UDC 621. 391
doi:10.31799/1684-8853-2023-1-61-70
EDN: PCFDIS

Articles

Signal detection amid noise using order statistics: detector sensitivity analysis and parameter choice

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Introduction: *Developing physical level techniques for machine type communications is a challenging task. In particular developing low complexity channel estimation with acceptable precision or maintaining accurate power control is cumbersome. One possible way to solve this problem is to use the reception techniques based on order statistics that do not require any form of channel estimation or power control. This paper deals with a communication system that uses frequency shift keying in a dynamically allocated instantaneous frequency band and an order-statistics-based receiver previously proposed by the author.* ***Purpose:*** *To analyze the sensitivity of the system under consideration to both noise and interference power variation and to explore the receiver parameter choice.* ***Results:*** *Simulation-based capacity analysis demonstrates that the receiver is resistant to signal-to-noise variations and thus can provide the desired performance even if the signal of the user under consideration is subject to drastic power variation. It is demonstrated that the number of possible symbol values being assigned maximum reliability optimized for the worst case number of users yields capacity close to optimal for a lower number of users. Finally, simulation confirms that the performance of the communication system under consideration is not dependent on the choice of reliability values. Thus values that minimize hardware complexity can be chosen.* ***Practical relevance:*** *The results obtained prove that the detector under consideration is practically usable and can be applied in a variety of real-life scenarios. The hardware complexity can be minimized while preserving the performance.*

Keywords *— machine type communications, frequency hopping, dynamically allocated hopset, noncoherent reception, α-detector, channel capacity.*

For citation: Osipov D. S. Signal detection amid noise using order statistics: detector sensitivity analysis and parameter choice. *Informatsionno-upravliaiushchie sistemy* [Information and Control Systems], 2023, no. 1, pp. 61–70. doi:10.31799/1684-8853-2023-1-61-70, EDN: PCFDIS

Introduction

Machine-type communications (MTC) are expected to play prevailing role in the future communication systems development [1, 2]. The signals transmitted in these systems are subject to severe mixed interference that is due to both multi-user interference and background noise. Thus channel estimation with desired precision requires high computational complexity [3, 4]. Power control is also very challenging [5–7] since closed loop methods cannot be used due to limitations on packet size and energy consumption as well as the burst-like traffic. Thus traditional techniques that are used in conventional digital communications systems turn out to be ill-suited for the problem in question. There are basically two approaches to address the problem. The first one makes use of the blind or semi-blind detection techniques with error correction coding and interference cancellation in order to enable multi-user reception [8–10]. Despite the many attractive features this approach enjoys interference cancellation leads to error propagation risk and requires the information on the number of active users. Successive interference cancellation also leads to increased delay that can be undesirable especially in critical machine type communications. Another approach is to use single user reception techniques that can withstand severe interference. In recent decades several order statistics-based reception techniques that meet this requirement were proposed in [11–15].

This paper deals with the α-detector proposed in [15] for the communication system that will be described in the following section. The α-detector is an order statistics-based receiver that uses only measurements obtained from the channel (powers of the signals) and avoids using any kind of side information by using measurements ordering only and assigning one reliability value to the α possible symbol values that correspond to signals with greatest powers and another to the remaining $q - \alpha$ ones, then using the reliability values in question for soft-input decoding of the error correction code in use. Thus both the value of the parameter α and the reliability values are to be chosen. Herein below the way those parameters are chosen affects the performance of the system is studied and the ways to choose those parameters in optimal way are revealed. The paper also deals with the problem of the system sensitivity to both multi-user interference and background noise power variations. Although some results on the matter were obtained as a by-product in [16–17] this problem has never been studied comprehensively.

Transmission and reception

Let us consider a single user reception in an uplink transmission scenario. Apart from the user under consideration K active users are assumed to transmit to the base station (following [15] those will be referred to as "interfering"). Each of the K active users is assumed to transmit codewords of an $C(N, k, d)$ code, each symbol of the codeword being mapped into a weight 1 vector of length q. Thus each codeword is mapped into a binary matrix $\mathbf{M}$ of the size $q \times N$. Each column of $\mathbf{M}$ contains a weight 1 vector. The matrix $\mathbf{M}$ is then complemented with an all-zero matrix $\mathbf{Z}$ of the size $(q - Q) \times N$:

$$\tilde{\mathbf{M}} = \begin{bmatrix} \mathbf{M} \\ \mathbf{Z} \end{bmatrix}.$$

The matrix $\tilde{\mathbf{M}}$ is then permuted column-wise (permutations are assumed to be independent, equiprobable and pseudo-random) and transmitted via the channel using OFDM.

The reception starts with the reception of N OFDM symbols corresponding to the codeword and inverse permutations of the corresponding columns in frequency domain. The receiver then extracts the first q rows of the resulting matrix and squares its elements to obtain the matrix $\mathbf{\Omega}$.

The α-detector

The α-detector has been proposed in [15]. It is convenient to consider the performance of the detector in question as a two stage process. Within the first stage reliability estimates for each symbol are to be assigned. The α-detector assigns reliability value λ_1 to the α possible values of the symbols that corresponds to the α subcarriers with greatest energies λ_0 to the remaining $q - \alpha$ ones. The second stage boils down to aggregating reliability estimates of the symbols to compute reliability estimates for each codeword and choosing a codeword with maximum reliability. Thus the α-detector is essentially a soft-input order statistics-based decoder/demodulator. To introduce the detector in question in a more formal way let us derive $\mathbf{\Omega}^{\downarrow}$ — the matrix obtained by sorting the matrix $\mathbf{\Omega}$ column-wise in descending order. Each element of the matrix of the reliability estimates $\mathbf{D}_{(\alpha,\lambda_0,\lambda_1)}$ is given by

$$\mathbf{D}_{(\alpha,\lambda_0,\lambda_1)}(t, z) = \begin{cases} \lambda_0 & \mathbf{\Omega}(t, z) < \mathbf{\Omega}^{\downarrow}(t, \alpha) \\ \lambda_1 & \mathbf{\Omega}(t, z) \geq \mathbf{\Omega}^{\downarrow}(t, \alpha) \end{cases},$$

where t is the column number; z is the row number; $\mathbf{\Omega}^{\downarrow}(t, \alpha)$ is the α greatest element of the t-th column, and $\lambda_1 > \lambda_0 \geq 0$, where λ_1 is the reliability assigned to the α possible values of the t-th symbol corresponding to α greatest elements of the column and λ_0 is the reliability of the remaining $q - \alpha$ values.

