Kidekin TRNG user manual

REVISION HISTORY

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1.0	2015-05		K

Contents

Chapter 1

Introduction

Kidekin TRNG is a true random number generator in the popular "USB key" form factor which can be used in multiple ways on various platforms. The documentation is therefore broken down in several documents, each focusing on a particular task or use case. This document describe the hardware and present the content of the software package.

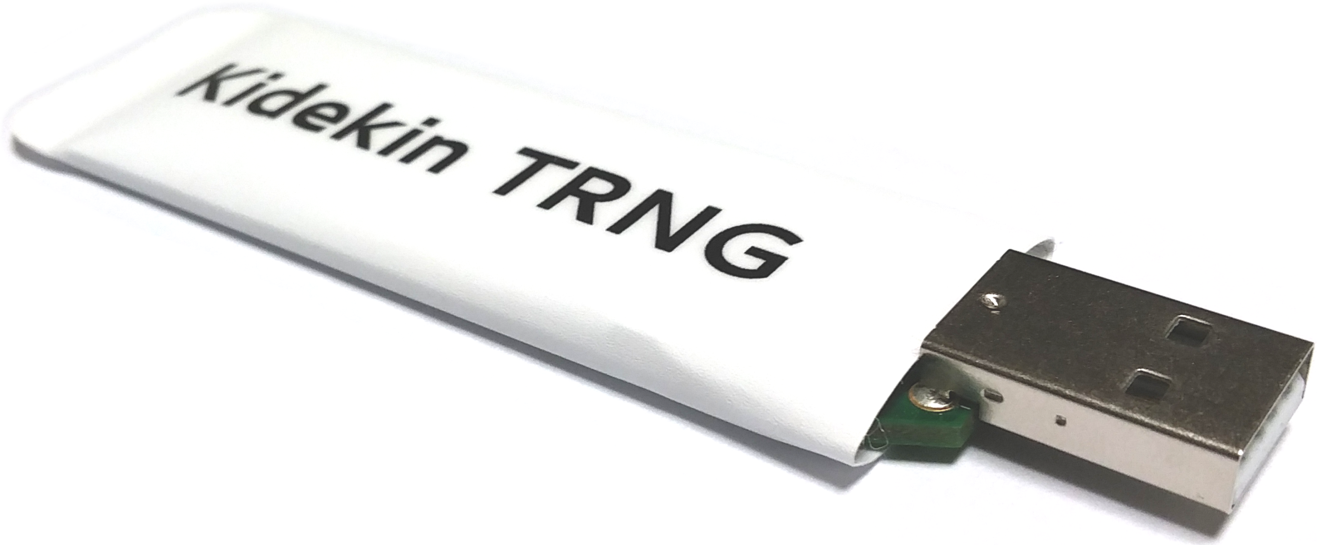


Figure 1.1: Kidekin TRNG (without epoxy fill option)

Chapter 2

Kidekin TRNG hardware

Kidekin TRNG contains a purely digital entropy source rather than analogue one. It delivers full entropy bits at a rate higher than 2Mbits/s (275Kbytes/s). As the entropy source is purely digital, it is much more stable than analogue sources with respect to operating conditions as well as process variations. The randomness comes from an array of small free running oscillators, like in most papers on the subject. Unlike typical implementation, the oscillators are register-less LFSRs with remapping of the null state. This allows to harness entropy from two phenomenon: the chaotic behavior of such LFSRs and the lack of synchronization between them. This also avoid the "self alignment" tendency often found with arrays of ring oscillators. The raw random bits have a very good entropy out of the box, estimation tools typically report higher than 7.9 bits of entropy per byte.

ENTROPY ESTIMATION OVER A 956MB FILE OF RAW RANDOM BITS:

1. min-entropy: 7.996690052203161
2. shannon-entropy: 7.999999658975694
3. NIST’s frequency test entropy: 7.975869236184793 (as described in SP800-90B 9.3.7.3)

About entropy report by the tool "ent"
ent reports the shannon entropy, and it makes rounding errors on big data files. It reported 8.0 bits/bytes on the same 956MB file.

