ANALYSIS ON THE OPTIMUM GROUP SYNCHRONIZATION CODE OF TIROS SATELLITE

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ABSTRACT

In this paper, the group synchronization code (length n = 60 bit) of the TIROS Satellite was analysed. It seems to us the code isn't optimization.

A series of optimum group sync codes (n = 60) have been searched out with error tolerance E = 1, 2, 3, 4, 5, 6 and 10, 12. Their error sync probabilities are less than the error sync probability of the TIROS code (from two times to two order of magnitudes about). These optimum or qansi-optimum codes will be presented for application in the second generation of the Meteorological Satellites of China.

KEY WORDS, Optimum Code, Group Synchronization Code, Error Synchronization Probability.

INTRODUCTION

The group sync code (length n = 60 bit) of the information transmission system of the TIROS Meteorological Satellite (USA) is as following,

1010,0001,0001,0110,1111,1101,0111,0001,1001,1101,1000,0011,1100,1001,0101.

By hexi-decimal signs, this pattern can be abbreviated to “”A116,FD71,9D83,C95”. The mane of this code is signed to S_τ in this paper.

Is this a optimum group sync code?

That is a valuable or interest question.

When n = 60 bit, the number of binary codes ($N = 2^n -1 = 2^{60} -1 \approx 1.152921504E+18$) is very large. Under existing calculation speed of digital computer, it is very hard to use the classical exhaustion technique[1] for searching out the optimum group sync code in such great set of binary codes. Which like to fish for a little pin in the Pacific Ocean.

Fortunately, the code length (n = 60) is very near to the word length of m_{63} sequences (n=63), so that we can try to use a confined exhaustion method for searching out quasi-optimum or suboptimum code within the bounds of several smaller sets of the truncated (or cut-short) codes from the m_{63} sequences. Thereby, the work toad for searching the quasi-optimum or suboptimum group sync codes will be decreased in greatly.

A SHORT CUT

Just as an old Chinese saw was said. “Would rather coming home to weave a fishing nets than standing along the sea coast to envy the fishes”. We can find a way after all.

The m_{63} sequences have three primitive polynomials as following,

$$f_1(x) = x^6+x^5+x^2+x+1 \qquad (1)$$
$$f_2(x) = x^6+x^5+1 \qquad (2)$$
$$f_3(x) = x^6+x^4+x^3+x+1 \qquad (3)$$

Based on these polynomial and by a repeating technique, one by one, step by step, to alternately cut out 3 bits from the m_{63} sequences (n = 63 bit), then we can get a set of the truncated codes of length n = 60 bit. The total sum of these truncated codes is 189 (63x3).

For distinction, among the mentioned above 189 truncated codes, the first set of 63 codes do be signed as $S_{i/I}$ which are generated by f_1 (x), and the second set of 63 codes do be signed as $S_{i/II}$ which are generated by f_2 (x), and the third set, $S_{i/III}$, by f_3 (x). In $S_{i/I}$, $S_{i/II}$ and $S_{i/III}$, i (the order number of truncated codes) = 1, 2, 3, 4,...,63.

For comparison, under the bit error probability P_o = 0.1 and the error toelrance E = 1,2,3,4,5,6 and 10,12 separately, the error sync probabilities of mentioned cut-short codes have been calculated by computer progrom according to the formula (4) .

$$P_{f_2} = 2\sum_{K=1}^{n-1}\sum_{i=0}^{\min(K,E)}\left(\left\{\sum_{j=i+\phi(K)-K}^{\min[i,\phi(K)]}\left[\binom{\phi(K)}{j}\binom{K-\phi(K)}{i-j}(1-P_o)^{[\phi(K)+i-2j]}P_o^{[K-\phi(K)-i+2j]}\right]\right\}\left\{\frac{1}{2^{n-K}}\sum_{m=0}^{\min(E-i,n-K)}\binom{n-K}{m}\right\}\right) \qquad (4)$$

Where

E = number of error tolerance

P_o = the probability that the element of group sync code will be changed by noice

$\psi(K)$ = agreement vector
n = the length of group sync code.

