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United States Patent [19]

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Moon et al.

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[54] **METHOD AND APPARATUS FOR IMPLEMENTING MAXIMUM TRANSITION RUN CODES**

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4,779,072	10/1988	Van Gestel	341/59
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[57] **ABSTRACT**

[21] Appl. No.: **730,716**

Apparatus and method for coding to improve the minimum distance properties of sequence detectors operating at high densities in storage systems is presented. The coding scheme of the present invention is referred to as maximum transition run (MTR) code and eliminates data patterns producing long runs of consecutive transitions while imposing the usual k constraint necessary for timing recovery. The code has a distance gaining property similar to an existing (1,k) runlength-limited (RLL) code, but can be implemented with considerably higher code rates. When the MTR code is used with fixed delay tree search (FDTS) or high order partial response maximum likelihood (PRML) detectors, the bit error rate performance improves significantly over existing combinations of codes and detectors.

[22] Filed: **Oct. 15, 1996**

Related U.S. Application Data

[60] Provisional application No. 60/014,954 Apr. 5, 1996.

[51] **Int. Cl.**⁶ **H03M 7/00**

[52] **U.S. Cl.** **341/59; 341/94**

[58] **Field of Search** 341/58, 59, 61, 341/94

References Cited

U.S. PATENT DOCUMENTS

4,760,378 7/1988 Iketani et al. 340/347 DD

21 Claims, 14 Drawing Sheets

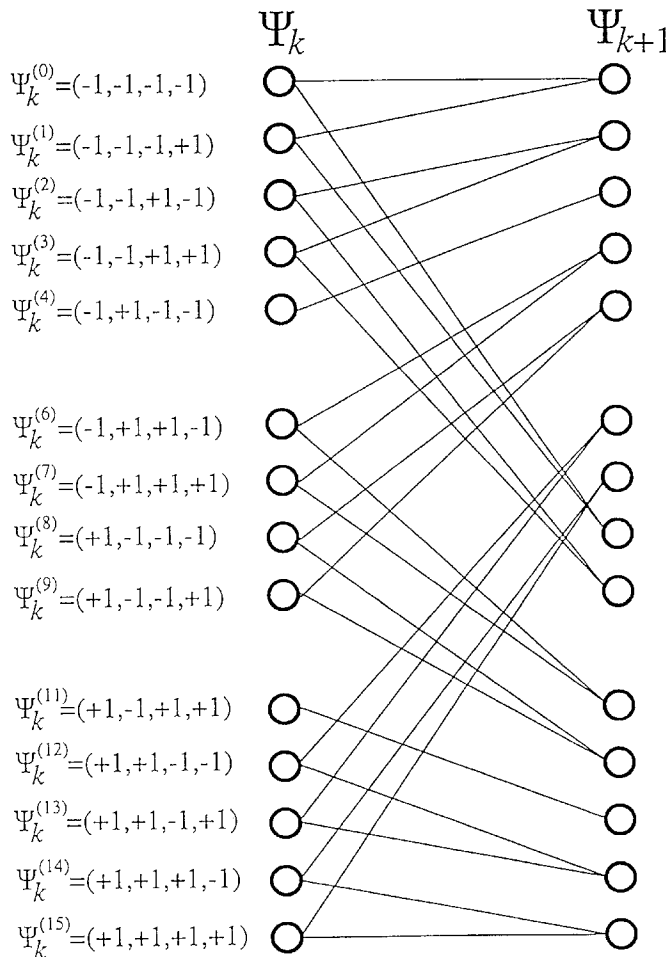


Fig. 1

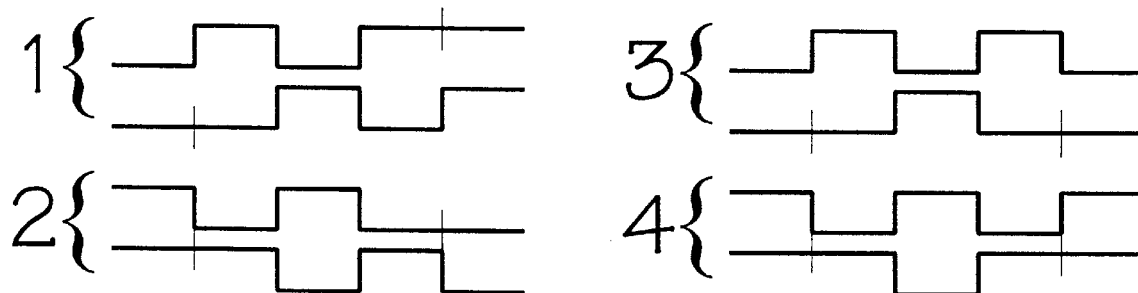


Fig. 2

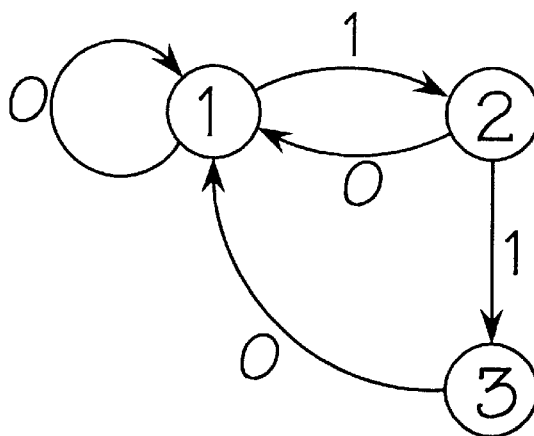


