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Family of Two-Dimensional Correcting Codes on a Basis of Perfect Binary Array

P. E. Baranov, M. I. Mazurkov, V. Ya. Chechelnytskyi, and A. A. Yakovenko
Odessa National Polytechnic University, Odessa, Ukraine
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Abstract—We consider a family of two-dimensional correcting $E(N)$-codes on a basis of perfect binary arrays $H(N)$, and we show correcting possibilities of $E(N)$-codes in comparison with corresponding BCH-codes with maximal length are essentially better with regard to correction of package (correlated) errors, at that, uncorrelated errors are corrected identically.

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Perfect binary arrays (PBA) are described in many papers and they are used in many fields of application [1–7]. Main purpose of the paper is research of correction possibilities of two-dimension cyclic codes on a basis of PBA.

Let $H_0(N)=||h_{i,j}||,\ i=\overline{1,N},\ j=\overline{1,N},\ h_{i,j}\in -1,+1$ is Nth order PBA, where $N=2^k$ or $N=3\times 2^k$. We represent two-dimension periodic auto-correlation function (TPACF) of this array in matrix form:

$$R(m,n)=\sum_{i=0}^{N-1}\sum_{j=0}^{N-1}h_{i,j}h_{i+m,j+n}=\mathrm{tr}[H_0\cdot(L_mH_0Q_n)^{\mathrm{T}}]=\begin{cases}N^2, & m=n=0,\\ 0, & \text{other } m \text{ and } n,\end{cases} \tag{1}$$

where L_m and Q_n are array cyclic shifts operators, correspondingly, by rows (down) and columns (to the left) on a value $m=\overline{0,N-1},\ n=\overline{0,N-1}$, $\mathrm{tr}(A)$ is matrix A trace.

For example, one of arrays, which is a part of total class of PBA [6], represented in sign form $\{\pm 1\}\Rightarrow\{\pm\}$, and its TPACF are following:

$$H_0(6)=\begin{bmatrix}+++++- \\ +-++-+ \\ -+-+-- \\ ++--++ \\ -+-+-- \\ -++++-\end{bmatrix},\qquad ||R(m,n)||=\begin{bmatrix}36&0&0&0&0&0\\0&0&0&0&0&0\\0&0&0&0&0&0\\0&0&0&0&0&0\\0&0&0&0&0&0\\0&0&0&0&0&0\end{bmatrix}. \tag{2}$$

Two-dimension $E(N)$-code is built on a basis of randomly selected (reference) array $H_0(N)$ by means of all cyclic shifts on rows and (or) columns. As it follows from the definition, volume of $E(N)$-code is $J=N^2$. We consider structural and correlation properties of two-dimensional and correspondent one-dimension code words of $E(N)$-code.

We unroll sequentially by rows each array of $E(N)$-code, then we obtain one-dimension orthogonal non-cyclic $h(J)$-code of J order, which has a property of two-loop cyclic N-shift [8]. Hence, $h(J)$-codes can be efficiently decoded by means of fast Vilenkin–Krestenson transformation, calculating N-convolutions or dyadic convolutions (correlations) [8].

In this paper main attention is paid to decoding of two-dimension $E(N)$-codes on a basis of accounting of two-dimension periodic cross-correlation functions (TPCCF) arrays of $E(N)$-codes. We note that TPCCF of