The decoder then computes the reliability estimate for the g-th codeword

$$S_g = \sum_{j=1}^{q} \sum_{k=1}^{N} \left(\mathbf{D}_{(\alpha,\lambda_0,\lambda_1)}(j, k) \cdot \mathbf{X}_g(j, k) \right), \qquad (1)$$

for each codeword and chooses

$$g^* = \arg \max_{g \in [1,\ldots,M]} S_g, \qquad (2)$$

where g^* is the set of numbers of codewords that correspond to maximal reliability value. If $|g^*| = 1$, i.e. there is only one such codeword, the detector declares this codeword to be the decoded codeword. Otherwise decoding failure is declared.

An equivalent (α, *p*)-channel and its capacity

The reception process described above corresponds to the vector channel depicted in Fig. 1. In the following section an equivalent (α, p)-channel introduced in [16] will be considered. In our consideration of the channel in question we follow notation introduced in [17].

Let us define

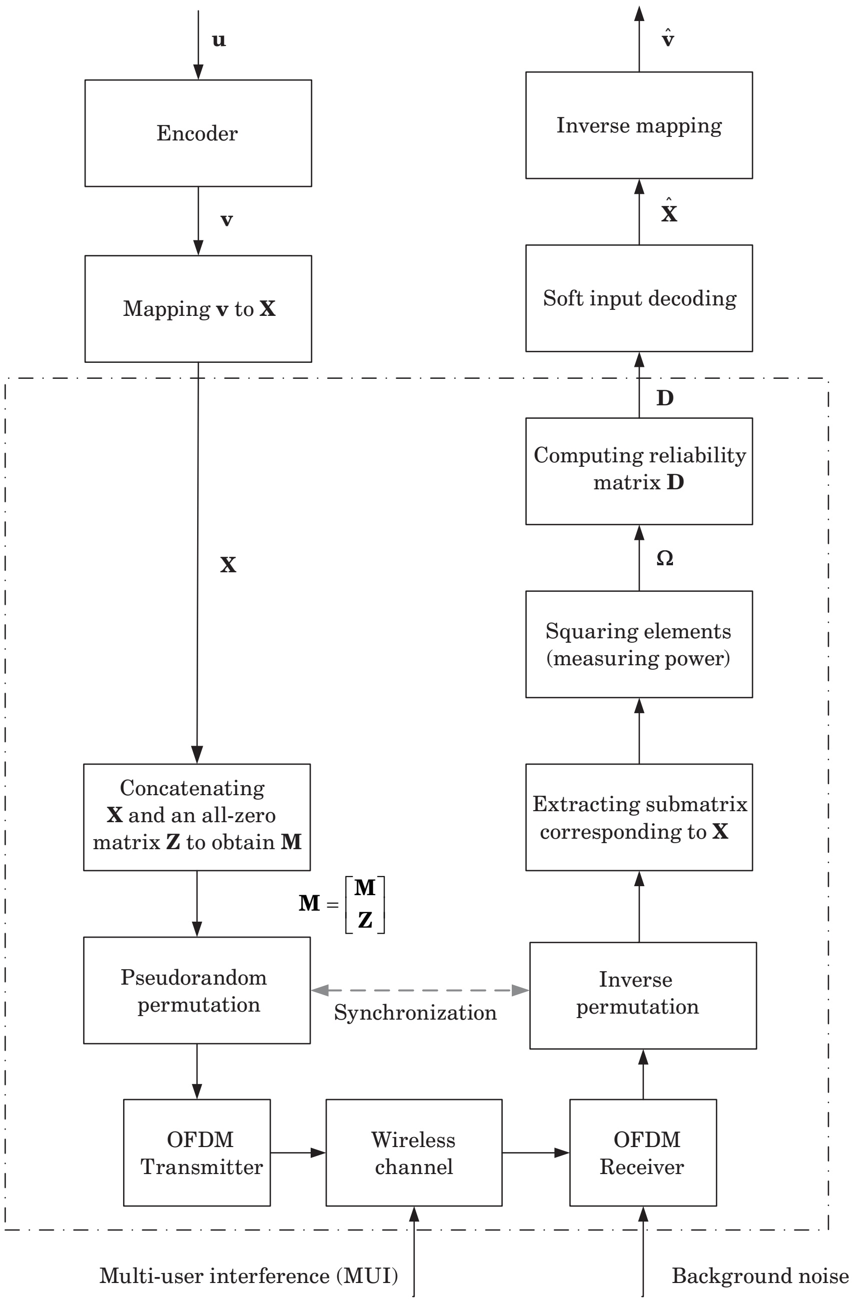
$$\mathbb{B}_q^x = \left\{ \mathbf{b} = \left(b_1, \ldots, b_q\right)^{\mathrm{T}} : \forall\ i \in \{1:q\}\, b_i \in \{0, 1\}, \right.$$
$$\left. w_H(\mathbf{b}) = x \right\},$$

where $\mathbb{B}_q^x$ is the set of all binary column vectors of length q with Hamming weight x and the sets

$$\mathbb{S}^1(\mathbf{z}, \alpha) = \left\{ \mathbf{s} : \mathbf{s} \in \mathbb{B}_q^{\alpha},\ \mathbf{s} \wedge \mathbf{z} = \mathbf{z} \right\};$$
$$\mathbb{S}^0(\mathbf{z}, \alpha) = \left\{ \mathbf{s} : \mathbf{s} \in \mathbb{B}_q^{\alpha},\ \mathbf{s} \wedge \mathbf{z} \neq \mathbf{z} \right\}.$$

