THE SEARCHING METHOD OF QUASI-OPTIMUM GROUP SYNC CODES ON THE SUBSET OF PN SEQUENCES

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ABSTRUCT

As the code length is increasing, the search of optimum group sync codes will be more and more difficult, even impossible. This paper gives the searching method of quasi-optimum group sync codes on the small subset of PN sequences -- CVT-TAIL SEARCHING METHOD and PREFIX-SUFFIX SEARCHING METHOD. We have searched out quasi-optimum group sync codes for their lengths N=32-63 by this method and compared them with corresponding optimum group sync codes for their lengths N=32-54. They are very approximative. The total searching time is only several seconds. This method may solves the problems among error sync probability, code length and searching time. So, it is a good and practicable searching method for long code.

KEY WORDS : OPTIMUM GROUP SYNC CODES, CODE, SYNCHRONIZATION, QUASI-OPTIMUM GROUP CODE

1. INTRODUCTION

In recent years, we have given several improved searching method [2], [3] of optimum group sync codes, and have searched out optimum group sync codes for their lengths N=32-54. Their searching speeds are greater than the exhausion [1]. But, not only exhausion is impossible, but also our several new methods are limited by computer time so seriously for longer code lengths that they become inefficient. Because, there are 2^N of binary codes for the length N and the searching time of optimum group sync codes increases exponentially with N. So, even though head 1-tail 0 criterion, code weight criterion and the same inverse-completary criterion are used in our several searching methods, the situation is still so for long code. In order to keep acceptable the seaching time of longer optimum group sync codes, we hope to find out a small subset of the codes so that the code words in it have good group sync performances and the size of this subset should grow linearly, rather than exponentially, with N.

In reference [4], we try confining the search of group sync codes to the subset S_6 by CUT-TAIL SEARCHING METHOD, which consists of PN sequences of length 2^6 - 1. As we hope, there are many better group sync codes than the code used in TIROS SATELLITE. This is a basis of the searching method presented in this paper.

In the paper, we present the searching method of quasi-optimum group sync codes on the small subset of PN sequences -- CUT-TAIL SEARCHING METHOD and PREFIX-SUFFIX SEARCHING METHOD, briefly called as PN-SEQUENCE-SUBSET SEARCHING METHOD. By this method, we have searched out the quasi-optimum group sync codes of lengths 32-63 and find that their error sync probabilities are 1.004 - 2 times those of corresponding optimum group sync codes of lengths 32-54 and they are very approximative. So, in the search of long group sync codes, we recommend to use PN-SEQUENCE-SUBSET SEARCHING METHOD. It is really practicable and good searching method.

2. PN-SEQUENCE-SUBSET SEARCHING METHOD

For a given value of L, PN sequence is a pseudonoise or maximum-length sequence of length 2^L-1. PN sequences are pseudonoise. That is

<A>. In every sequence period, the number of 1's does not differ from the number of o's by more than 1.

<B>. Pseudonoise sequences have periodic autocorrelation functions with sidelobes -1.

According to reference [3], it is ideal to use PN sequences as group sync codes. Of course, only a period of PN sequences can be used in rcality and so, they have not performance of ideal sidelobes -1. But as shown below, they are still good group sync codes.

PN sequences can be generated by a L-stage linear Feedback shift register. The generated PN sequences differ as the initial conditions of linear feedback shift register. So, there are 2^L - 1 of PN sequences for a characteristic polynomial. We can construct such a sequence subset which consists of all the PN sequences of the same lengths. For a given value of L, this sequence subset is called as subset S_L. For example, when L=5, there are three characteristic polynomial and subset S_5 includes 93 of PN sequences (3*2 -1 = 93). When L=6. there are three characteristic polynomial and subset S_6 includes 189 of PN sequences. When L=7, subset S_7 includes 1143 of PN sequences.