2.1 Optional CBC-MAC AES128 post processor

It allows to make the full entropy claim and follows NIST’s SP800-90B recommendations: it is a CBC-MAC using AES-128 encryption. It is done in hardware and cannot be switch off. As a result the device does not have any configuration, making it user friendly and hard to misuse. The access to the raw entropy bits is useful only during the design phase anyway, to know how many blocks the CBC-MAC should process to achieve full entropy. With 7.9 bits of entropy per byte, 3 blocks are enough, actually this would be enough even with 6.7 bits of entropy per byte, so this provides a large safety margin. This is an option because some people may prefer to mix the raw bits with other entropy sources and then perform their favourite cryptographic post processing.

2.2 USB descriptors

The software package contains ready made software to use Kidekin TRNG. The following information can be useful if you whish to build your own software or linux's udev rules.

lsusb command to find the device:

```
user@debian:$sudo lsusb
Bus 001 Device 001: ID 1d6b:0001 Linux Foundation 1.1 root hub
Bus 001 Device 002: ID 80ee:0021 VirtualBox USB Tablet
Bus 001 Device 006: ID 0403:6010 Future Technology Devices International, Ltd FT2232C Dual USB-UART/FIFO IC
```

Kidekin TRNG is based on the USB chip "FT2232C Dual USB-UART/FIFO IC". In this example there is only one such device so we know right away that it is the TRNG. If they are several, the fields inside the device descriptor structure contain unambiguous identifiers.

lsusb output showing device descriptor structure (extract):

```
user@debian:$sudo lsusb -s 001:006 -v

Bus 001 Device 006: ID 0403:6010 Future Technology Devices International, Ltd FT2232C Dual USB-UART/FIFO IC
Device Descriptor:
  bLength                18
  bDescriptorType         1
  bcdUSB               1.10
  bDeviceClass            0 (Defined at Interface level)
  bDeviceSubClass         0
  bDeviceProtocol         0
  bMaxPacketSize0        64
  idVendor           0x0403 Future Technology Devices International, Ltd
  idProduct          0x6010 FT2232C Dual USB-UART/FIFO IC
  bcdDevice            7.00
  iManufacturer           1 kidekin
  iProduct                2 kidekin_trng
  iSerial                 3 20150523AES0000
  bNumConfigurations      1
  Configuration Descriptor:
    bLength                 9
    bDescriptorType         2
    wTotalLength           55
    bNumInterfaces          2
    bConfigurationValue     1
    iConfiguration          0
    bmAttributes         0x80
      (Bus Powered)
    MaxPower              500mA
    Interface Descriptor:
      bLength                 9
      bDescriptorType         4
      bInterfaceNumber        0
      bAlternateSetting       0
      bNumEndpoints           2
      bInterfaceClass       255 Vendor Specific Class
      bInterfaceSubClass    255 Vendor Specific Subclass
      bInterfaceProtocol    255 Vendor Specific Protocol
      iInterface              2 kidekin_trng
```

The number idVendor is always equal to 0x0403 and the idProduct always equal to 0x6010 however this is not specific to Kidekin TRNG.

The fields iManufacturer and iProduct are specific to Kidekin TRNG and can be use to filter all connected TRNGs

The number iSerial (line 17), is unique for each device. It consist of three fields.

SERIAL NUMBER FIELDS

- Fabrication date (YYYYMMDD format)
- Configuration
  - RAW: the device output raw random numbers
  - AES: the device has the CBC-MAC AES128 post processor
- Daily serial number: an hexadecimal number unique for each device programmed on the same day.

About USB interfaces

The device contains two USB interface, random numbers are available only on the "B" interface. Sending commands or reading the "A" interface can "brick" the device. Sending commands to the "B" interface can also "brick" the device. In summary, only read operation on the "B" interface is supported.