RESULTS AND COMPARISON

Among the above mentioned 189 cut-short codes, according to their error sync probabilities P_{f2} from small to large sequencely, under E = 1, 2, 3, 4, 5, 6 up to E = 10 and 12, the first good code (the best code) are $S_{16/II}$, and the $S_{21/I}$ (i.e TIROS group sync code) is No.156 (at E = 1) No.149 (at E = 2), No.149 (at E = 3), No.143 (at E = 4), No.149 (at E = 5), No.137 (at E = 6), No.129 (at E = 10), No.123 (at E = 12).

The pattern of $S_{16/II}$ (the best code) is as following,

1111,0101,0110,0110,1110,1101,0010,0111,0001,0111,1001,0100,0110,0001,0000.

By hexadecimal sign, this pattern can be abbreviated to “F566, ED27, 1794, 810".

The autocorrelation function of this best code ($S_{16/II}$ is ,

-1, -2, -3, -4, -1, -2, -1, -2, -5, 0, -3, 2, -1, -2, -1, -4, -3, 0, -5, 2, -5, 0, -1, 2, 1, -2, -3, 2,

-7, 2, 7, -2, -5, 2, -1, 2, -3, 0, 1, 6, 1, -4, 3, 0, -3, 2, 1, 2, -1, 4, 1, 2, 1, 2, 5, 0, -1, -2,-34, 60.

The autocorrelation function of $S_{21/I}$ (the group sync code of TIROS) is ,

1, -2, 3, -4, 3, -4, 1, 2, -5, 4, -1, 4, -1, 4, -1, 0, -5, -2, 5, -2, 3, 2, -3, 2, 1, 0, -1, 4, -9, 0, 5,

0, -7, 0, -1, -2, 3, -6, 5, 6, -1, -2, -7, 0, -7, 0, -3, 4, -3, -4, 5, -6, -1, -4, 1, 0, -3, 2, -1, 60.

The limit of subpeak of the autocorrelation function of the best code ($S_{16/II}$) is (-7, 7) and $S_{21/I}$ is (-9, 6).

The comparison of the error sync probabilities for borth codes ($S_{16/II}$ and $S_{21/I}$) are listed in Table.

Table 1. The comparison of P_{f2}

E	$S_{21/I}$ (TIROS)	$S_{16/II}$ (Best)	Rate $P_{f2/t}$ / $P_{f2/B}$
1	0.5808E-15 (No.156)	0.2082E-16 (NO.1)	27.90
2	0.1786E-13 (No.149)	0.7672E-15 (No.1)	23.28
3	0.3618E-12 (No.149)	0.1848E-13 (No.1)	19.58
4	0.5425E-11 (No.143)	0.3280E-12 (No.1)	16.54
5	0.6421E-10 (No.149)	0.4574E-11 (No.1)	14.04
6	0.6245E-9 (No.137)	0.5226E-10 (No.1)	11.95
10	0.1234E-5 (No.129)	0.1945E-6 (No.1)	6.35
12	0.2678E-4 (No.123)	0.5778E-5 (No.1)	4.64

CONCLOUSION

(1). When E changes from 1 to 12, the TIROS group sync code S_τ (i.e. $S_{21/I}$) is all not first good code in the sets of the above mentioned truncated codes. The error sync probability $P_{f2/T}$ of S_T is all greatter than $P_{f2/B}$ of the best code $S_{16/II}$ by 28 times to 7 times approximately. So, the TIROS group sync code S_T (i.e. $S_{21/T}$) is really not a optimum group sync code in the set o binary codes of length n = 60 bit.

(2). At different E, the first good code is generated by the primitive polynomial f_2 (x), and S_T (i.e. $S_{21/I}$) is generated by f_1 (x), f_1 (x) can not get better codes. Perhaps, we would surmise that the designer of S_T is not careful consideration when to choose the group sync code.

(3). Sence the searching work is only carried on the partial set of the binary codes for n = 60 bit, it goes without saying that the first good code $S_{16/II}$ is probably not a optimum group sync code but quasi-optimum or suboptimum group sync code. However, this code ($S_{16/II}$) is better than TIROS group sync code S_T, and so, this code ($S_{16/II}$) will be recommended for application in the information transmission systems of the second generation of Meteorological Satellites China.

REFERENCE

[1]. J. L. Maury, Jr. and F. J. Styles, 1964, “development of Optimum Frame Synchronization Codes For GODDARD Space Flight Center PCM Telemetry Standard”, USA.