Now, we will give two brief searching methods of long group sync codes on the small subset of PN sequences:

1>. CUT-TAIL SEARCHING METHOD

In reference [4], it is CUT-TAIL SEARCHING METHOD that the searching method we used is. The searching subset of CUT-TAIL SEARCHING METHOD is determined as follow:

For the group sync codes of length N, we always get such a L, where L is determined by

$$2^{L-1} - 1 < N < 2^{L} - 1 \qquad (1)$$

Then, the searching subset of CUT-TAIL SEARCHING METHOD can be obtained by cuting K-N bits out of the PN sequences in subset S_L. It can be called as cut-tail-sequence subset and presented by S_{LC} .

Apparently, cut-tail-sequence subset may be generated by cuting PN sequences of longer length. That is, this subset can be more than one. But as you see below, we only choose the subset S_{LC} determined by (1) in general.

<2> PREFIX-SUFFIX SEARCHING METHOD

Besides CUT-TAIL SEARCHING METHOD, we will present another searching method of quasi-optimum group sync codes Prefixing PN sequences by bit 1 and suffixing PN sequences by bit o. It is briefly called as PREFIX-SUFFIX SEARCHING METHOD.

As shown in reference [3], the code weight W of optimum group sync codes is [N/2]-1 or [N/2]+1 when the length N is odd, and N/2-1, N/2, or N/2+1 when even.

For the group sync codes of length N, choose PN sequences of length $K=2^L-1$ where L is determined by

$$2^{L} - 1 < N < 2^{L+1} - 1 \qquad (2)$$

Due to the numbers of 1's are always one more than those of o's, the searching subset of PRIFIX-SUFFIX SEACHING MEHTOD is determined as follow:

The searching subset can be obtained by Prefixing (N-K)/2 of 1 to and suffixing (N-K)/2 of o to all the PN sequences in subset S_L when N-K is even, and by prefixing [(N-K)/2] of 1 to and suffixing [(N-K)/2]+1 of o to all the PN sequences in subset S_L when N-K is odd.

This searching subset can be presented by S_{Lp}.

Of course, prefix-suffix-sequence subset may be generated by prefixing and sufixing shorter PN sequences. But. as we see below, we choose the subset S_{Lp} determinted by (2) in general.

3. Comparation of CUT TAIL and PRIFIX-SUFFIX SEARCHING MEHTOD

The group sync codes, are shown in TABLE 1 and TABLE 5, searched out by CUT-TAIL SEARCHING METHOD respectively in subset S_6 and S_7 and in TABLE 2, 3 and 4, by PREFIX-SUFFIX SEARCHING METHOD respectively in subset S_5 and S_6.

From TABLE 1, and 2, when the length N are far from the length of PN sequences, the performance of the best group sync codes by CUT-TAIL SEARCHING METHOD are not as good as the those by PREFIX-SUFFIX SEARCHING METHOD, except N=32,33. The error sync probabilities of group sync codes by the former are about 3-4 times the those by the latter. The performance of the group sync code by PREFIX-SUFFIX SEARCHING METHOD is the best approximate to that of optimum group sync code when the length is middle (47) between 31 and 63. That is, $P_{ps} / P_{op} = 1.004$. As the lengths increase or decrease, the performances become bad gradually, but they are still better than those by CUT-TAIL SEARCHING METHOD.

The latter improve gradually and are better than the former when the lengths are close to the length of PN sequences. TABLE 3, 4 and 5 illustrate this point

4. Conclusion

From about analysis, we can get several conclusions.

<1>. To search good long group sync codes, CUT-TAIL SEARCHING METHOD and PREFIX-SUFFIX SEARCHING METHOD should be used alternatively. The former should be used when the length of group sync code is close to that of PN sequence and the latter should be used when the length of group sync code is far from that of PN sequence.

<2>. In general, for a given value of N, the subset of PN sequences is chosen as the searching subset of CUT-TAIL SEARCHING METHOD, whose lengths are determinted by (1), and of PREFIX-SUFFIX SEARCHING METHOD, whose lengths are determinted by (2).

<3>. Because PN-SEQUENCE-SUBSET SEARCHING METHOD can search out very good group sync codes in a small subset and only spend several seconds, it is a very practical tool, especially at the situation needing long group sync codes.

