Transinformation of MPSKSC Diversity System in Weibull Fading

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Abstract – **In this paper, we analyze the diversity reception of phase-shift keying signals transmitted over Weibull fading channel. Selection combining (SC) of the signals is used on the reception. By means of computer simulation, transinformation and bit error rate are determined and constellation diagrams are drawn. The effects of the number of receiving antennas and fading depth on this system performance are observed.**

Keywords– **Phase-Shift Keying, Fading, Selection combining, Transinformation.**

I. INTRODUCTION

The development of wireless communication has exceeded the limits of the initial expectations becoming an indispensable part of modern life. There is a constant aspiration for greater date transfer and better services that are used in wireless communications.

In wireless communication, the variation of instantaneous value of the received signal, i.e. fading is one of the main causes of performance degradation. Diversity technique is certainly one of the most commonly used methods for minimizing fading effect and increasing the communication reliability without enlarging either transmitting power or bandwidth of the channel [1, 2]. In this paper diversity technique with selection combining (SC) is observed because its practical implementation simplicity.

The Weibull distribution is a flexible statistical model for describing multipath fading channels in both indoor and outdoor radio propagation environments. When the number of incoming radio paths is limited, the Rayleigh distribution may not be an appropriate fading model. Some evidence indicates that the signal amplitude can be well described by Weibull distribution in this situation. [3, 4]

In [5] the symbol error rate performance of dual-branch switched and stay combining (SSC) receivers in Weibull fading environment is studied.Paper [6] analyzes the performance of L-branch selection combining receiver over correlated Weibull fading channels in the presence of correlated Weibull-distributed cochannel interference.

While previously mentioned papers considered the error rate performance of different signal detection in Weibull fading, we evaluate transinformation in Weibull channel during Binary Phase-Shift Keying (BPSK) and Quadrature Phase-Shift Keying (QPSK) transmission while multibranch SC is applied.

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II. SYSTEM MODEL

Signal is transmitted from the transmitter to the receiver via channel with Weibull fading. The received signal envelope can be described by Weibull distribution given by

$$f_r(r) = \frac{mr^{m-1}}{\gamma}\exp\left[-\frac{r^m}{\gamma}\right], \quad m > 0, \quad r \geq 0, \quad (1)$$

where the index *m* is called the Weibull fading parameter and γ is a positive parameter related to the moments and the fading parameter. The more the value of parameter *m*, the less fading severity is.

Diversity techniques are applied to combine the multiple received signals of a diversity reception device into a single improved signal. Receiver with SC technique processes only one of the diversity branches, and because of that it is simpler for practical realization than maximum ratio combining (MRC) and equal gain combining (EGC) techniques. Assuming that noise power is equally distributed over branches, selection combining selects the branch with the highest signal-to-noise ratio (SNR), which is the branch with the strongest signal (see Fig. 1).

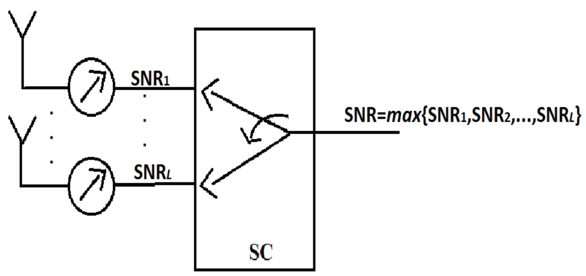

Fig. 1. Diversity receiver with selection combining scheme

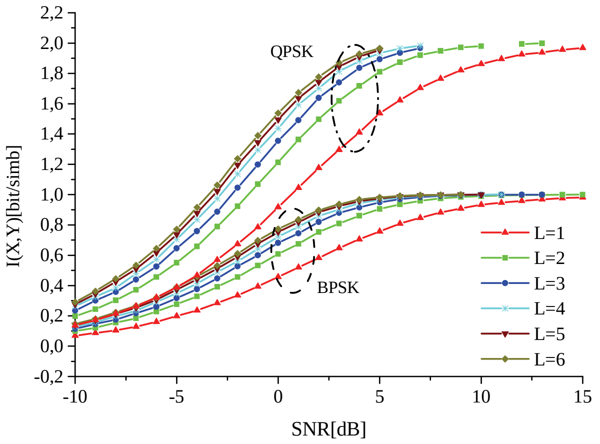

Fig. 2. Transinformation dependence on average SNR for different values of diversity order in Weibull channel with the Weibull fading parameter *m*=1.5

