1 PRG270 Analyse Zufallsrohdaten nach AIS31 (kurz)

```
**********************************************************************
*                                                                    *
*               AIS31 evaluation tests                                *
*                                                                    *
**********************************************************************

 date, time:   03/27/2019,  14:21:54
 tested file:  PRG270r.rnd
 size of file:  10240000 bytes

 ----------------------------------------------------------------------
 Introduction
 ----------------------------------------------------------------------
 The purpose of the following tests is to evaluate the suitability
 of a true (physical) random number generator for cryptographic
 applications. In [1] an evaluation methodology for physical random
 number generators has been proposed by the German Federal Security
 Agency. In the mathematical-technical reference to [1], five tests
 are defined for the P2-evaluation of a physical random number
 generator (cf. [3] and [4]) which are implemented in the following
 tests 1 - 5.

 ----------------------------------------------------------------------
 Results of test 1  (test (P2.i)(vii.a) of AIS 31, cf. [3] and [4])
 ----------------------------------------------------------------------
 In this test, the relative frequency r of bit 1 ocurring in the
 first 100000 bits of the bit sequence is computed. Then the bit
 sequence passes the test if |r - 0.5| < 0.025.

 test scope:  first 100000 bits
 number of ones:  50092
 relative frequency:  0.500920
 test value:  0.00092000  < 0.025

 sequence passes test 1

 ----------------------------------------------------------------------
 Results of test 2  (test (P2.i)(vii.b) of AIS 31, cf. [3] and [4])
 ----------------------------------------------------------------------
 In this test, two disjoint sub-sequences TF(0) and TF(1) of bit pairs
 are considered where TF(i) consists of the first 100000 bit pairs
 of the form (i,x) ocurring in the bit sequence after the test scope
 of test 1. Let v(i,j) denote the relative frequency of all bit pairs
 of the form (i,j) in TF(i). Then the bit sequence passes the test
 if |v(0,1) + v(1,0) - 1| < 0.02.

 number of 2-bit words looked up: 200333
 relative frequency v(0,1):  0.500600
 relative frequency v(1,0):  0.499440
 test value:  0.00004000 < 0.02

 sequence passes test 2

 ----------------------------------------------------------------------
 Results of test 3  (test (P2.i)(vii.c) of AIS 31, cf. [3] and [4])
 ----------------------------------------------------------------------
 In this test, 4 disjoint sub-sequences TF(0,0),..., TF(1,1) of
 3-tupels are considered where TF(i,j) consists of the first 100000
 3-tupels of bits of the form (i,j,x) ocurring in the bit sequence
```

after the test scope of test 2. For every i,j in {0,1}, let S(i,j)
denote the sub-sequence of all bits k such that (i,j,k) is element
of TF(i,j). Then sample S(0,j) is compared with S(1,j) for every
j = 0,1. In this context, a comparison of two bit sequences g and h
of equal length is performed by a computation of the test value
t = (g_0 - h_0)^2 /(g_0 + h_0) + (g_1 - h_1)^2 /(g_1 + h_1) where
g_i resp. h_i is the number of bit i occurring in sequence g resp. h.
Let t_j be the test value for the comparison of S(0,j) with S(1,j)
Then the bit sequence passes the test if t_j < 15,13 for j = 0,1.

number of 3-bit words looked up: 401104
test value t_1: 0.737284 <= 15.13
test value t_2: 0.016820 <= 15.13

sequence passes test 3

Results of test 4 (test (P2.i)(vii.d) of AIS 31, cf. [3] and [4])

In this test, 8 disjoint sub-sequences TF(0,0,0),..., TF(1,1,1) of
4-tupels are considered where TF(i,j,k) consists of the first 100000
4-tupels of bits of the form (i,j,k,x) ocurring in the bit sequence
after the test scope of test 3. For every i,j in {0,1}, let S(i,j,k)
denote the sub-sequence of all bits b such that (i,j,k,b) is an
element of TF(i,j,k). Then sample S(0,j,k) is compared with S(1,j,k)
for every j,k of {0,1}. In this context, a comparison of two bit
sequences g and h of equal length is performed by a computation of the
test value t = (g_0 - h_0)^2 /(g_0 + h_0) + (g_1 - h_1)^2 /(g_1 + h_1)
where g_i resp. h_i is the number of bit i occurring in sequence g
resp. h. Let t_jk be the test value for the comparison of S(0,j,k)
with S(1,j,k). Then the bit sequence passes the test if t_jk < 15,13
for all j,k of {0,1}.

