	QPSK	**UE1**	**0.1**	0.4919005	0.4848343	0.4689687	0.4420039	0.3991067	0.325445	0.2389174	0.1574562	0.0946937	0.0525965	0.0266649
			0.2	0.465469	0.4437704	0.3970402	0.3279448	0.2387841	0.1636891	0.0962602	0.0527298	0.0255316	0.0129325	0.0063329
			0.3	0.4317379	0.3874408	0.3103793	0.2238517	0.1429571	0.0866609	0.0469969	0.024265	0.0125325	0.0057996	0.0028665
			0.4	0.3967402	0.3261783	0.2389507	0.154723	0.0940937	0.0530298	0.0263316	0.0145324	0.0076662	0.0028665	0.0012666
		UE1	**0.9**	0.2133524	0.1367242	0.0777282	0.0445304	0.0214652	0.0109993	0.0057996	0.0027332	0.0012666	0.0004666	0.0002
			0.8	0.2544164	0.174455	0.1065262	0.0607959	0.0328645	0.0179321	0.0083994	0.0039331	0.0013332	0.0007333	0.0003333
			0.7	0.3099127	0.2306513	0.1598227	0.1029265	0.0590294	0.0332644	0.0157989	0.0080661	0.0038664	0.0019332	0.0008666
			0.6	0.3649757	0.3151123	0.2614492	0.2047863	0.145657	0.0898607	0.0554296	0.0300647	0.0150657	0.0072662	0.0032664
	16-QAM	**UE2**	**0.1**	0.5154799	0.5002504	0.501003	0.5040363	0.4830754	0.5045455	0.4854227	0.4861314	0.4779904	0.4518318	0.3425926
			0.2	0.4947994	0.5028841	0.49529	0.5081384	0.5063355	0.502768	0.4885086	0.4455843	0.3409556	0.206533	0.1481317
			0.3	0.4894737	0.5120451	0.521671	0.4809822	0.4840116	0.4696756	0.4256498	0.3299207	0.1914527	0.1440519	0.0952
			0.4	0.5035282	0.5211268	0.4814458	0.4901865	0.4676966	0.4530612	0.3333333	0.210804	0.1297214	0.0995019	0.0581801
		UE2	**0.9**	0.4916339	0.4705596	0.4570568	0.4421053	0.322365	0.2493958	0.1548323	0.099108	0.0568906	0.0266094	0.010749
			0.8	0.5007603	0.4846348	0.4950348	0.420241	0.3537924	0.2746653	0.191924	0.1088619	0.0644286	0.0184332	0.0142708
			0.7	0.5030211	0.5020101	0.4787908	0.4276181	0.4011185	0.32	0.2133603	0.1330214	0.0610119	0.049677	0.023
			0.6	0.4889447	0.5184224	0.4741551	0.4559256	0.4218316	0.3463222	0.2970568	0.2169381	0.152916	0.117654	0.07731