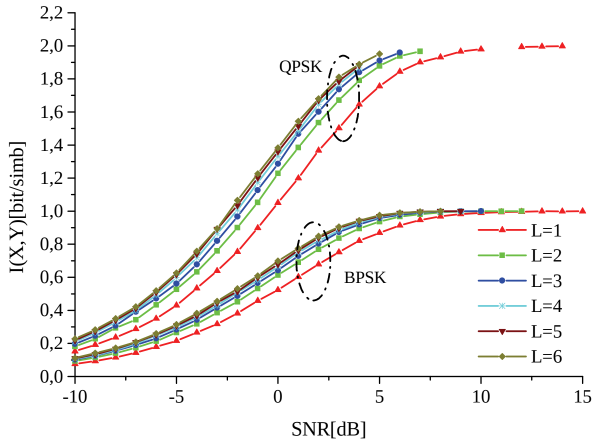

Fig. 3. Transinformation dependence on average SNR for different values of diversity order in Weibull channel with the Weibull fading parameter *m*=3

III. Performance Determination and Results

A. Transinformation

In this section it will be consider how transinformation depends on SNR [dB] in Weibull channel during BPSK and QPSK modulation. It will be also observed the effect of increasing the number of reception branches of SC combineron transinformation during BPSK transfer.

Transinformation can be calculated as difference between the average self-information of shipping list *X*, denoted by *H*(*X*), and equivocation, denoted by *H*(*X*/*Y*) and it is given by [7-9]:

$$I(X,Y) = H(X) - H(X/Y). \quad (2)$$

H(*X*)describes the measure of uncertainty about the random process *X* that the potential user has before the begining of transfer[7-9]:

$$H(X) = \sum_{i=1}^{m} P(x_i) ld \frac{1}{P(x_i)}. \quad (3)$$

The entropy of variable *Y* conditional on the variable *X* taking a certain value *x*represents average uncertainty about *X* list after receiving a symbol from *Y* list and it is given by [7-9]:

$$H(X/y_j) = \sum_{i=1}^{m} P(x_i/y_j) ld \frac{1}{P(x_i/y_j)}. \quad (4)$$

Equivocation illustrates the average user uncertainty about shipping list *X* when all symbols from *Y* list are received. It is given by [7-9]:

$$H(X/Y) = \sum_{j=1}^{r} P(y_j) H(X/y_j). \quad (5)$$

These formulas are used to calculate transinformation for different values of SNR.

Fig. 2 shows transinformation dependence on SNR in Weibull channel with *m*=1.5 during BPSK and QPSK signal transmission with selection combining on the reception during which the order of combiner is different (*L*=1-6). The same is given in Fig. 3, except for the parameter *m*=3. In Fig. 2, the transinformation values of different diversity order *L*for the same SNR can be read for BPSK. For SNR=5 dB, *I*(*X*,*Y*)=0.7573 bit/simb for *L*=1 and *I*(*X*,*Y*)=0.9824 bit/simb for *L*=6. It is noticed that when the diversity order is increased, the value of transinformation is higher. In Fig. 3, the same characteristics are read. For SNR=5 dB, *I*(*X*,*Y*)=0.8693bit/simb for *L*=1 and *I*(*X*,*Y*)=0.9751bit/simb for *L*=6. It is shown that transinformation is increased for 0.2251 bit/simb when the number of branches in SC reception is increased from 1 to 6, for SNR=5 dB when the Weibull fading parameter *m*=1.5 during BPSK transmission. When the Weibull fading parameter has the value *m*=3, the transinformation is increased for 0.1058 bit/simb. We can see that transinformation is more increased when the Weibull fading parameter *m* is lower, while the number *L* of SC branches is increasing for the same SNR. The conclusions for

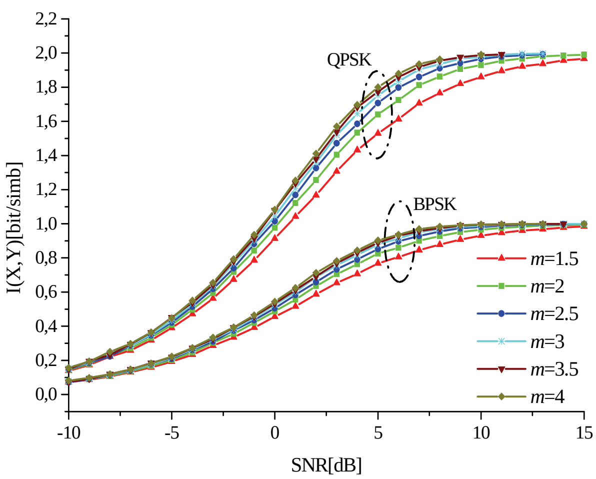

Fig. 4. Transinformation dependence on average SNR in Weibull channel withdifferent values of the Weibull fading parameter (*L*=1)