2.3 Optional epoxy filling

The default casing is a white vinyl sticker simply wrapped around the PCB. It protects against light coffee spills only. The optional filling is made in hard epoxy, it is injected within the sticker, protecting the electronics from pretty much anything, including the worse coffee spills :-). If the white cover is peeled-off, it is then tamper-evident, unless one goes through the pain of replicating the filling after damaging it… This option is expensive because it involves a lot of manual work with nasty substances.

2.4 Dimension

THE DIMENSIONS VARY SLIGHTLY DEPENDING IF YOU HAVE EPOXY FILLING OR NOT:

1. Without epoxy filling: 26x102x7 (rounded corners)
2. With epoxy filling: 29x98x10 (square corners)

As both casing are handmade, the dimensions may also vary from one sample to another by few millimeters.

2.5 RNG test suits reports

The quality of the output has been checked using several tools. For all tests, the data has been gathered using **trng_capture.exe**. Unless otherwise stated, the tests are run on a file of 954MB (that's a bit more than 1 billion bits).

RNG TEST TOOLS:

1. ent: an open source program available in many Linux distributions (http://www.fourmilab.ch/random/)
2. dat_analysis::entropy: custom entropy estimation tool
3. AIS31: AIS31 reference program from BSI. Test run on 4 MB files.
4. STS: NIST's STS 2.1.2 (http://csrc.nist.gov/groups/ST/toolkit/rng/documentation_software.html). Data is processed as 1000 streams of 1 million bits.
5. Dieharder: Robert G. Brown's dieharder, version 3.31.1 (http://www.phy.duke.edu/~rgb/General/dieharder.php). Test run on 4095MB files, command "dieharder -a -g 201 -f file_name".

The folder "doc/rpt" of the software package contain those reports and additional ones like cold temperature, hot temperature.

2.5.1 Without post processor

ent report:

```
Entropy = 8.000000 bits per byte.

Optimum compression would reduce the size
of this 1000341504 byte file by 0 percent.

Chi square distribution for 1000341504 samples is 259.21, and randomly
would exceed this value 41.49 percent of the times.

Arithmetic mean value of data bytes is 127.4978 (127.5 = random).
Monte Carlo value for Pi is 3.141736948 (error 0.00 percent).
Serial correlation coefficient is -0.000005 (totally uncorrelated = 0.0).
```

dat_analysis::entropy report:

```
min_entropy             7.996690052203161
shannon_entropy         7.999999658975694
frequency_test_entropy 7.975869236184793
```

Links to AIS31 reports:

1. TEST-SUITE: P1/T0 (passed)
2. TEST-SUITE: P1/T1-T5 (passed)
3. TEST-SUITE: P2 (passed)

STS report:

```
-------------------------------------------------------------------------------
RESULTS FOR THE UNIFORMITY OF P-VALUES AND THE PROPORTION OF PASSING SEQUENCES
-------------------------------------------------------------------------------
   generator is <data/kidekin_trng_room_temp.dat>
-------------------------------------------------------------------------------
 C1  C2  C3  C4  C5  C6  C7  C8  C9 C10  P-VALUE  PROPORTION  STATISTICAL TEST
-------------------------------------------------------------------------------
105 114  86 102 108 108  97  90 105  85  0.429923    993/1000    Frequency
113 107 102  99 100  88 111  86  97  97  0.635037    992/1000    BlockFrequency
108  94  94  90  94 112 102 103  95 108  0.818343    992/1000    CumulativeSums
105 110 102 106  98  84  94  83 106 112  0.410055    991/1000    CumulativeSums
 97 107 103  98 105 111  89 111  83  96  0.570792    991/1000    Runs
 97  99  92 100  92 104 128  99  95  94  0.350485    985/1000    LongestRun
106  80 112 112 107 101  76 118  96  92  0.040901    987/1000    Rank
100 112 105  94  99  78  90  85 113 124  0.040108    991/1000    FFT
107  92 108  90  89 119 103  99  94  99  0.528111    992/1000    NonOverlappingTemplate
101 105  95  91  92  96 108 101 100 111  0.912724    994/1000    NonOverlappingTemplate
 86  99  92  99 107 113 115  92 106  91  0.450297    990/1000    NonOverlappingTemplate
 89 114 102  89  88 117 101 115 108  77  0.049664    992/1000    NonOverlappingTemplate
 97 106  90  99  98 115 103 100 100  92  0.877083    989/1000    NonOverlappingTemplate
 90  75 103  77 103 100 125 105 121 101  0.004908    991/1000    NonOverlappingTemplate
118  93  87 111 109 101  99  92  89 101  0.408275    987/1000    NonOverlappingTemplate
113  98  99  89 109 123  91  81  84 113  0.038565    992/1000    NonOverlappingTemplate
 84 104 107  98 103  92 103  92  93 124  0.278461    995/1000    NonOverlappingTemplate
103 104  83 108  97 105  90 104 100 106  0.775337    985/1000    NonOverlappingTemplate
 99  95 107  89  93 109  93 113  97 105  0.761719    991/1000    NonOverlappingTemplate
 89  97 107  91 109 113 101  96 100  97  0.801865    993/1000    NonOverlappingTemplate
100  91  95  93 127 103  99  94 101  97  0.401199    993/1000    NonOverlappingTemplate
 89  97 100 100  85  98 110 102 114 105  0.653773    992/1000    NonOverlappingTemplate
 77 106 102 107  95 100  97 114  95 107  0.417219    992/1000    NonOverlappingTemplate
```

```
  87  83 107 109  89  95 116 107 117  90  0.112708    992/1000    NonOverlappingTemplate
 105  96 104  88  92  99 105  99 105 107  0.932333    991/1000    NonOverlappingTemplate
 116  91  83 122  93  92  77 103  94 129  0.001770    992/1000    NonOverlappingTemplate
 117  99  95 109  89 109 111  71  96 104  0.068571    988/1000    NonOverlappingTemplate
 105 101 103 105  99 102  88 118  85  94  0.540204    994/1000    NonOverlappingTemplate
  92 105  93  91 102 107  94 112 103 101  0.866097    982/1000    NonOverlappingTemplate
  91 100 118  81  92  95 106 108 100 109  0.322135    988/1000    NonOverlappingTemplate
 104  95  89 105 101 118 112  92  80 104  0.251837    989/1000    NonOverlappingTemplate
  85 114 105  98  89 106  97 116  94  96  0.415422    990/1000    NonOverlappingTemplate
  92 114  85  94  98 122  97  94 109  95  0.236810    994/1000    NonOverlappingTemplate
  98 101  99  93 105 107  97 110  86 104  0.875539    989/1000    NonOverlappingTemplate
  95 101 101  97 105 101  91 108  95 106  0.975644    997/1000    NonOverlappingTemplate