Reference

[1] T. L. Marry, Jr and F. J. Styies, “Development Of Optimum Frame Synchronization Codes For GODDARD Space Flight Center PCM Telemetry Standards”, NTC'64, 1964, USA.

[2] Xie Qiu-Cheng: “A New Searching Method For PCM Telemetry Optimum Frame Synchronization Codes”, ITC'86, 1986, USA.

[3] Cao Jie and Xie Qiu-Cheng: "The Searching Method Of Optimum Frame Synchronization Codes Based On The Synthetic Optimum Criterion", ITC'88, 1988, USA.
[4] Xie Qiu-Cheng and Cao Jie: "Analysis On The Optimum Group Synchronization Codes Of TIROS-III Satellite", ITC'88, 1988, USA.

TABLE 1. THE BEST FRAME SYNC CODES BY CUT-TAIL SEARCHING METHOD IN SUBSET S_6

LENGTH	PATTERN	ERROR SYNC PROB. Pc
N= 32	0000 1001 0001 1011 0010 1101 0111 0111	0.10565627E-06
N= 33	0000 1001 0001 1011 0010 1101 0111 0111 1	0.42613227E-07
N= 34	1111 1011 0100 0100 0010 1100 1010 1001 00	0.59529395E-07
N= 35	0000 0110 1110 0110 0011 1010 1111 1101 101	0.24333190E-07
N= 36	1110 1100 1101 0101 1111 1000 0010 0001 1000	0.12495788E-07
N= 37	0000 1001 0001 1011 0010 1101 0111 0111 1001 1	0.69472885E-08
N= 38	0000 1110 0001 0010 0011 0110 0101 1010 1110 11	0.26604112E-08
N= 39	0000 1110 0001 0010 0011 0110 0101 1010 1110 111	0.11886775E-08
N= 40	0000 0111 0000 1001 0001 1011 0010 1101 0111 0111	0.60856736E-09
N= 41	0000 0111 0000 1001 0001 1011 0010 1101 0111 0111 1	0.22792300E-09
N= 42	0000 1100 0101 0011 1101 0001 1100 1001 0110 1110 11	0.34592557E-09
N= 43	1111 1101 1010 0010 0001 0110 0101 0100 1001 1110 000	0.12844845E-09
N= 44	1111 1101 1010 0010 0001 0110 0101 0100 1001 1110 0000	0.46794294E-10
N= 45	0000 0111 0000 1001 0001 1011 0010 1101 0111 0111 1001 1	0.33254222E-10
N= 46	1011 1111 0110 1000 1000 0101 1001 0101 0010 0111 1000 00	0.22491085E-10
N= 47	0000 1000 0110 0010 1001 1110 1000 1110 0100 1011 0111 011	0.88569195E-11
N= 48	0000 0100 0011 0001 0100 1111 0100 0111 0010 0101 1011 1011	0.46351924E-11
N= 49	1101 0111 1110 1101 0001 0000 1011 0010 1010 0100 1111 0000 0	0.25367828E-11
N= 50	1110 1011 1111 0110 1000 1000 0101 1001 0101 0010 0111 1000 00	0.12599035E-11
N= 51	0000 1011 0010 1010 0100 1111 0000 0110 1110 0110 0011 1010 111	0.72278576E-12
N= 52	0010 1100 1010 1001 0011 1100 0001 1011 1001 1000 1110 1011 1111	0.32021786E-12
N= 53	0001 0110 0101 0100 1001 1110 0000 1101 1100 1100 0111 0101 1111 1	0.12043093E-12
N= 54	0000 1011 0010 1010 0100 1111 0000 0110 1110 0110 0011 1010 1111 11	0.47400696E-13
N= 55	0010 0001 0110 0101 0100 1001 1110 0000 1101 1100 1100 0111 0101 111	0.41735929E-13
N= 56	0010 0001 0110 0101 0100 1001 1110 0000 1101 1100 1100 0111 0101 1111	0.17691831E-13
N= 57	0010 0001 0110 0101 0100 1001 1110 0000 1101 1100 1100 0111 0101 1111 1	0.67319680E-14
N= 58	0001 0000 1011 0010 1010 0100 1111 0000 0110 1110 0110 0011 1010 1111 11	0.28329235E-14
N= 59	0001 0000 1100 0101 0011 1101 0001 1100 1001 0110 1110 1100 1101 0101 111	0.16679574E-14
N= 60	0000 1000 0110 0010 1001 1110 1000 1110 0100 1011 0111 0110 0110 1010 1111	0.76715340E-15
N= 61	0000 1000 0110 0010 1001 1110 1000 1110 0100 1011 0111 0110 0110 1010 1111 1	0.32720600E-15
N= 62	0000 1000 0110 0010 1001 1110 1000 1110 0100 1011 0111 0110 0110 1010 1111 11	0.15203180E-15
N= 63	0000 0100 0011 0001 0100 1111 0100 0111 0010 0101 1011 1011 0011 0101 0111 111	0.75911850E-16