Fig. 3

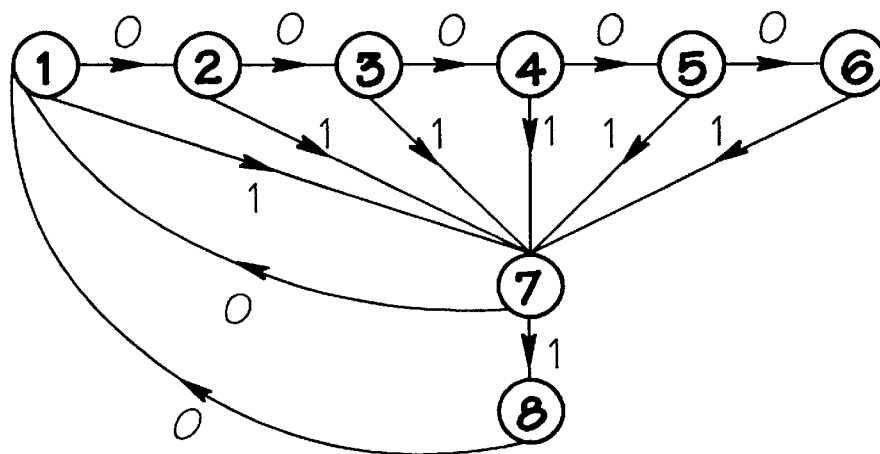


Fig. 4

RLL k Constraint	Capacity with MTR $j = 2$
∞	0.8791
10	0.8782
9	0.8774
8	0.8760
7	0.8732
6	0.8680
5	0.8579
4	0.8376
3	0.7947

Fig. 5

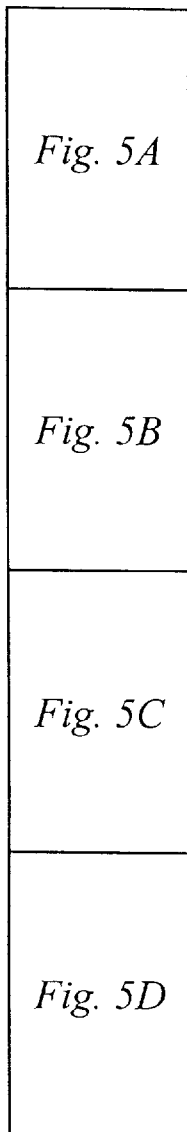


Fig. 6

DATAWORD • CODEWORD

0000 • 10000
0001 • 00001
0010 • 00010
0011 • 10001
0100 • 00100
0101 • 00101
0110 • 00110
0111 • 10110
1000 • 01000
1001 • 01001
1010 • 01010
1011 • 10010
1100 • 01100
1101 • 01101
1110 • 10100
1111 • 10101

Fig. 11



Fig. 5A

n	k	m	rate	efficiency	----- codewords -----	
					available	required
4	4	2	0.5000	0.5969	6	4
4	5	2	0.5000	0.5828	7	4
4	6	3	0.7500	0.8640	8	8
5	4	3	0.6000	0.7163	12	8
5	5	3	0.6000	0.6994	13	8
5	6	3	0.6000	0.6912	14	8
5	7	3	0.6000	0.6871	15	8
5	8	4	0.8000	0.9133	16	16
6	4	4	0.6667	0.7959	20	16
6	5	4	0.6667	0.7771	23	16
6	6	4	0.6667	0.7680	26	16
6	7	4	0.6667	0.7634	27	16
6	8	4	0.6667	0.7611	28	16
6	9	4	0.6667	0.7598	29	16
6	10	4	0.6667	0.7591	30	16
7	4	5	0.7143	0.8527	36	32
7	5	5	0.7143	0.8326	41	32
7	6	5	0.7143	0.8229	46	32
7	7	5	0.7143	0.8180	49	32
7	8	5	0.7143	0.8154	52	32
7	9	5	0.7143	0.8141	53	32
7	10	5	0.7143	0.8133	54	32
8	4	6	0.7500	0.8954	66	64
8	5	6	0.7500	0.8742	75	64
8	6	6	0.7500	0.8640	84	64
8	7	6	0.7500	0.8589	89	64
8	8	6	0.7500	0.8562	94	64
8	9	6	0.7500	0.8548	97	64
8	10	6	0.7500	0.8540	100	64
9	4	6	0.6667	0.7959	116	64
9	5	7	0.7778	0.9066	137	128
9	6	7	0.7778	0.8960	154	128
9	7	7	0.7778	0.8907	163	128
9	8	7	0.7778	0.8879	172	128
9	9	7	0.7778	0.8864	177	128
9	10	7	0.7778	0.8856	182	128
10	4	7	0.7000	0.8357	208	128
10	5	7	0.7000	0.8159	247	128
10	6	8	0.8000	0.9216	282	256
10	7	8	0.8000	0.9161	299	256
10	8	8	0.8000	0.9133	316	256
10	9	8	0.8000	0.9117	325	256
10	10	8	0.8000	0.9109	334	256

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