  96 104  93 106  94  97 102 102 107  99  0.987896    992/1000    NonOverlappingTemplate
 103  86 100 113  89 105 117 101  98  88  0.385543    987/1000    NonOverlappingTemplate
 101  89  97 110 102  99 102 106  98  96  0.965860    994/1000    NonOverlappingTemplate
 111  86 113 106  89  92  99 109  95 100  0.520102    989/1000    NonOverlappingTemplate
  95  90  97  95  99 118 106  88 109 103  0.581082    990/1000    NonOverlappingTemplate
 102 112 105 100 110  85  94  94 103  95  0.735908    992/1000    NonOverlappingTemplate
 105  95  81 102 100  99 124  97 109  88  0.199045    986/1000    NonOverlappingTemplate
  91  99 100 100  91 108 111  96 103 101  0.927677    994/1000    NonOverlappingTemplate
  96 121 106  96 102  90  95  84 125  85  0.042255    987/1000    NonOverlappingTemplate
  97  90 107 105 101 109  96 106  96  93  0.922855    995/1000    NonOverlappingTemplate
  93 100 105  78  94 103 101  84 121 121  0.042531    995/1000    NonOverlappingTemplate
 109  96  98  90  97 108 105 103  91 103  0.912724    986/1000    NonOverlappingTemplate
  93 100  90  90 106 122 101 103  99  96  0.538182    994/1000    NonOverlappingTemplate
 111 105 100 105  93  72 104  96  88 126  0.029205    988/1000    NonOverlappingTemplate
  99 119  95 100 103  86  93 102 105  98  0.664168    991/1000    NonOverlappingTemplate
 104 110  95 117 101  77 111  99  94  92  0.223648    991/1000    NonOverlappingTemplate
  91 120  85 103 107  97 111  82  97 107  0.173770    992/1000    NonOverlappingTemplate
  97 104  88 111 101 105  94 110  88 102  0.739918    992/1000    NonOverlappingTemplate
  95  97  83 112 111  89  88  92 115 118  0.100709    988/1000    NonOverlappingTemplate
 101  95 100  92  88 105  99  89 101 130  0.170922    995/1000    NonOverlappingTemplate
 102 114  85  92 104 103  91 111 103  95  0.585209    994/1000    NonOverlappingTemplate
 111 106  90 100  97  99  92  93  97 115  0.725829    987/1000    NonOverlappingTemplate
 101  97 100  93 102 111  91 123  93  89  0.380407    985/1000    NonOverlappingTemplate
  95 112  94 109  92  99  94 123  94  88  0.278461    994/1000    NonOverlappingTemplate
 106  99  88 111 102  93 110  85 109  97  0.564639    985/1000    NonOverlappingTemplate
  96 103 105 116 109  87  94  98  91 101  0.660012    991/1000    NonOverlappingTemplate
  93 108 107  90 104 112 101 112  96  77  0.267573    993/1000    NonOverlappingTemplate
  98 118  93 104  92 102  96  98 108  91  0.713641    989/1000    NonOverlappingTemplate
 120  98  98 106  86  97 103  98 102  92  0.605916    986/1000    NonOverlappingTemplate
  80  97  88 124  79 109 109 118  86 110  0.005128    991/1000    NonOverlappingTemplate
  97  86 111 102 112  78  91 102 112 109  0.177628    984/1000    NonOverlappingTemplate
 104  87  98  92 107 113 105 107  92  95  0.705466    992/1000    NonOverlappingTemplate
  96 109 117  88 107  87 111  97  85 103  0.267573    989/1000    NonOverlappingTemplate
 115  98 109 111 110  99 101  92  84  81  0.205531    989/1000    NonOverlappingTemplate
  94  93 111  94 104 102  86 114 112  90  0.439122    991/1000    NonOverlappingTemplate
 105 105 101  94 107 103 106  92  95  92  0.949278    986/1000    NonOverlappingTemplate
  99 108  94 105 111 109 102 102  83  87  0.540204    989/1000    NonOverlappingTemplate
  98 100  92  88 109  89 130 113  85  96  0.045088    992/1000    NonOverlappingTemplate
 112  98  94 110 112  99  87  86 106  96  0.488534    990/1000    NonOverlappingTemplate
 112  85  79  86  92  97 116 109 106 118  0.038062    993/1000    NonOverlappingTemplate
 110 106  96 104  89  89  98 112  91 105  0.674543    988/1000    NonOverlappingTemplate