NOTE : E = 2 , P = 0.1

TABLE 2. THE BEST FRAME SYNC CODES BY PREFIX-SUFFIX SEARCHING METHOD IN SUBSET S_5

LENGTH	PATTERN	ERROR SYNC PROB. P_{FS}
N= 32	1110 1111 1001 0011 0000 1011 0101 0000	0.11617073E-06
N= 33	1101 1111 0110 0111 0000 1101 0100 1000 0	0.51099827E-07
N= 34	1111 0111 1100 1001 1000 0101 1010 1000 00	0.21011095E-07
N= 35	1111 1011 1110 0100 1100 0010 1101 0100 000	0.90097991E-08
N= 36	1111 1011 1110 0100 1100 0010 1101 0100 0000	0.18544782E-08
N= 37	1111 1101 1111 0010 0110 0001 0110 1010 0000 0	0.23512283E-08
N= 38	1111 1101 1111 0010 0110 0001 0110 1010 0000 00	0.11654233E-08
N= 39	1111 1110 1111 1001 0011 0000 1011 0101 0000 000	0.56940397E-09
N= 40	1111 1011 1110 1100 1110 0001 1010 1001 0000 0000	0.29481351E-09
N= 41	1111 1011 1011 1110 0100 1100 0010 1101 0100 0000 0	0.15152067E-09
N= 42	1111 1011 1011 1110 0100 1100 0010 1101 0100 0000 00	0.78223150E-10
N= 43	1111 1101 1101 1111 0010 0110 0001 0110 1010 0000 000	0.40376699E-10
N= 44	1111 1101 1111 0110 0111 0000 1101 0100 1000 1000 0000	0.20933545E-10
N= 45	1111 1110 1110 1111 1001 0011 0000 1011 0101 0000 0000 0	0.10838930E-10
N= 46	1111 1110 1010 1110 1100 0111 1100 1101 0010 0000 0000 00	0.56039318E-11
N= 47	1111 1111 1110 1100 1110 0001 1010 1001 0001 0110 0000 000	0.28985139E-11
N= 48	1111 1111 0010 1111 1011 0011 1000 0110 1010 0100 0000 0000	0.15033048E-11
N= 49	1111 1111 1110 1100 1110 0001 1010 1001 0001 0111 0000 0000 0	0.77703013E-12
N= 50	1111 1111 1110 1100 1110 0001 1010 1001 0001 0111 0000 0000 00	0.40222890E-12
N= 51	1111 1111 1100 1111 1001 1010 0100 0010 1011 1011 0000 0000 000	0.21017381E-12
N= 52	1111 1111 1111 0110 0111 0000 1101 0100 1000 1011 1000 0000 0000	0.10851082E-12
N= 53	1111 1111 1111 1011 0011 1000 0110 1010 0100 0101 1100 0000 0000 0	0.56736317E-13
N= 54	1111 1111 1111 0110 0111 0000 1101 0100 1000 1011 1100 0000 0000 00	0.29926023E-13
N= 55	1111 1111 1111 1011 0011 1000 0110 1010 0100 0101 1110 0000 0000 000	0.15982987E-13
N= 56	1111 1111 1111 1011 0011 1000 0110 1010 0100 0101 1110 0000 0000 0000	0.87363876E-14
N= 57	1111 1111 1111 1101 1001 1100 0011 0101 0010 0010 1111 0000 0000 0000 0	0.49561600E-14
N= 58	1111 1111 1111 1000 1111 1001 1010 0100 0010 1011 1011 0000 0000 0000 00	0.29616268E-14
N= 59	1111 1111 1111 1100 0111 1100 1101 0010 0001 0101 1101 1000 0000 0000 000	0.18940586E-14
N= 60	1111 1111 1111 1100 0111 1100 1101 0010 0001 0101 1101 1000 0000 0000 0000	0.13075512E-14
N= 61	1111 1111 1111 1111 1000 0110 1010 0100 0101 1111 0110 0100 0000 0000 0000 0	0.97284220E-15
N= 62	1111 1111 1111 1111 1000 0110 1010 0100 0101 1111 0110 0100 0000 0000 0000 00	0.77097950E-15
N= 63	1111 1111 1111 1111 0110 0111 0000 1101 0100 1000 1011 1110 0000 0000 0000 000	0.64042880E-15