Table 3: BER values for two user environment over Rician fading channel

		POWER FACTOR		E_bN_0 (in dB)										
				0	**3**	**6**	**9**	**12**	**15**	**18**	**21**	**24**	**27**	**30**
RICIAN	**BPSK**	**UE1**	**0.1**	0.49676	0.48756	0.47696	0.45108	0.41296	0.34596	0.26052	0.16856	0.08912	0.04528	0.01848
			0.2	0.4778	0.45292	0.4122	0.34832	0.25904	0.16752	0.08784	0.04272	0.01972	0.00812	0.00312
			0.3	0.44912	0.40508	0.33372	0.24372	0.15172	0.08012	0.03828	0.01648	0.00704	0.00272	0.00096
			0.4	0.414	0.3508	0.25688	0.1682	0.0898	0.042	0.02004	0.00736	0.00328	0.0012	0.00048
		UE2	**0.9**	0.23112	0.1416	0.07132	0.03456	0.0148	0.00604	0.00308	0.00084	0.0002	4.00E-05	0
			0.8	0.26928	0.18356	0.1088	0.0532	0.0258	0.01108	0.00436	0.0016	0.0006	0.00032	0
			0.7	0.31536	0.24428	0.1722	0.10312	0.0528	0.02564	0.0114	0.00484	0.00168	0.00052	0.00024
			0.6	0.38252	0.32948	0.27548	0.21344	0.1556	0.09552	0.05104	0.0246	0.01028	0.00468	0.00216
	QPSK	**UE1**	**0.1**	0.4970626	0.4861753	0.4770881	0.4528512	0.4122397	0.3442664	0.2509187	0.1525712	0.0770481	0.0348491	0.0151496
			0.2	0.4755756	0.4534762	0.4122397	0.341354	0.2522937	0.1540961	0.078998	0.0352991	0.0144746	0.0053499	0.002
			0.3	0.4443514	0.398615	0.3289168	0.2337192	0.1390715	0.0675483	0.0298493	0.0126747	0.0047999	0.001825	0.000675
			0.4	0.4156056	0.3481768	0.2645157	0.1719219	0.089394	0.0389974	0.0141324	0.0045997	0.0006666	6.67E-05	0
		UE2	**0.9**	0.2162446	0.1262718	0.0629734	0.0292743	0.0113247	0.0040749	0.0017	0.000625	0.0003	0	0
			0.8	0.2610435	0.1714957	0.0939227	0.0442489	0.0194495	0.0083248	0.0026999	0.001	0.00045	0.000275	2.50E-05
			0.7	0.3151671	0.2346941	0.158671	0.0906227	0.0445739	0.0209745	0.0082998	0.0032249	0.001025	0.00055	0.000225
			0.6	0.3787747	0.3286448	0.279448	0.2174522	0.1525232	0.0944604	0.0505966	0.0209986	0.0071329	0.0023332	0.0003333
	16-QAM	**UE1**	**0.1**	0.487645	0.522763	0.5160124	0.5002504	0.4759409	0.5045455	0.50788	0.5037821	0.4897059	0.4798271	0.4847162
			0.2	0.4785	0.4922693	0.4896245	0.4777007	0.4943097	0.5002504	0.4950446	0.5053111	0.4625	0.380137	0.1853432
			0.3	0.5146832	0.4904523	0.4994813	0.4693267	0.5045455	0.4885086	0.4798271	0.4563728	0.3610408	0.1597889	0.0764
			0.4	0.4818627	0.5092025	0.495	0.5005139	0.5050556	0.4854227	0.468135	0.3713755	0.187006	0.0827426	0.0319386
		UE2	**0.9**	0.4977511	0.4816514	0.4959839	0.4553967	0.4129406	0.3418217	0.222668	0.1368631	0.0536513	0.0223518	0.001938
			0.8	0.5065923	0.5178849	0.4943097	0.4853161	0.4528208	0.3540916	0.2529833	0.1680926	0.0771734	0.0244716	0.004221
			0.7	0.5071066	0.490835	0.478666	0.4823411	0.4525994	0.4004975	0.3078412	0.2063492	0.1193584	0.0348584	0.0114
			0.6	0.4904137	0.4918759	0.4784154	0.5133607	0.4561572	0.4260327	0.3793578	0.3001514	0.1994808	0.1180711	0.0743857

Table 4: BER values for three user environment over AWGN , Rayleigh and Rician channels