number of 4-bit words looked up: 806323
test value t_00: 0.857033 <= 15.13
test value t_01: 1.705292 <= 15.13
test value t_10: 4.287390 <= 15.13
test value t_11: 0.095220 <= 15.13

sequence passes test 4

Results of test 5 (test (P2.i)(vii.e) of AIS 31, cf. [3] and [4])

In this test, the Coron test with the parameters L = 8, Q = 2560,
and K = 256000 is performed (cf. [2]). For the first Q+K 8-bit-words
after the test scope of test 4, the test value f of the Coron test is
computed. The bit sequence passes the test if f > 7.976.

8-bit words looked up: 2560 + 256000 bytes
f-value: 7.99648328
7.99648328 > 7.976

sequence passes test 5

References
---
[1] AIS 31: Functionality Classes and Evaluation Methodology for
    Physical Random Number Generators. Version 1 (25.09.2001),
    (mandatory if a German IT security certificate is applied for;
    English translation).
    available at www.bsi.bund.de/zertifiz/zert/interpr/ais31e.pdf

[2] J.- S. Coron: On the Security of Random Sources. In: Public Key Cryptography - PKC 99. Lecture Notes in Computer Science, Vol. 1560, 29-42, Springer-Verlag, 2002.

[3] W. Killmann and W. Schindler: A Proposal for: Functionality Classes and Evaluation Methodology for True (Physical) Random Number Generators. Version 3.1 (25.09.2001), mathematical-technical reference of [1] (English Translation); available at www.bsi.bund.de/zertifiz/zert/interpr/trngk31e.pdf

[4] W. Schindler and W. Killmann: Evaluation Criteria for True (Physical) Random Number Generators Used in Cryptographic Applications. In: Cryptographic Hardware and Empedded Systems - CHES 2002. Lecture Notes in Computer Science, Vol. 2523, 431-449, Springer-Verlag, 2002.