The channel is defined in the following way

$$\forall\ \alpha \geq 2;\ q > \alpha;\ \mathbf{x} \in \mathbb{B}_q^1,\ \mathbf{y} \in \mathbb{B}_q^{\alpha}\ \frac{1}{2} < p < 1;$$
$$\sum_{\mathbf{y} \in \mathbb{S}^1(\mathbf{x},\alpha)} p(\mathbf{y} \mid \mathbf{x}) = p;$$
$$\forall\ \mathbf{x} \in \mathbb{B}_q^1,\ \mathbf{y}_a \in \mathbb{S}^1(\mathbf{x}, \alpha),\ \mathbf{y}_b \in \mathbb{S}^1(\mathbf{x}, \alpha),$$
$$a \neq b : p(\mathbf{y}_a \mid \mathbf{x}) = p(\mathbf{y}_b \mid \mathbf{x}) = p_1;$$
$$\forall\ \mathbf{x} \in \mathbb{B}_q^1,\ \mathbf{y}_n \in \mathbb{S}^0(\mathbf{x}, \alpha),\ \mathbf{y}_l \in \mathbb{S}^0(\mathbf{x}, \alpha),$$
$$n \neq l : p(\mathbf{y}_n \mid \mathbf{x}) = p(\mathbf{y}_l \mid \mathbf{x}) = p_0. \qquad (3)$$

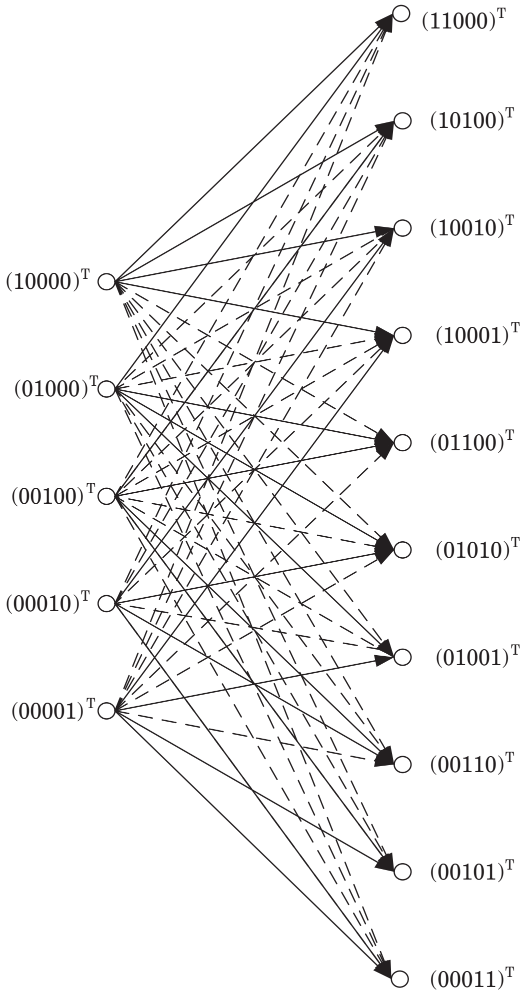


■ ***Fig. 1.*** The communication system and the vector channel under consideration

Equation (3) can be interpreted in the following way: the detector forms a list of α subcarriers with greatest output energy. The probability p is then interpreted as the probability of the fact that the subcarrier that corresponds to the symbol sent will be in the list. An example of the equivalent (α, p)-channel diagram and transition matrix (for the case $q = 5$ and $\alpha = 2$) is given in Fig. 2. In order to keep the size of the output alphabet moderate we have chosen relatively small values of q and α respectively. As can be seen from Fig. 2 since $\alpha = 2$ any vector of weight 2 can appear at the output of the channel since each time the detector chooses α-subchannels with maximum energy and assigns reliability λ_1 to the respective symbol values (these symbols are labelled with 1. Later it will be shown that the output vectors can be represented as binary ones and this representation doesn't affect the performance of the decoder).

Analytical expression for the channel capacity of the (α, p)-channel was obtained in [16] and is given by

$$C_{(\alpha,p)} = \log_2(q) - p\log_2(\alpha) - (1-p)\times \\ \times \log_2(q-\alpha) - H(p), \quad (4)$$



$$\begin{array}{cc}
 & \begin{matrix} \begin{pmatrix}1\\1\\0\\0\\0\end{pmatrix} & \begin{pmatrix}1\\0\\1\\0\\0\end{pmatrix} & \begin{pmatrix}1\\0\\0\\1\\0\end{pmatrix} & \begin{pmatrix}1\\0\\0\\0\\1\end{pmatrix} & \begin{pmatrix}0\\1\\1\\0\\0\end{pmatrix} & \begin{pmatrix}0\\1\\0\\1\\0\end{pmatrix} & \begin{pmatrix}0\\1\\0\\0\\1\end{pmatrix} & \begin{pmatrix}0\\0\\1\\1\\0\end{pmatrix} & \begin{pmatrix}0\\0\\1\\0\\1\end{pmatrix} & \begin{pmatrix}0\\0\\0\\1\\1\end{pmatrix} \end{matrix} \\
\begin{matrix} (1\ 0\ 0\ 0\ 0)^{\mathrm{T}} \\ (0\ 1\ 0\ 0\ 0)^{\mathrm{T}} \\ (0\ 0\ 1\ 0\ 0)^{\mathrm{T}} \\ (0\ 0\ 0\ 1\ 0)^{\mathrm{T}} \\ (0\ 0\ 0\ 0\ 1)^{\mathrm{T}} \end{matrix} & \begin{pmatrix}
p_1 & p_1 & p_1 & p_1 & p_0 & p_0 & p_0 & p_0 & p_0 & p_0 \\
p_1 & p_0 & p_0 & p_0 & p_1 & p_1 & p_1 & p_0 & p_0 & p_0 \\
p_0 & p_1 & p_0 & p_0 & p_1 & p_0 & p_0 & p_1 & p_1 & p_0 \\
p_0 & p_0 & p_1 & p_0 & p_0 & p_1 & p_0 & p_1 & p_0 & p_1 \\
p_0 & p_0 & p_0 & p_1 & p_0 & p_0 & p_1 & p_0 & p_1 & p_1
\end{pmatrix}
\end{array}$$