NOTE : E = 2 , P = 0.1

TABLE 3. THE BEST FRAME SYNC CODES BY PREFIX-SUFFIX SEARCHING METHOD IN SUBSET S_5

LENGTH	PATTERN	ERROR SYNC PROB. P_{ps}
N= 70	1111 1111 1111 1111 1111 0010 0110 0001 0110 1010 0011 1011 1110 0000 0000 0000 0000 00	0.27520018E-15
N= 80	1111 1111 1111 1111 1111 1111 1001 0011 0000 1011 0101 0001 1101 1111 0000 0000 0000 0000 0000 0000	0.97115603E-16
N= 90	1111 1111 1111 1111 1111 1111 1111 1100 1001 1000 0101 1010 1000 1110 1111 1000 0000 0000 0000 0000 0000 0000 00	0.34351739E-16
N= 100	1111 1111 1111 1111 1111 1111 1111 1111 1110 0100 1100 0010 1101 0100 0111 0111 1100 0000 0000 0000 0000 0000 0000 0000 0000	0.12149700E-16
N= 110	1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 0010 0110 0001 0110 1010 0011 1011 1110 0000 0000 0000 0000 0000 0000 0000 0000 0000 00	0.42967128E-17
N= 120	1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1001 0011 0000 1011 0101 0001 1101 1111 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000	0.15193640E-17

NOTE : E = 2 , P = 0.1

TABLE 4. THE BEST FRAME SYNC CODES BY PREFIX-SUFFIX SEARCHING METHOD IN SUBSET S_6

LENGTH	PATTERN	ERROR SYNC PROB. P_{ps}
N= 70	1111 1101 1001 0110 1011 1011 1100 1100 0101 0100 1111 1101 0000 0111 0000 1001 0000 00	0.75672799E-18
N= 80	1111 1111 1111 1010 0011 1001 0010 1101 1101 1001 1010 1011 1111 0000 0100 0011 0001 0100 0000 0000	0.84004417E-21
N= 90	1111 1111 1111 1101 1110 1000 1110 0100 1011 0111 0110 0110 1010 1111 1100 0001 0000 1100 0101 0000 0000 0000 00	0.10129754E-23
N= 100	1111 1111 1111 1111 1100 1100 0111 0101 1111 1011 0100 0100 0010 1100 1010 1001 0011 1100 0001 1011 1000 0000 0000 0000 0000	0.11973174E-26
N= 110	1111 1111 1111 1111 1111 1110 0000 1101 1100 1100 0111 0101 1111 1011 0100 0100 0010 1100 1010 1001 0011 1100 0000 0000 0000 0000 0000 00	0.13998614E-29
N= 120	1111 1111 1111 1111 1111 1111 1111 0000 0110 1110 0110 0011 1010 1111 1101 1010 0010 0001 0110 0101 0100 1001 1110 0000 0000 0000 0000 0000 0000 0000	0.41700226E-32