 108  96 102  98 108  87 109 106  92  94  0.800005    993/1000    NonOverlappingTemplate
  88 101  97 104 108 106  95  97 114  90  0.739918    990/1000    NonOverlappingTemplate
  87  91  97 102 108 103 105 109 101  97  0.873987    992/1000    NonOverlappingTemplate
 111 102 111 105 107  83  91  91 112  87  0.286836    987/1000    NonOverlappingTemplate
 114 110  86 103  97  87  98 103 100 102  0.641284    989/1000    NonOverlappingTemplate
  98  88 104 114  98  94  91 102 103 108  0.781106    987/1000    NonOverlappingTemplate
 107  94 106  90  88 120 103  98  93 101  0.506194    992/1000    NonOverlappingTemplate
 101 104 100 111  93  99  79 111 106  96  0.532132    988/1000    NonOverlappingTemplate
  84  99  84  88 117 105 100 117 106 100  0.164425    989/1000    NonOverlappingTemplate
 89 105  85 100  98 108  96 111  94 114  0.526105    991/1000    NonOverlappingTemplate
112  90  98  99 104 106 104 101  90  96  0.887645    991/1000    NonOverlappingTemplate
101 104 105  94  94 114  89  94 128  77  0.037566    990/1000    NonOverlappingTemplate
 95  95  95 108  83 104  98  92 121 109  0.323668    994/1000    NonOverlappingTemplate
105 113 101  95 100 118 104  97  85  82  0.263572    994/1000    NonOverlappingTemplate
109 103 100 104 103  99  82 107  84 109  0.508172    985/1000    NonOverlappingTemplate
111  96 107  93  84 106 105  88 111  99  0.516113    989/1000    NonOverlappingTemplate
116  93  95 105  98 111  92 109  87  94  0.504219    987/1000    NonOverlappingTemplate
 95 109  95  90 113  95 110  91  98 104  0.713641    989/1000    NonOverlappingTemplate
 93 114  91 101 107 101  96  92 103 102  0.859637    996/1000    NonOverlappingTemplate
123  97 125  92 102  75  86  93 102 105  0.011383    986/1000    NonOverlappingTemplate
 98 103 102 103  90 102  95 104 107  96  0.984415    993/1000    NonOverlappingTemplate
 96 100 109 107  93  96  92 109  94 104  0.906069    988/1000    NonOverlappingTemplate
109 105 102 107  95  91 117  97  93  84  0.467322    988/1000    NonOverlappingTemplate
125 105  94  91  89 114  96  80  96 110  0.063615    985/1000    NonOverlappingTemplate
101 107 103 108  98  98  89 102  93 101  0.961869    990/1000    NonOverlappingTemplate
128  98 112  87  98  87 106 102  89  93  0.095426    989/1000    NonOverlappingTemplate
110  88  87 110 101 120  98  93  98  95  0.353733    994/1000    NonOverlappingTemplate
112 104 100 104  88  91  98 101 100 102  0.904708    989/1000    NonOverlappingTemplate
103 112  84 110  88  92 105 111  98  97  0.459717    989/1000    NonOverlappingTemplate
 98  97  97 102  97  95 106 113  96  99  0.971006    988/1000    NonOverlappingTemplate
110 106  94  84  89 107  99 104 105 102  0.695200    986/1000    NonOverlappingTemplate
 89 115  97  88 113  95 106 106  90 101  0.469232    994/1000    NonOverlappingTemplate
106  97  96 107 112  99  91 104  86 102  0.786830    990/1000    NonOverlappingTemplate
 89  92 110 113 115 107  97  94  97  86  0.368587    991/1000    NonOverlappingTemplate
 93  94 103 103 106 116 102  92 101  90  0.775337    990/1000    NonOverlappingTemplate
 86  97 111  83  97  86 118 100 110 112  0.126658    993/1000    NonOverlappingTemplate
 87  98 112 123 107 114 107  79  90  83  0.019857    991/1000    NonOverlappingTemplate
 95 105 111  86 125 105  94  87  96  96  0.184549    992/1000    NonOverlappingTemplate
125 106  88  99  94 120  89 102  86  91  0.058243    986/1000    NonOverlappingTemplate
105 101 101 107  89 104  89 102 110  92  0.832561    989/1000    NonOverlappingTemplate
108  93  89 107  91 113  93 102 103 101  0.743915    985/1000    NonOverlappingTemplate
112  94  94  98  91 116  88  99  94 114  0.406499    987/1000    NonOverlappingTemplate