■ ***Fig. 2.*** The equivalent (α, p)-channel diagram and transition matrix (for $q = 5$ and $\alpha = 2$)

where $H(p)$ is the binary entropy given by

$$H(p) = -p\log_2(p) - (1-p)\log_2(1-p).$$

To describe the performance of the equivalent channel we will use the normalized version of the equation (4)

$$C^{\alpha}_{norm}(\alpha, p) = \frac{C_{(\alpha,p)}}{\log_2(q)} = \\ = 1 - \frac{p\log_2(\alpha) + (1-p)\log_2(q-\alpha) + H(p)}{\log_2(q)}. \quad (5)$$

Communication system performance evaluation: simulation-based channel capacity-aided approach

In what follows we will use the normalized channel capacity given by (5) in order to reveal some of the properties of the communication system employing α-detector. The probability p depends on the background noise, multi-user interference and various parameters such as α, q and Q. In what follows simulation will be used in order to obtain $\hat{p}$ an estimate of the probability p that will be used to compute $C^{\alpha}_{norm}(\alpha, \hat{p})$. It is thus essential to describe the simulation setup in use.

Let us assume that the cardinality of the set of all subcarriers available to the users is set to $Q = 4096$. The background noise is modelled as additive white Gaussian noise (AWGN) described by signal-to-noise ratio (SNR)

$$SNR = 10\log_{10}\left(\frac{E_s}{\log_2(q)E_N}\right),$$

where E_s is the energy of the signal transmitted by the user under consideration; E_N is the noise energy (in the entire band). The multi-user interference is modeled in the following way: we assume that each of the K interfering users transmit signals similar to that of the user under consideration. The phase of each signal is modeled as a random variable with circular uniform distribution. The power of all signals transmitted by each user is the same P_t while the power at the receiver end for each (say i-th) interfering user $P_{r,i}$ is derived in the following way: the power ratio has log-normal distribution [18], i.e. [19]

$$L(d_i) = 10\log\left(\frac{P_t}{P_{r,i}}\right) =$$

$$= \bar{L}(d_i) + X_\sigma = L_{fs}(d_0) + 10\gamma_0 \log\left(\frac{d_i}{d_0}\right) + X_\sigma,$$

where d_i is the distance between the i-th interfering user; X_σ is a Gaussian random variable with mean 0 and variance σ; L_{fs} is the free-space path loss given by Friis law [20]; d_0 is the reference distance and γ_0 is the path-loss exponent, whereas the respective power ratio for the user under consideration also has log-normal distribution and is given by:

$$L\left(d^*\right) = 10\log\left(\frac{P_t}{P_r^*}\right) =$$

$$= \bar{L}\left(d^*\right) + X_\sigma = L_{fs}(d_0) + 10\gamma_0 \log\left(\frac{d^*}{d_0}\right) + X_\sigma,$$

where d^* is the distance between the user under consideration and the receiver; P_r^* is the power of the signal transmitted by the user under consideration at the receiver end and d_0 is reference distance. The signal-to-interference ratio thus depends on the values

$$\mu_i = \log_{10}\frac{d^*}{d^i},$$

where $i \in \{1, \ldots, K\}$.

In what follows we assume, that the values μ_i are random variables equiprobably distributed on a one dimensional gird. In particular we consider 2 scenarios. Within the scope of the Scenario 1 the values of μ_i are assumed to be equiprobably distributed on [0:0.01:2]. This scenario thus boils down to the assumption that $d_i \le d^*$ and therefore $\bar{L}(d_i) \le \bar{L}\left(d^*\right)$. Within the scope of the Scenario 2 the values of μ_i are assumed to be equiprobably distributed on [–2:0.01:2].

Let us first consider the problem of finding the optimal value of the parameter α. Fig. 3, *a* and *b* depicts the dependency of normalized capacity on the value of α for $q = 256$, different values of K, SNR and Scenario 1 and Scenario 2 respectively.

First and foremost it is worth pointing out that for all scenarios and parameters under consideration there is a value of α that corresponds to the maximum value of $C^{\alpha}_{norm}(\alpha, \hat{p})$. In what follows this value will be referred to as optimal. The optimal value lies within the range (q/16, q/2). The maximum value of $C^{\alpha}_{norm}(\alpha, \hat{p})$ is less than 0.5, i.e. only relatively low rate codes can be used. For small α ($\alpha \le q/16$) the $C^{\alpha}_{norm}(\alpha, \hat{p})$ is close to zero. Thus conventional frequency-shift keying (FSK) demodulation (i.e. the case that corresponds to α = 1) is not suitable. For large α normalized capacity doesn't depend on the number of interfering users or SNR. The optimal value of the parameter α for smaller number of interfering users is less than that for the greater number of interfering users. The maximum value of $C^{\alpha}_{norm}(\alpha, \hat{p})$ decreases as K increases (for the parameters under consideration 200 more interfering users results in approximately 15% decrease in maximum normalized capacity that can be obtained) but remains the same when SNR varies in a broad interval (10 dB in our case). For comparison we present dependences of normalized capacity on the value of α for $q = 16$, different values of K, SNR and Scenario 1 and Scenario 2 (Fig. 4, *a* and *b* respectively).