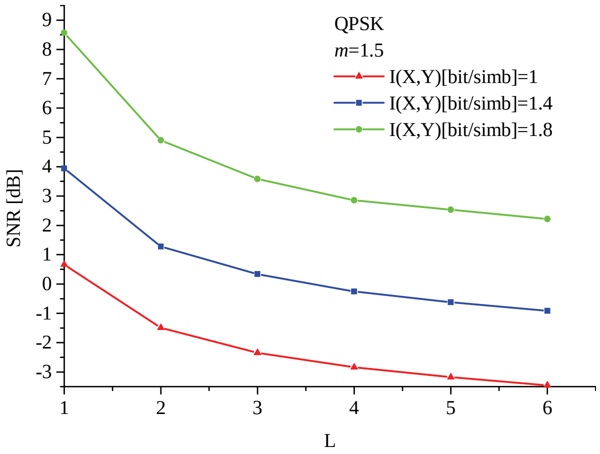

Fig. 5. Required SNR dependence on diversity order *L* in order to achieve given value of transinformation

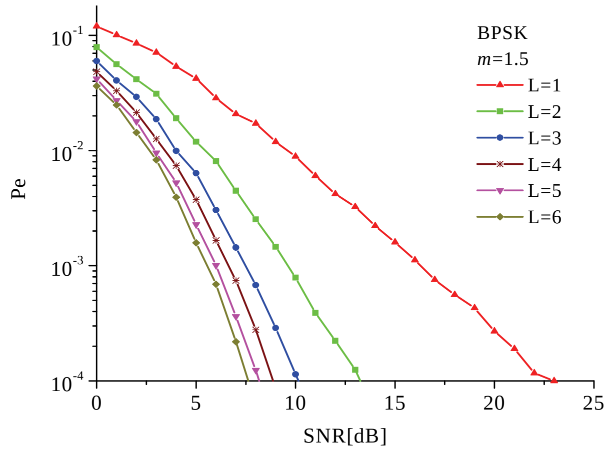

Fig. 7. Bit Error Rate dependence on average SNR for different values of diversity order in Weibull channel

QPSK are the same as for BPSK: the increase in the number of diversity order of SC combiner influences the increase in the value of transinformation and transinformation is more increased when the Weibull fading parameter *m* is lower, while the number *L* of SC branches is increasing for the same SNR.

In Fig 4. transinformation dependence on average SNR is shown during transmission of BPSK and QPSK signals over Weibull channel with different values of the Weibull fading parameter *m*. It is noticed that with the increase in Weibull fading parameter *m*, the transinformation is increased for the same values of SNR.

Fig. 5. shows the SNR dependence on diversity order for different values of transinformation in Weibull channel with *m*=1.5 for QPSK. In order to achieve transinformation of 1.8 bit/simb, if the number of the branches *L* is increased from 1 to 2, the required value of SNR is decreased from 8.5 to 5 dB. When the SC diversity order *L* is increased from 5 to 6, the required value of SNR is decreased from 3 to 2.5 dB. It means that if the SC diversity order is increased from 1 to 2, the value of the signal is lower for 3.5 dB (assuming that noise power is equally distributed over the branches), and when the SC diversity order is increased from 5 to 6, the value of the signal is lower for 0.5 dB. It is noticed that the gain in the signal strength is lower with higher SC diversity order.

The dependence shown in Fig. 6. shows how the Weibull fading parameter *m*influences on the SNR. We can notice that increasing the parameter *m* leads to lower signal strength if the value of transinformation is not changed. If we want a higher transinformation value, and the parameter *m* is same, we need a stronger signal (SNR, if the noise power is equal).

B. Bit Error Rate and Constellation Diagrams

In this section the influence of the number of SC receiving antennas *L* on it error rate (P_e) is observed. The results are presented in the graphs that show the probability of error dependence on SNR.

The bit error rate dependences on average SNR for different values of diversity order for BPSK in Weibull channel with the *m*=1.5 and *m*=3 are shown in Figs. 7 and 8.