104 102  84 108 107  92 106 106 106  85  0.548314    991/1000    NonOverlappingTemplate
 91 106 104  99 103 110  90  94 104  99  0.914025    990/1000    NonOverlappingTemplate
108 101 117  99 101  83 101 101  99  90  0.587274    990/1000    NonOverlappingTemplate
 98 103  88  97  91  99 112  94 115 103  0.676615    991/1000    NonOverlappingTemplate
108  80 108  89 117 100 101  92  98 107  0.307077    991/1000    NonOverlappingTemplate
123 111  89  95 109 106  95  85  87 100  0.148653    990/1000    NonOverlappingTemplate
110 104  93 110  98  99  78 112 101  95  0.415422    979/1000 *  NonOverlappingTemplate
 88 108  80 108 115 105 100  91 103 102  0.337688    995/1000    NonOverlappingTemplate
 94  93 107 109  90 109  96 103 105  94  0.849708    990/1000    NonOverlappingTemplate
102 100 102  97  90 108  94 104 106  97  0.972382    991/1000    NonOverlappingTemplate
 94 101  99  87 108 112 115  86 102  96  0.478839    992/1000    NonOverlappingTemplate
 88 101  94 107 100 102 108 100 100 100  0.965083    991/1000    NonOverlappingTemplate
 86  94 123 104 110  87  95 104 101  96  0.272977    993/1000    NonOverlappingTemplate
 87  99  98  96 103 113  91  99 104 110  0.773405    991/1000    NonOverlappingTemplate
 95  92 100  87 113  92 102 111 118  90  0.319084    995/1000    NonOverlappingTemplate
103  90 107 104  96 112 100  92  96 100  0.901959    991/1000    NonOverlappingTemplate
107  87 110 102  95 102 110 106  95  86  0.628790    993/1000    NonOverlappingTemplate
110 112  85 112 103  97  92  89  96 104  0.486588    990/1000    NonOverlappingTemplate
109  96  95  97  90  99 106  86 104 118  0.530120    994/1000    NonOverlappingTemplate
103  95 116  95  87  83 113  94  99 115  0.211064    989/1000    NonOverlappingTemplate
115  78  97 107 103  92  88 105 106 109  0.258307    989/1000    NonOverlappingTemplate
 94  94  92  94  94 111  98 111 120  92  0.420827    991/1000    NonOverlappingTemplate
102 117  96 104 106  93 109 104  96  73  0.185555    995/1000    NonOverlappingTemplate
 98 107  98  93  96 103 113 107 101  84  0.733899    991/1000    NonOverlappingTemplate
 89 106  86  99  95 115 104 110  98  98  0.607993    995/1000    NonOverlappingTemplate
 95 107  88  94  98 111 118 105  91  93  0.476911    994/1000    NonOverlappingTemplate
 99 110  84 101 101 104 105  94 105  97  0.859637    990/1000    NonOverlappingTemplate
 87  92  86 104  98 104 102 118  98 111  0.420827    989/1000    NonOverlappingTemplate
108 106 111  92  84  96 107  94 105  97  0.662091    992/1000    NonOverlappingTemplate
```

```
100 117 101 106  83  91 100  99  98 105  0.610070    994/1000    NonOverlappingTemplate
103  87 106  97 103  84  96 101 105 118  0.480771    990/1000    NonOverlappingTemplate
 95  90 103 102 115  93  95 111 101  95  0.755819    989/1000    NonOverlappingTemplate
 84 102 122 105 104  82  97 106 103  95  0.220159    994/1000    NonOverlappingTemplate
105 105  86 103 101 100 110  89 100 101  0.853049    989/1000    NonOverlappingTemplate
112  99  78 105  74 116 115 108  80 113  0.003657    989/1000    NonOverlappingTemplate
 96 100  89 109 100  90  96  99  95 126  0.322135    991/1000    NonOverlappingTemplate
 95 100 114  97 111 100  81 102  97 103  0.601766    986/1000    NonOverlappingTemplate
 97  89 104 113  98  95  92 102 102 108  0.851383    987/1000    NonOverlappingTemplate
106 113 115 100 101  93  95  93  90  94  0.647530    992/1000    OverlappingTemplate
108 101  99  84  90 102 110 113  83 110  0.286836    987/1000    Universal
 97  91 121 108  97  98 101  95  93  99  0.653773    991/1000    ApproximateEntropy
 55  60  75  54  63  63  58  65  66  60  0.780132    609/619     RandomExcursions