The observations we made for $q = 256$ are valid for $q = 16$. Again one can notice that normalized capacity depends on the number of interfering users but not on the SNR value. Although it is true in a very broad range of SNR values it is interesting to find out the region where this doesn't hold. To do so we present results for fixed K ($K = 500$) and q ($q = 256$) and plot values of the normalized capacity for different SNR values (Fig. 5, *a* and *b* respectively).

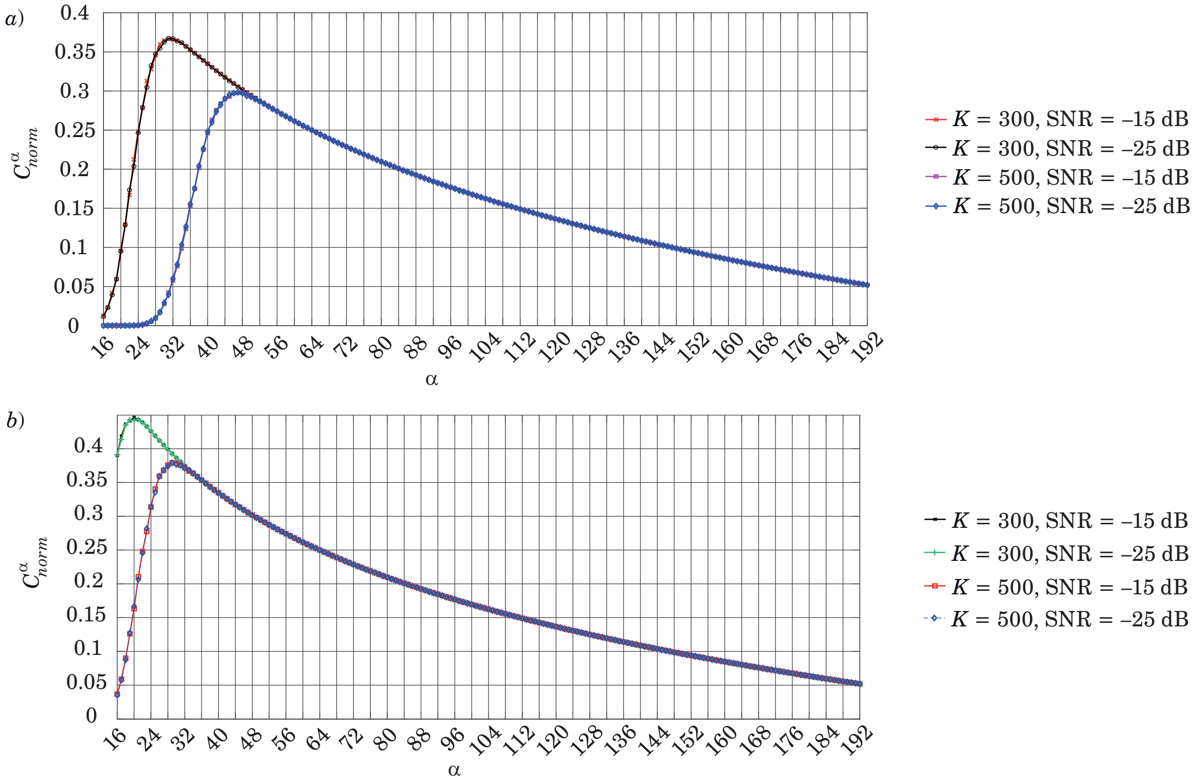
Let us note that the curves for SNR from –30 to –34 dB almost coincide for both scenarios. However for SNR < –34 normalized capacity decreases slowly as SNR decrease. For comparison results for $q = 16$ are presented in Fig. 6, *a* and *b* respectively.

For small q the trend is similar although normalized capacity decreases slowly as SNR decreases for SNR < –32. Nevertheless one can argue that normalized capacity of the equivalent channel (for fixed values of α and K) is almost the same for a very broad range of SNR values.

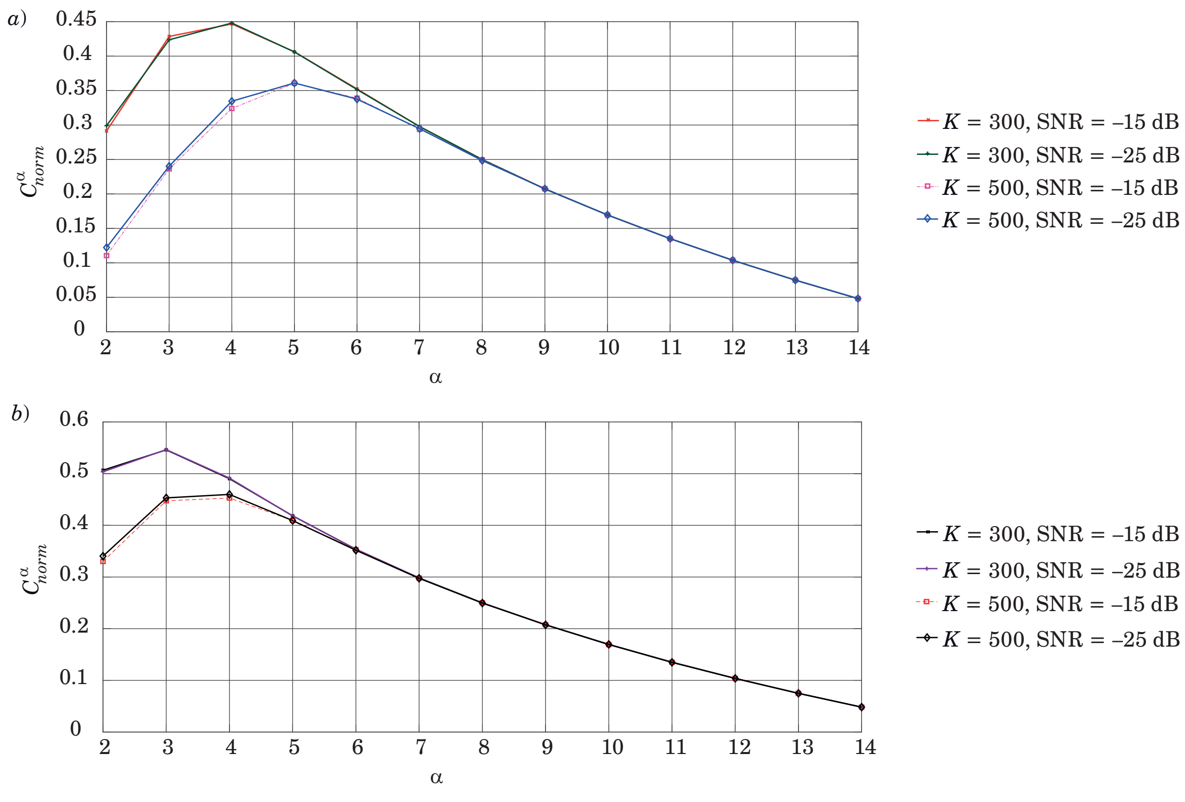
Let us now summarize our findings made in this section:

— the capacity of the equivalent channel remains the same for a very wide range of SNR values. Thus even if the power of the signal at the receiver side exhibits drastic variation (e.g. due to small scale fading or the transmitter mobility) the performance of the detector will not degrade unless SNR is not close to the threshold value;

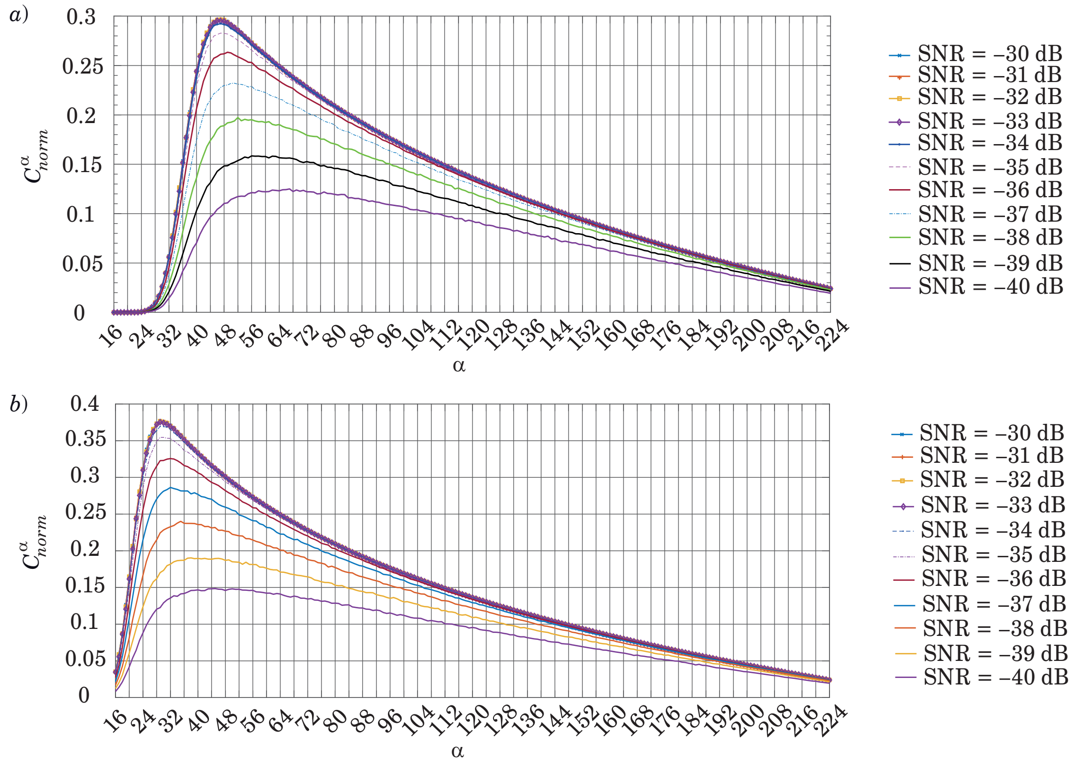
— the capacity of the equivalent channel depends on the power of the multi-user interference and thus on the number of interfering users. However the capacity degrades slowly as the number of interfering users increases. Thus even if the number of



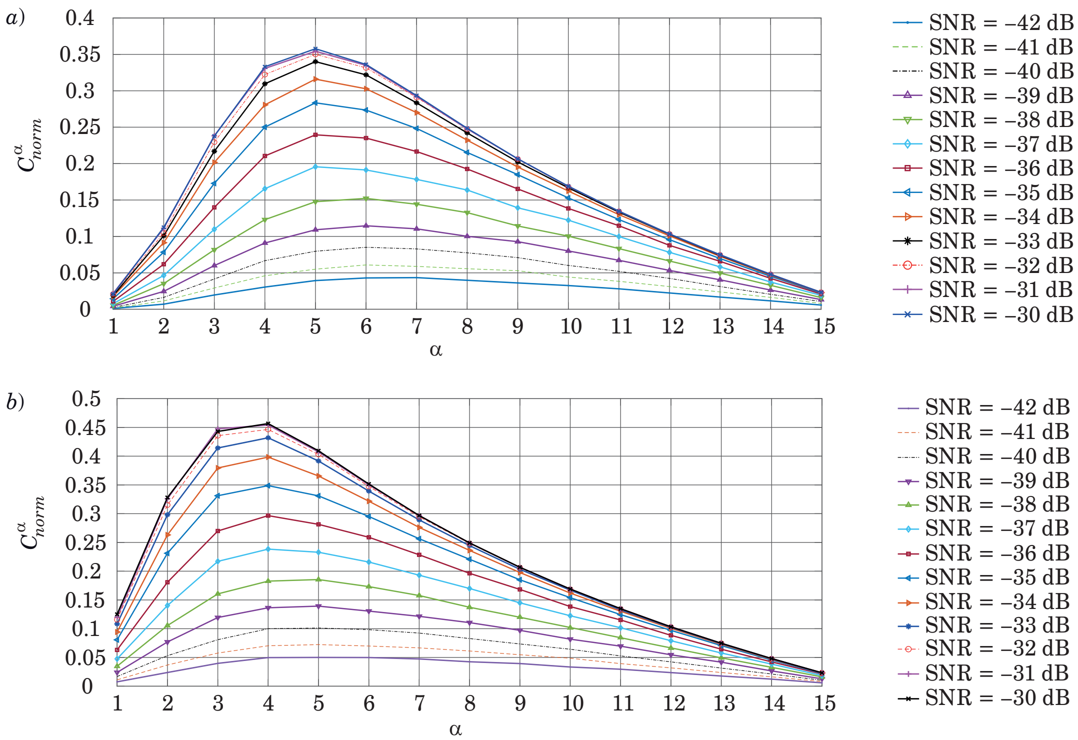
■ ***Fig. 3.*** Normalized capacity of the equivalent (α, p)-channel vs. α for q = 256, various values of K (number of interfering users), SNR and Scenario 1 (*a*) and Scenario 2 (*b*)