NOTE : E = 2 , P = 0.1

TABLE 5. THE BEST FRAME SYNC CODES BY CUT-TAIL SEARCHING METHOD IN SUBSET S_7

LENGTH	PATTERN	ERROR SYNC PROB. P_c
N= 70	1111 0111 0110 1011 1111 1010 0110 0001 1010 0001 0100 1011 0110 0101 0101 1000 1000 00	0.77687955E-18
N= 80	0000 0101 1000 0011 1010 0001 0011 1000 1101 0010 0101 1101 1011 1001 1011 0010 1011 0101 1111 0111	0.13609872E-20
N= 90	0000 1001 1000 0010 1010 1101 0010 0101 0011 1100 1000 1101 0100 0011 1111 1011 1011 0111 1010 0010 1100 1011 11	0.26017384E-23
N= 100	1110 1111 0100 0110 0110 1001 1000 1110 0101 0101 1101 0100 1001 0111 1111 0011 1110 1101 1100 0000 1010 0001 1011 0010 0000	0.18197669E-26
N= 110	0001 0100 0011 0110 0100 0001 1110 0010 1101 0110 0001 0001 0011 1011 1101 0001 1001 1010 0110 0011 1001 0101 0111 0101 0010 0101 1111 11	0.20124858E-29
N= 120	1111 1101 1111 0001 1101 0101 0010 1011 1101 0011 0011 1001 1010 1100 0100 0101 1101 1001 0000 1111 0010 1101 1100 0001 0100 0110 1101 0000 0011 0000	0.18071466E-32

NOTE : E = 2 , P = 0.1

TABLE 6. OPTIMUM FRAME SYNC CODES

LENGTH	PATTERN	ERROR SYNCH. PROB. P_{op}
N = 31	1111 1110 1100 0110 1001 0001 0100 000	0.10771E-06
N = 32	1111 1101 1011 0001 1000 0101 0100 0000	0.55268E-07
N = 33	1111 1110 1101 1000 1100 0010 1010 0000 0	0.28565E-07
N = 34	1111 1001 1110 1100 1101 0101 1000 0000 00	0.14726E-07
N = 35	1111 1101 1011 0110 0011 0001 0101 0000 000	0.76263E-08
N = 36	1111 1100 1110 1101 0101 1001 0110 0000 0000	0.39604E-08
N = 37	1111 1110 1010 1101 0011 0110 0011 0000 0000 0	0.20545E-08
N = 38	1111 1110 0111 0110 1010 1100 1011 0000 0000 00	0.10650E-08
N = 39	1111 1111 0101 0111 0010 0101 1000 1100 0000 000	0.55369E-09
N = 40	1111 1110 1010 1101 1001 0011 1000 1100 0000 0000	0.28764E-09
N = 41	1111 1110 1101 1011 0001 1010 1000 1110 0000 0000 0	0.14928E-09
N = 42	1111 1110 1101 1001 1010 1101 0100 0111 0000 0000 00	0.77313E-10
N = 43	1111 1111 1001 1011 0101 0001 1100 1001 0100 0000 000	0.40086E-10
N = 45	1111 1110 1101 0111 1010 0011 1000 1011 0010 0000 0000 0	0.10764E-10
N = 46	1111 1111 0110 0110 1011 1000 1011 0100 0010 0000 0000 00	0.55734E-11
N = 47	1111 1111 0101 1101 1001 1000 1110 0001 0110 1000 0000 000	0.28871E-11
N = 48	1111 1111 0111 1010 0101 1100 1100 1010 0010 1100 0000 0000	0.14938E-11
N = 49	1111 1111 0101 0111 0011 1001 0111 0010 0100 1000 0000 0000 0	0.77288E-12
N = 50	1111 1111 0101 1010 1111 0011 0001 0111 0100 1100 0000 0000 00	0.39973E-12
N = 51	1111 1111 1010 0111 0110 0111 0001 1011 0100 0101 0000 0000 000	0.20652E-12
N = 52	1111 1111 1011 0011 1101 0010 0111 0000 1010 1001 1000 0000 0000	0.10666E-12
N = 53	1111 1111 1010 1110 1011 0100 1100 1011 0001 0011 1000 0000 0000 0	0.55073E-13
N = 54	1111 1111 1010 0111 1010 0111 0011 0010 1100 0101 0100 0000 0000 00	0.28418E-13

