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*****  
*                                                                 *  
*                   AIS31 evaluation tests                       *  
*                                                                 *  
*****
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```
date, time:    01/22/2015, 12:21:16  
tested file:   prg620_1.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 occurring 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: 50168  
relative frequency: 0.501680  
test value: 0.00168000 < 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) occurring 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: 200277  
relative frequency  $v(0,1)$ : 0.498610  
relative frequency  $v(1,0)$ : 0.497830  
test value: 0.00356000 < 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 $TF(0,0), \dots, TF(1,1)$ of 3-tupels are considered where $TF(i,j)$ consists of the first 100000 3-tupels of bits of the form (i,j,x) occurring 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: 403533
test value t_1 : 2.191222 \leq 15.13
test value t_2 : 0.633680 \leq 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 $TF(0,0,0), \dots, TF(1,1,1)$ 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) occurring 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: 801736
test value t_{00} : 0.397620 \leq 15.13
test value t_{01} : 2.767690 \leq 15.13
test value t_{10} : 1.501520 \leq 15.13
test value t_{11} : 0.141120 \leq 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: 8.00109772
8.00109772 $>$ 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 Embedded Systems - CHES 2002. Lecture Notes in Computer Science, Vol. 2523, 431-449, Springer-Verlag, 2002.