■ ***Fig. 4.*** Normalized capacity of the equivalent (α, p)-channel vs. α for q = 16, various values of K (number of interfering users), SNR and Scenario 1 (*a*) and Scenario 2 (*b*)



■ ***Fig. 5.*** Normalized capacity of the equivalent (α, p)-channel vs. α for $q = 256$, $K = 500$, various SNR values and Scenario 1 (a) and Scenario 2 (b)



■ ***Fig. 6.*** Normalized capacity of the equivalent (α, p)-channel vs. α for $q = 16$, various SNR values and Scenario 1 (a) and Scenario 2 (b)

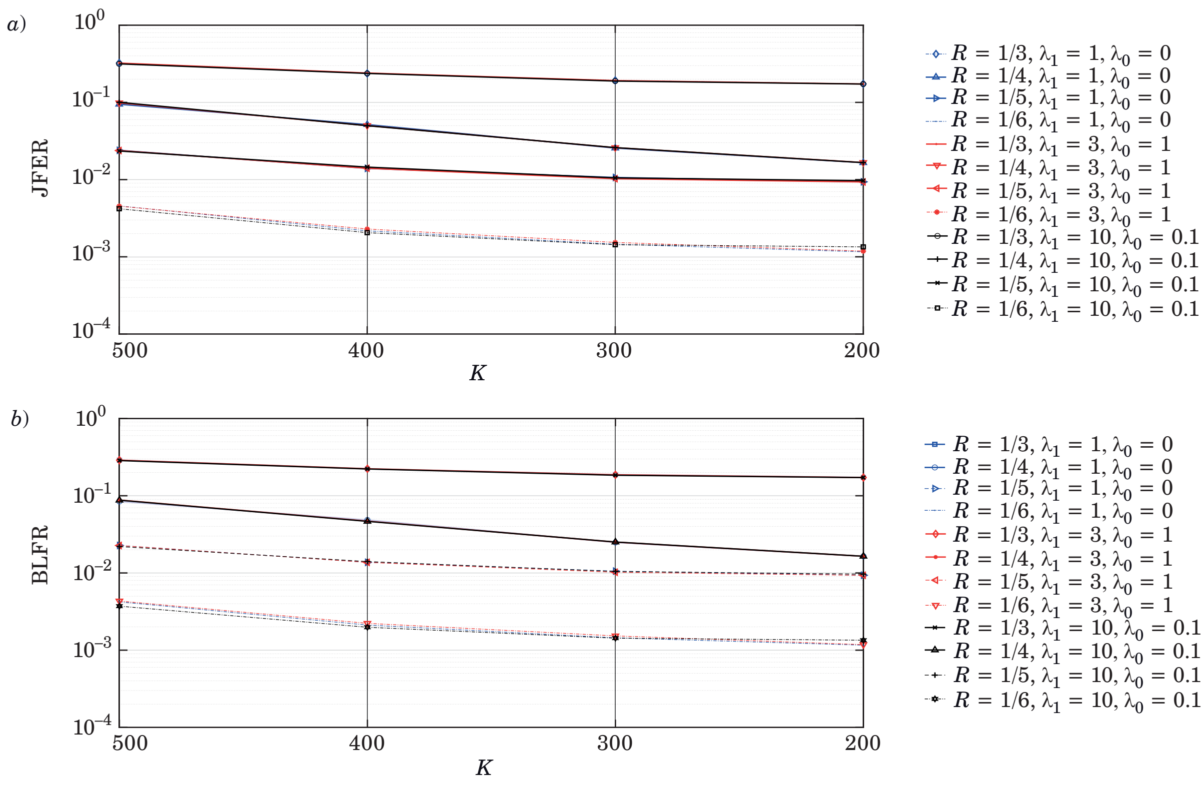
interfering users change the performance will not change in any meaningful way;

— for any K there exists value of the α parameter that results in channel with highest capacity. For different K this value is different however the optimal value changes slowly as K increases (decreases). Thus onse a certain value of α is fixed the performance of the detector will be very close to optimal even if the number of interfering users will vary.

Communication system performance evaluation: simulation-based performance-aided approach

In our consideration of the equivalent (α, p)-channel reliability values were not used since channel capacity doesn't depend on labelling. However since reliabilities of the codewords depend on the reliabilities values it is essential to find out how the choice of λ_1 and λ_0 affects the detector performance. In what follows we shall use the same simulation scenario we described above. The error correction codes in use are maximum distance separable codes obtained by appropriate puncturing Reed — Solomon code $C_{16}(15, 2, 14)$ to the desired rate. Since detection given by the rule (2) can result in both decoding failure and erroneous decoding in what follows we shall consider joint probability that either decoding failure or error will take place — Joint Failure and Error Rate (JFER). For different values of the number of interfering users we use the same value of α, the one that maximizes the capacity for the maximum number of interfering users under consideration, i.e. $K = 500$ and SNR = –25 dB. JFER vs. the number of interfering users is plotted for various values of λ_0 and λ_1 and Scenario 1. As can be seen from Fig. 7, *a*, the performance of the communication system that uses α-detector remains the same for different values of λ_0 and λ_1 for any rate R under consideration.