2 PRG270 Analyse Zufallsrohdaten nach AIS31 (lang)

```
##########################################################################
#                                                                        #
#                  Results of RawTest                                    #
#                                                                        #
##########################################################################


date, time:   03/27/2019,  14:22:16
tested file:  PRG270r.rnd
size of file:  10240000 bytes


************************************************************************
*                                      *
*             Results of the frequency test            *
*                                      *
************************************************************************
test scope:    first 10240000 bytes
relative frequency of bit 1:  0.49885028

block length L =  2:  chi^2 =    0.8029,  p-value = 0.84877426
block length L =  3:  chi^2 =    3.7160,  p-value = 0.81184453
block length L =  4:  chi^2 =   23.8915,  p-value = 0.06695912
block length L =  5:  chi^2 =   21.7103,  p-value = 0.89190171
block length L =  6:  chi^2 =   61.2409,  p-value = 0.53928097
block length L =  7:  chi^2 =  142.9590,  p-value = 0.15776941
block length L =  8:  chi^2 =  339.2798,  p-value = 0.00031975
block length L =  9:  chi^2 =  507.1169,  p-value = 0.54018726
block length L = 10:  chi^2 = 1019.0559,  p-value = 0.52892354


************************************************************************
*                                      *
*              Results of the serial test              *
*                                      *
************************************************************************
test scope:    first 10000000 bytes
relative frequency of bit 1:  0.49884703

block length L =  2:  chi^2 =    0.3929,  p-value = 0.82163189
block length L =  3:  chi^2 =    6.8763,  p-value = 0.14256942
block length L =  4:  chi^2 =   10.6797,  p-value = 0.22051571
block length L =  5:  chi^2 =   21.3932,  p-value = 0.16388572
block length L =  6:  chi^2 =   37.7913,  p-value = 0.22165605
```

```
block length L =  7:  chi^2 =   80.6102,  p-value = 0.07849718
block length L =  8:  chi^2 =  137.0836,  p-value = 0.27549824
block length L =  9:  chi^2 =  278.1932,  p-value = 0.16278436
block length L = 10:  chi^2 =  534.2785,  p-value = 0.23974751


**********************************************************************
*                                                                    *
*           Results of the modular monobit test                      *
*                                                                    *
**********************************************************************
test scope:    first 10240000 bytes
relative frequency of bit 1:  0.49885028

modular monobit test for block length L = 3:
bit  0:  rf = 0.49889763, chi^2 =  0.24490077, p-value = 0.62068871
bit  1:  rf = 0.49892118, chi^2 =  0.54903998, p-value = 0.45871022
bit  2:  rf = 0.49873207, chi^2 =  1.52637368, p-value = 0.21665751

modular monobit test for block length L = 4:
bit  0:  rf = 0.49873340, chi^2 =  1.11915417, p-value = 0.29010066
bit  1:  rf = 0.49858765, chi^2 =  5.65060635, p-value = 0.01744934
bit  2:  rf = 0.49887124, chi^2 =  0.03598760, p-value = 0.84954109
bit  3:  rf = 0.49920884, chi^2 = 10.53195423, p-value = 0.00117328

modular monobit test for block length L = 5:
bit  0:  rf = 0.49882001, chi^2 =  0.06006282, p-value = 0.80639668
bit  1:  rf = 0.49872534, chi^2 =  1.02300565, p-value = 0.31180712
bit  2:  rf = 0.49890192, chi^2 =  0.17473628, p-value = 0.67593638
bit  3:  rf = 0.49900531, chi^2 =  1.57510598, p-value = 0.20946705
bit  4:  rf = 0.49879883, chi^2 =  0.17349921, p-value = 0.67702049

modular monobit test for block length L = 6:
bit  0:  rf = 0.49884574, chi^2 =  0.00112619, p-value = 0.97322899
bit  1:  rf = 0.49899918, chi^2 =  1.21087189, p-value = 0.27115951
bit  2:  rf = 0.49871808, chi^2 =  0.95450499, p-value = 0.32857524
bit  3:  rf = 0.49894952, chi^2 =  0.53790050, p-value = 0.46330413
bit  4:  rf = 0.49884318, chi^2 =  0.00275658, p-value = 0.95812780
bit  5:  rf = 0.49874606, chi^2 =  0.59324439, p-value = 0.44116727

modular monobit test for block length L = 7:
bit  0:  rf = 0.49882213, chi^2 =  0.03710921, p-value = 0.84724288
bit  1:  rf = 0.49888450, chi^2 =  0.05482455, p-value = 0.81487130
bit  2:  rf = 0.49885767, chi^2 =  0.00255741, p-value = 0.95966747
bit  3:  rf = 0.49892834, chi^2 =  0.28522483, p-value = 0.59329695