NOTE : E = 2 , P = 0.1

TABLE 7. COMPARATION

LENGTH	P_{op}	P_c	P_{ps}	P_c / P_{op}	P_{ps} / P_{op}	P_c / P_{ps}
N= 32	0.55268E-07	0.10565627E-06	0.11617073E-06	1.912	2.102	0.909
N= 33	0.28565E-07	0.42613227E-07	0.51999827E-07	1.492	1.820	0.819
N= 34	0.14726E-07	0.59529395E-07	0.21911095E-07	4.042	1.488	2.716
N= 35	0.76263E-08	0.24333190E-07	0.90097991E-08	3.190	1.181	2.701
N= 36	0.39604E-08	0.12495788E-07	0.48544782E-08	3.155	1.226	2.573
N= 37	0.20545E-08	0.69472885E-08	0.23512283E-08	3.381	1.144	2.955
N= 38	0.10650E-08	0.26604112E-08	0.11654233E-08	2.498	1.094	2.283
N= 39	0.55369E-09	0.11886775E-08	0.56940397E-09	2.147	1.028	2.088
N= 40	0.28764E-09	0.60856736E-09	0.29481351E-09	2.125	1.025	2.001
N= 41	0.14928E-09	0.22792300E-09	0.15152067E-09	1.527	1.060	1.440
N= 42	0.77313E-10	0.34592557E-09	0.78223150E-10	4.474	1.012	4.421
N= 43	0.40086E-10	0.12844845E-09	0.40376699E-10	3.204	1.007	3.182
N= 44	0.20759E-10	0.46794294E-10	0.20933545E-10	2.254	1.008	2.236
N= 45	0.10764E-10	0.33254222E-10	0.10838930E-10	3.089	1.007	3.067
N= 46	0.55734E-11	0.22491085E-10	0.56039318E-11	4.035	1.005	4.015
N= 47	0.28871E-11	0.88569195E-11	0.28985139E-11	3.068	1.004	3.056
N= 48	0.14938E-11	0.46351924E-11	0.15033048E-11	3.103	1.006	3.084
N= 49	0.77288E-12	0.25367828E-11	0.77703013E-12	3.282	1.005	3.264
N= 50	0.39973E-12	0.12599035E-11	0.40222890E-12	3.152	1.006	3.132
N= 51	0.20652E-12	0.72278576E-12	0.21017381E-12	3.500	1.009	3.467
N= 52	0.10666E-12	0.32021786E-12	0.10851082E-12	3.000	1.017	2.950
N= 53	0.55073E-13	0.12043093E-12	0.56736317E-13	2.187	1.031	2.121
N= 54	0.28418E-13	0.47400696E-13	0.29926023E-13	1.668	1.053	1.584
N= 55		0.41735929E-13	0.15982987E-13			2.611
N= 56		0.17691831E-13	0.87363876E-14			2.025
N= 57		0.67319680E-14	0.49561600E-14			1.358
N= 58		0.28329235E-14	0.29616268E-14			0.956
N= 59		0.16679574E-14	0.18940586E-14			0.880
N= 60		0.76715340E-15	0.13075512E-14			0.587
N= 61		0.32720600E-15	0.97284220E-15			0.336
N= 62		0.15203180E-15	0.77097950E-15			0.197
N= 63		0.75911850E-16	0.64042880E-15			0.118

NOTE : E = 2 , P = 0.1