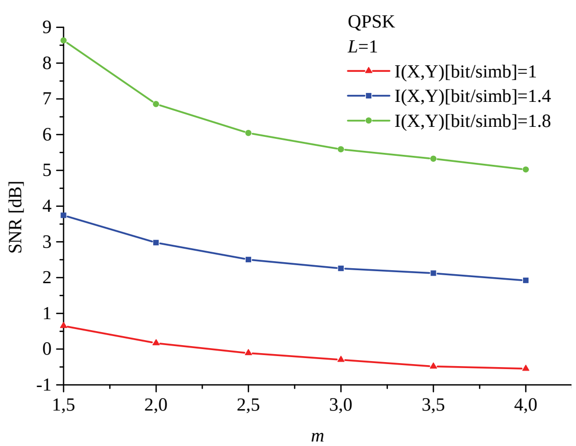

Fig. 6. Required SNR dependence on the Weibull fading parameter *m*in order to achieve given value of transinformation

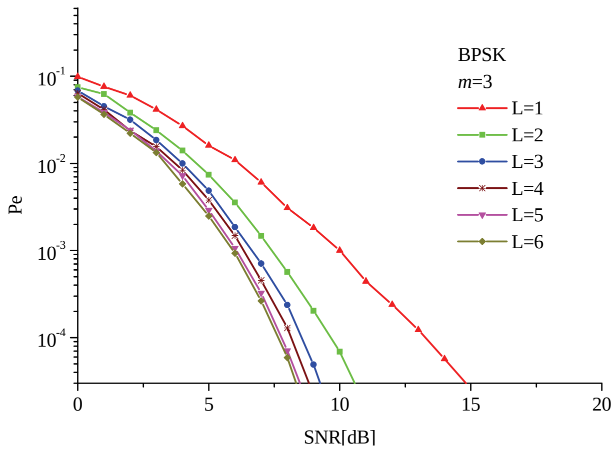

Fig. 8. Bit Error Rate dependence on average SNR for different values of diversity order in Weibull channel

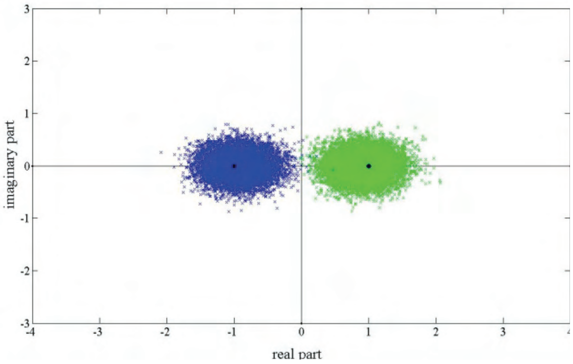

Fig. 9. Constellation diagrams for BPSK in Weibull channel with the Weibull fading parameter *m*=3 for *L*=1

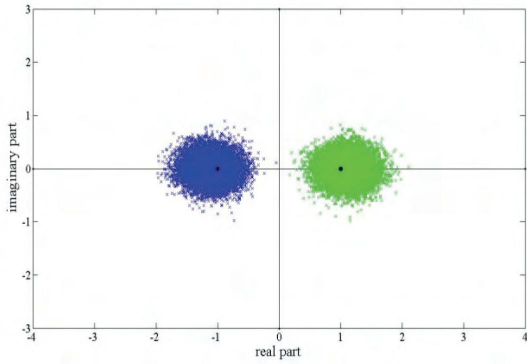

Fig. 10. Constellation diagrams for BPSK in Weibull channel with the Weibull fading parameter *m*=3 for *L*=4

By examining this results, we can notice that bit error rate is decreased when the diversity order is increased.

These results are confirmed by constellation diagrams. Constellation diagrams are suitable for graphical display of possible states, and for the influence of diversity order on decision-making. Constellation diagrams for BPSK in Weibull channel with the parameter *m*=3 for diversity orders *L*=1 and *L*=4 of selection combining are given in Figs. 9. and 10.

Black dots in these graphics show two possible states 0 and 1, which are different for π radians. Green and blue dots are 10.000 possible values on the reception, when 0 and 1 are sent. The black line represents the threshold of decision between the two states. It is noticed that abstraction of points around central value is lower when the order of SC diversity technique is higher (Abstraction of points is lower in the case *L*=4 then *L*=1). For higher number of branches in SC receiver, bit error rate is reduced, because fewer dots are crossing the limit of decision.

IV. Conclusion

In this paper we have analysed performance of SC receiver for BPSK and QPSK signals transmitted over Weibull fading channel. The effects of the number of receiving antennas and fading depth on this system performance are observed. It is noticed that the increase of the diversity order of SC receiver influences the increase in the values of transinformation. Also, it is noticed that the value of transinforamtion is more increased when the Weibull fading parameter *m* is lower. This is valid for both PSK transmitions.

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