bit  4:  rf = 0.49879282, chi^2 =  0.15458067, p-value = 0.69419579
bit  5:  rf = 0.49870984, chi^2 =  0.92322997, p-value = 0.33662832
bit  6:  rf = 0.49895671, chi^2 =  0.53022199, p-value = 0.46651354

modular monobit test for block length L = 8:
bit  0:  rf = 0.49850195, chi^2 =  4.96979083, p-value = 0.02579377
bit  1:  rf = 0.49797471, chi^2 = 31.40130451, p-value = 0.00000002
bit  2:  rf = 0.49829268, chi^2 = 12.73548629, p-value = 0.00035878
bit  3:  rf = 0.49881602, chi^2 =  0.04809137, p-value = 0.82641834
bit  4:  rf = 0.49896484, chi^2 =  0.53758966, p-value = 0.46343337
bit  5:  rf = 0.49920059, chi^2 =  5.02638039, p-value = 0.02496402
bit  6:  rf = 0.49944980, chi^2 = 14.72228713, p-value = 0.00012457
bit  7:  rf = 0.49960166, chi^2 = 23.12495021, p-value = 0.00000152

modular monobit test for block length L = 9:
bit  0:  rf = 0.49876140, chi^2 =  0.28761543, p-value = 0.59175269
bit  1:  rf = 0.49891400, chi^2 =  0.14783269, p-value = 0.70061518
bit  2:  rf = 0.49864934, chi^2 =  1.47008483, p-value = 0.22533231
bit  3:  rf = 0.49903452, chi^2 =  1.23589296, p-value = 0.26626405
bit  4:  rf = 0.49897574, chi^2 =  0.57312173, p-value = 0.44902108
bit  5:  rf = 0.49861473, chi^2 =  2.02006121, p-value = 0.15523288
bit  6:  rf = 0.49889697, chi^2 =  0.07937655, p-value = 0.77814408
bit  7:  rf = 0.49887379, chi^2 =  0.02012525, p-value = 0.88718782
bit  8:  rf = 0.49893213, chi^2 =  0.24390860, p-value = 0.62139726

modular monobit test for block length L = 10:
```

```
bit  0:  rf = 0.49884607, chi^2 =  0.00058118, p-value = 0.98076672
bit  1:  rf = 0.49877759, chi^2 =  0.17315533, p-value = 0.67732265
bit  2:  rf = 0.49886438, chi^2 =  0.00651383, p-value = 0.93567394
bit  3:  rf = 0.49920068, chi^2 =  4.02334659, p-value = 0.04487459
bit  4:  rf = 0.49881812, chi^2 =  0.03390265, p-value = 0.85391405
bit  5:  rf = 0.49879395, chi^2 =  0.10399579, p-value = 0.74708622
bit  6:  rf = 0.49867310, chi^2 =  1.02874189, p-value = 0.31045434
bit  7:  rf = 0.49893945, chi^2 =  0.26056302, p-value = 0.60973361
bit  8:  rf = 0.49880994, chi^2 =  0.05333537, p-value = 0.81735791
bit  9:  rf = 0.49877954, chi^2 =  0.16397560, p-value = 0.68552235


*************************************************************************
*                                                                       *
*           Results of the autocorrelation test                         *
*                                                                       *
*************************************************************************
test scope:    first 10000000 bytes
relative frequency of bit 1:  0.49884703

bit shift d =  1:  chi^2 =  0.39278546,  p-value = 0.53083887
bit shift d =  2:  chi^2 =  6.48125728,  p-value = 0.01090178
bit shift d =  3:  chi^2 =  2.46247860,  p-value = 0.11659467
bit shift d =  4:  chi^2 =  8.21160098,  p-value = 0.00416234
bit shift d =  5:  chi^2 =  2.05132705,  p-value = 0.15207359
bit shift d =  6:  chi^2 =  0.10100523,  p-value = 0.75062663
bit shift d =  7:  chi^2 =  5.81991488,  p-value = 0.01584571
bit shift d =  8:  chi^2 =  0.35732770,  p-value = 0.54999412
bit shift d =  9:  chi^2 =  0.45959177,  p-value = 0.49781482
bit shift d = 10:  chi^2 = 10.06823737,  p-value = 0.00150847


*************************************************************************
*                                                                       *
*             Results of the dependency test                            *
*                                                                       *
*************************************************************************
test scope:    first 10240000 bytes
relative frequency of bit 1:  0.49885028

dependency test for block length L = 3:

bit place 1 if bit 0 = 0:
rf = 0.49893345, chi^2 =  0.37864621, p-value = 0.53832865
bit place 1 if bit 0 = 1:
rf = 0.49890889, chi^2 =  0.18716006, p-value = 0.66529086
bit place 2 if bit 1 = 0:
rf = 0.49871916, chi^2 =  0.94101459, p-value = 0.33201705
bit place 2 if bit 1 = 1:
rf = 0.49874507, chi^2 =  0.60322352, p-value = 0.43735074
bit place 3 if bit 2 = 0:
rf = 0.49880899, chi^2 =  0.09335123, p-value = 0.75995922
bit place 3 if bit 2 = 1:
rf = 0.49898669, chi^2 =  1.01361762, p-value = 0.31403773

dependency test for block length L = 4:

bit place 1 if bit 0 = 0:
rf = 0.49864333, chi^2 =  1.75872734, p-value = 0.18478333
bit place 1 if bit 0 = 1:
rf = 0.49853173, chi^2 =  4.14589745, p-value = 0.04173553
bit place 2 if bit 1 = 0:
rf = 0.49880659, chi^2 =  0.07839631, p-value = 0.77948256
```