		POWER FACTOR		$E_b N_0$ (in dB)										
				0	2	4	6	8	10	12	14	16	18	20
AWGN	BPSK	UE3	0.6	0.2199778	0.1790682	0.1414886	0.1076289	0.0785792	0.0563594	0.0342097	0.0205298	0.0096099	0.003	0.0006
		UE2	0.3	0.3369266	0.299307	0.2545375	0.2087079	0.1588984	0.1126189	0.0716093	0.0405096	0.0191598	0.0064799	0.00111
		UE1	0.1	0.4453455	0.4328257	0.4114459	0.3908461	0.3590464	0.3271667	0.2847372	0.2401676	0.1868081	0.1322987	0.0791392
	QPSK	UE3	0.6	0.2197856	0.1806364	0.1392672	0.1070979	0.0779084	0.0556389	0.0363893	0.0189496	0.0091598	0.0027999	0.00052
		UE2	0.3	0.3380132	0.300674	0.2539649	0.2071859	0.1577568	0.1100278	0.0710086	0.0388992	0.0192896	0.0063599	0.0013
		UE1	0.1	0.4436211	0.4277214	0.4108418	0.3907722	0.3611228	0.3298834	0.2872043	0.2422052	0.1861763	0.1300474	0.0769285
	16-QAM	UE3	0.6	0.7799622	0.702533	0.599524	0.4726853	0.3423866	0.2274777	0.1479385	0.095249	0.0569194	0.0282497	0.0103199
		UE2	0.3	0.8845812	0.8569014	0.8156018	0.7537325	0.6643334	0.5433446	0.404776	0.2580474	0.1385886	0.0599394	0.0205498
		UE1	0.1	0.9259007	0.9199808	0.9124109	0.901741	0.8830412	0.8567714	0.8147419	0.7508525	0.6585334	0.5334847	0.3806062
RAYLEIGH	BPSK	UE3	0.6	0.2014925	0.1402542	0.0970958	0.0568445	0.033189	0.0153181	0.0093344	0.0032573	0.0018223	0.0004737	0.0004545
		UE2	0.3	0.4005602	0.3651832	0.3273885	0.2618957	0.209934	0.1774256	0.1546434	0.1416562	0.1165289	0.1068005	0.0763033
		UE1	0.1	0.4582951	0.4319654	0.3889537	0.3963535	0.3785011	0.3976143	0.4051864	0.4152824	0.4255319	0.4608295	0.4595588
	QPSK	UE3	0.6	0.2374005	0.2007909	0.1323283	0.08603	0.0572267	0.0376845	0.0190779	0.0138249	0.0061872	0.0025381	0.0008425
		UE2	0.3	0.3533271	0.2989601	0.2408907	0.1725191	0.1285301	0.0912519	0.0516717	0.0310263	0.0171451	0.0082781	0.0033985
		UE1	0.1	0.4721435	0.4509009	0.4245123	0.390625	0.3776435	0.3808073	0.3765989	0.3841136	0.405515	0.4051864	0.4215852
	16-QAM	UE3	0.6	0.8374205	0.7778777	0.6940559	0.5983122	0.4575214	0.3434343	0.2459119	0.195831	0.1463296	0.0828866	0.0411061
		UE2	0.3	0.88899	0.8523852	0.82662	0.7539749	0.6674491	0.535461	0.4229129	0.3162534	0.2466137	0.1481778	0.077956
		UE1	0.1	0.8984726	0.8849558	0.8888889	0.8340284	0.785546	0.7127584	0.6024096	0.5437738	0.4670715	0.3930818	0.3527337
RICIAN	BPSK	UE3	0.6	0.2801887	0.2326986	0.1693305	0.1171285	0.0719844	0.0397326	0.022206	0.007573	0.0039032	0.0003905	0
		UE2	0.3	0.3992395	0.3647321	0.2954152	0.2268557	0.1717909	0.1170058	0.063304	0.03766	0.0167286	0.0071118	0.0008278
		UE1	0.1	0.4878049	0.4422822	0.448833	0.4332756	0.3892565	0.3625816	0.3576538	0.363901	0.4043672	0.3863988	0.4081633
	QPSK	UE3	0.6	0.2881818	0.2286229	0.1707942	0.1064189	0.0721003	0.0398956	0.0233711	0.0116034	0.0018382	0.0015686	0.0004102
		UE2	0.3	0.3880037	0.3348778	0.2941953	0.2171053	0.1598017	0.1064227	0.0631032	0.0342219	0.0155657	0.0059856	0.0016793
		UE1	0.1	0.4868549	0.4591368	0.4241525	0.4016064	0.3785011	0.3443526	0.3652301	0.3641661	0.3843198	0.4009623	0.4255319
	16-QAM	UE3	0.6	0.8511797	0.8052536	0.733156	0.6680815	0.5321782	0.4160866	0.3207687	0.2549269	0.1871412	0.098989	0.054352
		UE2	0.3	0.8962351	0.8760036	0.8327526	0.7963605	0.7329451	0.6345412	0.5420495	0.4608586	0.3329552	0.1912592	0.1196422
		UE1	0.1	0.9157509	0.9017133	0.8795075	0.862069	0.8176615	0.7558579	0.7072136	0.6414368	0.5396654	0.45106	0.3729952

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