For comparison we present curves for Block Failure Rate (BLFR) vs. the number of interfering users for the same values λ_0 and λ_1 and code rate R (Fig. 7, *b*). BLFR is the same for different values of λ_0 and λ_1 for any rate R under consideration. Thus performance doesn't depend on the values of λ_0 and λ_1 (as long as $0 \le \lambda_0 < \lambda_1$) and therefore $\lambda_0 = 0$ and $\lambda_1 = 1$ can be used. Although the matrix $\mathbf{D}_{(\alpha,\lambda_0,\lambda_1)}$ need not be stored since codeword reliability values (1) can be computed on the fly the values of the codeword reliability values in question (both intermediate and final values) should be stored. Thus the choice $\lambda_0 = 0$ and $\lambda_1 = 1$ minimizes the hardware complexity since there is no need to store any values for λ_0 and λ_1 and the value for each codeword



■ ***Fig. 7.*** JFER (*a*) and BLFR (*b*) vs. the number of interfering users K for various values of λ_0 and λ_1, code rates R and Scenario 1 requires $\lceil \log_2(N) \rceil$ bits for storage only. The choice $\lambda_0 = 0$ and $\lambda_1 = 1$ minimizes the hardware complexity of the (final) decision making step given by the decoding rule (2) as well since it depends on the bit width of the input. It's worth noting that the curves for JFER and BLFR given in Fig. 7, *a* and *b* respectively are very similar. That confirms that the probability of decoding failure is much higher than that of erroneous decoding for the α-detector. Moreover the fact that both JFER and BLFR curves exhibit minor change as K varies confirms our previous conclusion that the performance of the detector doesn't change significantly as the number of interfering users vary.

Conclusion

Hereinabove a communication system that uses frequency shift keying in a dynamically allocated hopset with α-detector is considered. This paper address the sensitivity of the communication system under consideration to both noise and interference power variation and detector parameters choice. Even though results obtained in [16] suggested that the communication system that makes use of the α-detector is resilient to background noise intensity variations this problem has never before been studied comprehensively. Hereinabove we have demonstrated that the communication system under consideration exhibits such feature in a vast range of SNR values for various values parameters and scenarios. Moreover the fact that the capacity of the equivalent channel exhibits threshold behaviour i.e. for any specific set of parameters and scenario there is a critical value of SNR such that for any SNR value less than the critical value the capacity of the equivalent channel starts to degrade as SNR reduces has been revealed for the first time. The analytical bound obtained in [17] demonstrated that the performance of the detector is not affected by the choice of λ_0 and λ_1. This paper shows that it is true for the communication system under consideration for all rates, different system parameters and scenarios. Thus the values of λ_0 and λ_1 can be chosen in the way that minimizes the hardware complexity. It has been demonstrated that the value of α that yields maximum capacity of the equivalent channel varies slowly with SNR. Thus parameters choice optimized for certain conditions yields performance close to optimal even if the parameters of the communication system change. To the best of the author's knowledge none of the results discussed above has been obtained before.

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УДК 621.391
doi:10.31799/1684-8853-2023-1-61-70
EDN: PCFDIS

Обнаружение сигнала на фоне помех на основе порядковых статистик: анализ чувствительности и выбор параметров детектора

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Введение: разработка методов физического уровня для систем межмашинной связи является нетривиальной задачей. В частности проблематична разработка методов оценивания характеристик канала с низкой сложностью и методов контроля мощности с необходимой точностью. Один из возможных способов решения этой проблемы — использование методов приема, основанных на порядковых статистиках и не требующих каких-либо техник оценивания или контроля мощности. **Цель:** исследовать чувствительность системы связи, использующую частотно-позиционное кодирование в динамически выделяемом диапазоне, и приемник на основе порядковых статистик, предложенный автором, к изменениям мощности фонового шума, многопользовательских помех и к выбору параметров приемников. **Результаты:** анализ вычисленной с использованием моделирования значений пропускной способности эквивалентного канала подтверждает, что рассматриваемый приемник устойчив к флуктуациям отношения сигнал/шум и, следовательно, может использоваться даже в том случае, если энергия сигнала на приемном конце подвержена значительным изменениям. Показано, что величина числа значений, которым приписывается наибольшее значение оценки достоверности, оптимизированная для наибольшего числа активных пользователей, гарантирует значения пропускной способности, близкие к оптимальному, даже если число активных пользователей меняется. Также с помощью моделирования показано, что вероятностные характеристики не зависят от выбора значений оценок достоверности. Это говорит о том, что можно использовать значения, минимизирующие аппаратную сложность детектора. **Практическая значимость:** полученные результаты подтвердили то, что детектор рассматриваемого типа допускает практическую реализацию и использование в широком диапазоне сценариев. Аппаратная сложность может быть минимизирована без ущерба для качества связи.

Ключевые слова — межмашинная связь, псевдослучайно переключаемые частоты, динамически выделяемые поддиапазоны, некогерентный прием, α-детектор, пропускная способность.

Для цитирования: Osipov D. S. Signal detection amid noise using order statistics: detector sensitivity analysis and parameter choice. *Информационно-управляющие системы*, 2023, № 1, с. 61–70. doi:10.31799/1684-8853-2023-1-61-70, EDN: PCFDIS

For citation: Osipov D. S. Signal detection amid noise using order statistics: detector sensitivity analysis and parameter choice. *Informatsionno-upravliaiushchie sistemy* [Information and Control Systems], 2023, no. 1, pp. 61–70. doi:10.31799/1684-8853-2023-1-61-70, EDN: PCFDIS