bit place 2 if bit 1 = 1:
rf = 0.49893630, chi^2 = 0.30223530, p-value = 0.58248447
bit place 3 if bit 2 = 0:
rf = 0.49918787, chi^2 = 4.67858798, p-value = 0.03054084
bit place 3 if bit 2 = 1:
rf = 0.49922995, chi^2 = 5.89106667, p-value = 0.01521788
bit place 4 if bit 3 = 0:
rf = 0.49864423, chi^2 = 1.74171201, p-value = 0.18692205
bit place 4 if bit 3 = 1:
rf = 0.49882280, chi^2 = 0.03089404, p-value = 0.86047698

dependency test for block length L = 5:

bit place 1 if bit 0 = 0:
rf = 0.49877986, chi^2 = 0.16289789, p-value = 0.68650240
bit place 1 if bit 0 = 1:
rf = 0.49867063, chi^2 = 1.05507955, p-value = 0.30434011
bit place 2 if bit 1 = 0:
rf = 0.49880547, chi^2 = 0.06595378, p-value = 0.79732184
bit place 2 if bit 1 = 1:
rf = 0.49899891, chi^2 = 0.72205166, p-value = 0.39547175
bit place 3 if bit 2 = 0:
rf = 0.49892984, chi^2 = 0.20786913, p-value = 0.64844271
bit place 3 if bit 2 = 1:
rf = 0.49908117, chi^2 = 1.74307528, p-value = 0.18674964
bit place 4 if bit 3 = 0:
rf = 0.49889551, chi^2 = 0.06715974, p-value = 0.79551799
bit place 4 if bit 3 = 1:
rf = 0.49870182, chi^2 = 0.72075281, p-value = 0.39589708
bit place 5 if bit 4 = 0:
rf = 0.49869205, chi^2 = 0.82243033, p-value = 0.36447055
bit place 5 if bit 4 = 1:
rf = 0.49894852, chi^2 = 0.31550860, p-value = 0.57431940

dependency test for block length L = 6:

bit place 1 if bit 0 = 0:
rf = 0.49902651, chi^2 = 0.85006533, p-value = 0.35653386
bit place 1 if bit 0 = 1:
rf = 0.49897180, chi^2 = 0.40228097, p-value = 0.52591361
bit place 2 if bit 1 = 0:
rf = 0.49864466, chi^2 = 1.15688457, p-value = 0.28211259
bit place 2 if bit 1 = 1:
rf = 0.49879187, chi^2 = 0.09298305, p-value = 0.76041854
bit place 3 if bit 2 = 0:
rf = 0.49892653, chi^2 = 0.15917285, p-value = 0.68991920
bit place 3 if bit 2 = 1:
rf = 0.49897271, chi^2 = 0.40823654, p-value = 0.52286593
bit place 4 if bit 3 = 0:
rf = 0.49884038, chi^2 = 0.00268478, p-value = 0.95867624
bit place 4 if bit 3 = 1:
rf = 0.49884606, chi^2 = 0.00048500, p-value = 0.98242984
bit place 5 if bit 4 = 0:
rf = 0.49879371, chi^2 = 0.08759486, p-value = 0.76725735
bit place 5 if bit 4 = 1:

rf = 0.49869826, chi^2 = 0.62962767, p-value = 0.42749192
bit place 6 if bit 5 = 0:
rf = 0.49869151, chi^2 = 0.69004807, p-value = 0.40614803
bit place 6 if bit 5 = 1:
rf = 0.49900067, chi^2 = 0.61602744, p-value = 0.43252736

dependency test for block length L = 7:

bit place 1 if bit 0 = 0:
rf = 0.49866151, chi^2 = 0.83597410, p-value = 0.36055072
bit place 1 if bit 0 = 1:
rf = 0.49910863, chi^2 = 1.55852617, p-value = 0.21188115
bit place 2 if bit 1 = 0:
rf = 0.49898883, chi^2 = 0.45028521, p-value = 0.50219954
bit place 2 if bit 1 = 1:
rf = 0.49872602, chi^2 = 0.36062522, p-value = 0.54815921
bit place 3 if bit 2 = 0:
rf = 0.49891914, chi^2 = 0.11124742, p-value = 0.73872841
bit place 3 if bit 2 = 1:
rf = 0.49893766, chi^2 = 0.17830162, p-value = 0.67283688
bit place 4 if bit 3 = 0:
rf = 0.49887474, chi^2 = 0.01403065, p-value = 0.90571028
bit place 4 if bit 3 = 1:
rf = 0.49871063, chi^2 = 0.45550608, p-value = 0.49973174
bit place 5 if bit 4 = 0:
rf = 0.49864182, chi^2 = 1.01961123, p-value = 0.31261124
bit place 5 if bit 4 = 1:
rf = 0.49877829, chi^2 = 0.12101819, p-value = 0.72793280
bit place 6 if bit 5 = 0:
rf = 0.49851360, chi^2 = 2.65997786, p-value = 0.10290217
bit place 6 if bit 5 = 1:
rf = 0.49940219, chi^2 = 7.11118353, p-value = 0.00766045
bit place 7 if bit 6 = 0:
rf = 0.49914447, chi^2 = 2.02997958, p-value = 0.15422268
bit place 7 if bit 6 = 1:
rf = 0.49849834, chi^2 = 2.89299085, p-value = 0.08896563

dependency test for block length L = 8:

bit place 1 if bit 0 = 0:
rf = 0.49801221, chi^2 = 14.42771020, p-value = 0.00014564
bit place 1 if bit 0 = 1:
rf = 0.49793708, chi^2 = 17.02789516, p-value = 0.00003683
bit place 2 if bit 1 = 0:
rf = 0.49816952, chi^2 = 9.52954792, p-value = 0.00202190
bit place 2 if bit 1 = 1:
rf = 0.49841693, chi^2 = 3.83048463, p-value = 0.05032838
bit place 3 if bit 2 = 0:
rf = 0.49885372, chi^2 = 0.00024288, p-value = 0.98756586
bit place 3 if bit 2 = 1:
rf = 0.49877815, chi^2 = 0.10618502, p-value = 0.74452996
bit place 4 if bit 3 = 0:
rf = 0.49908332, chi^2 = 1.11487965, p-value = 0.29102368
bit place 4 if bit 3 = 1:
rf = 0.49884590, chi^2 = 0.00039212, p-value = 0.98420140

bit place 5 if bit 4 = 0:
rf = 0.49927504, chi^2 = 3.70260750, p-value = 0.05432751
bit place 5 if bit 4 = 1:
rf = 0.49912592, chi^2 = 1.55284923, p-value = 0.21271531
bit place 6 if bit 5 = 0:
rf = 0.49944532, chi^2 = 7.26302691, p-value = 0.00703886
bit place 6 if bit 5 = 1:
rf = 0.49945440, chi^2 = 7.46249875, p-value = 0.00629975
bit place 7 if bit 6 = 0:
rf = 0.49952289, chi^2 = 9.27541015, p-value = 0.00232251
bit place 7 if bit 6 = 1:
rf = 0.49968070, chi^2 = 14.10757558, p-value = 0.00017265
bit place 8 if bit 7 = 0:
rf = 0.49820456, chi^2 = 8.54622234, p-value = 0.00346240
bit place 8 if bit 7 = 1:
rf = 0.49879973, chi^2 = 0.05229822, p-value = 0.81911140

dependency test for block length L = 9:

bit place 1 if bit 0 = 0:
rf = 0.49894923, chi^2 = 0.17869412, p-value = 0.67249790
bit place 1 if bit 0 = 1:
rf = 0.49887870, chi^2 = 0.01467090, p-value = 0.90359321
bit place 2 if bit 1 = 0:
rf = 0.49868570, chi^2 = 0.49415344, p-value = 0.48208038
bit place 2 if bit 1 = 1:
rf = 0.49861271, chi^2 = 1.02523509, p-value = 0.31128044
bit place 3 if bit 2 = 0:
rf = 0.49890268, chi^2 = 0.05012540, p-value = 0.82284522
bit place 3 if bit 2 = 1:
rf = 0.49916696, chi^2 = 1.82076242, p-value = 0.17722255
bit place 4 if bit 3 = 0:
rf = 0.49880162, chi^2 = 0.04319242, p-value = 0.83536337
bit place 4 if bit 3 = 1:
rf = 0.49915065, chi^2 = 1.63932326, p-value = 0.20041834
bit place 5 if bit 4 = 0:
rf = 0.49841123, chi^2 = 3.51646976, p-value = 0.06076174
bit place 5 if bit 4 = 1:
rf = 0.49881919, chi^2 = 0.01756392, p-value = 0.89456593
bit place 6 if bit 5 = 0:
rf = 0.49860476, chi^2 = 1.10045066, p-value = 0.29416722
bit place 6 if bit 5 = 1:
rf = 0.49919092, chi^2 = 2.10654362, p-value = 0.14667027
bit place 7 if bit 6 = 0:
rf = 0.49904958, chi^2 = 0.72469579, p-value = 0.39460791
bit place 7 if bit 6 = 1:
rf = 0.49869733, chi^2 = 0.42491558, p-value = 0.51449440
bit place 8 if bit 7 = 0:
rf = 0.49906048, chi^2 = 0.80613884, p-value = 0.36926427
bit place 8 if bit 7 = 1:
rf = 0.49880331, chi^2 = 0.04007269, p-value = 0.84133853
bit place 9 if bit 8 = 0:
rf = 0.49891971, chi^2 = 0.08795149, p-value = 0.76679775
bit place 9 if bit 8 = 1:
rf = 0.49860230, chi^2 = 1.11708306, p-value = 0.29054742

dependency test for block length L = 10:

bit place 1 if bit 0 = 0:
rf = 0.49897064, chi^2 = 0.23788177, p-value = 0.62574022
bit place 1 if bit 0 = 1:
rf = 0.49858352, chi^2 = 1.16319639, p-value = 0.28080362
bit place 2 if bit 1 = 0:
rf = 0.49893230, chi^2 = 0.11048195, p-value = 0.73959610
bit place 2 if bit 1 = 1:
rf = 0.49879601, chi^2 = 0.04814479, p-value = 0.82632350
bit place 3 if bit 2 = 0:
rf = 0.49902017, chi^2 = 0.47395602, p-value = 0.49117282
bit place 3 if bit 2 = 1:
rf = 0.49938214, chi^2 = 4.62413419, p-value = 0.03152517
bit place 4 if bit 3 = 0:
rf = 0.49880501, chi^2 = 0.03363095, p-value = 0.85449404
bit place 4 if bit 3 = 1:
rf = 0.49883138, chi^2 = 0.00584135, p-value = 0.93907803
bit place 5 if bit 4 = 0:
rf = 0.49892235, chi^2 = 0.08529225, p-value = 0.77024964
bit place 5 if bit 4 = 1:
rf = 0.49866506, chi^2 = 0.56077159, p-value = 0.45394953
bit place 6 if bit 5 = 0:
rf = 0.49858897, chi^2 = 1.12141947, p-value = 0.28961301
bit place 6 if bit 5 = 1:
rf = 0.49875775, chi^2 = 0.13995413, p-value = 0.70832662
bit place 7 if bit 6 = 0:
rf = 0.49867868, chi^2 = 0.48375578, p-value = 0.48672601
bit place 7 if bit 6 = 1:
rf = 0.49920174, chi^2 = 2.01843886, p-value = 0.15539884
bit place 8 if bit 7 = 0:
rf = 0.49883950, chi^2 = 0.00190920, p-value = 0.96514799
bit place 8 if bit 7 = 1:
rf = 0.49878037, chi^2 = 0.07990295, p-value = 0.77742897
bit place 9 if bit 8 = 0:
rf = 0.49898606, chi^2 = 0.30275649, p-value = 0.58215949
bit place 9 if bit 8 = 1:
rf = 0.49857216, chi^2 = 1.26428358, p-value = 0.26084182
bit place 10 if bit 9 = 0:
rf = 0.49846188, chi^2 = 2.47760626, p-value = 0.11547788
bit place 10 if bit 9 = 1:
rf = 0.49923201, chi^2 = 2.38164236, p-value = 0.12276842