 61  54  69  62  79  48  65  65  63  53  0.237412    607/619     RandomExcursions
 50  59  72  63  62  69  61  60  64  59  0.798751    617/619     RandomExcursions
 62  70  60  67  55  58  64  59  56  68  0.903699    615/619     RandomExcursions
 48  56  50  63  63  61  76  71  72  59  0.178012    612/619     RandomExcursions
 64  55  63  64  61  54  54  76  60  68  0.630292    612/619     RandomExcursions
 58  55  56  52  64  68  60  66  67  73  0.657592    613/619     RandomExcursions
 65  50  57  67  80  54  59  63  64  60  0.341275    614/619     RandomExcursions
 64  67  63  58  61  71  62  45  82  46  0.038548    613/619     RandomExcursionsVariant
 65  62  68  64  60  68  59  67  45  61  0.647360    612/619     RandomExcursionsVariant
 70  56  51  68  83  65  54  58  54  60  0.117173    615/619     RandomExcursionsVariant
 66  56  63  56  65  78  61  62  54  58  0.609831    617/619     RandomExcursionsVariant
 66  54  68  57  59  63  74  70  49  59  0.443349    617/619     RandomExcursionsVariant
 58  75  53  61  71  66  49  76  56  54  0.132590    614/619     RandomExcursionsVariant
 57  68  56  75  59  56  65  63  60  60  0.786394    614/619     RandomExcursionsVariant
 56  55  75  58  74  51  48  69  74  59  0.079874    611/619     RandomExcursionsVariant
 61  53  65  68  53  54  47  69  88  61  0.016832    617/619     RandomExcursionsVariant
 59  54  57  69  71  60  57  61  66  65  0.853839    610/619     RandomExcursionsVariant
 57  63  54  59  52  59  65  63  73  74  0.529198    610/619     RandomExcursionsVariant
 51  53  62  55  61  69  70  64  71  63  0.582671    614/619     RandomExcursionsVariant
 53  50  58  63  70  62  73  61  63  66  0.592833    615/619     RandomExcursionsVariant
 51  59  66  66  71  68  59  62  60  57  0.804842    615/619     RandomExcursionsVariant
 44  69  80  65  59  61  71  56  55  59  0.098397    612/619     RandomExcursionsVariant
 50  69  63  66  58  52  73  69  63  56  0.449467    615/619     RandomExcursionsVariant
 59  65  57  59  70  69  45  55  77  63  0.208728    613/619     RandomExcursionsVariant
 62  58  66  67  54  59  58  61  62  72  0.899148    610/619     RandomExcursionsVariant
 92  99 110  98  96 102 100  89 114 100  0.829047    993/1000    Serial
 85 102  93 101  90 114 115  92 107 101  0.424453    993/1000    Serial
 95 102  77 112 106 108 114  97  89 100  0.257004    993/1000    LinearComplexity


- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
The minimum pass rate for each statistical test with the exception of the
random excursion (variant) test is approximately = 980 for a
sample size = 1000 binary sequences.

The minimum pass rate for the random excursion (variant) test
is approximately = 605 for a sample size = 619 binary sequences.

For further guidelines construct a probability table using the MAPLE program
provided in the addendum section of the documentation.
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

Dieharder report:

```
#=============================================================================#
#            dieharder version 3.31.1 Copyright 2003 Robert G. Brown          #
#=============================================================================#
   rng_name    |           filename             |rands/second|
 file_input_raw|     kidekin_trng_room_temp3.dat|  1.83e+07  |
#=============================================================================#
        test_name   |ntup| tsamples |psamples|  p-value |Assessment
#=============================================================================#
   diehard_birthdays|   0|       100|     100|0.83863430|  PASSED
      diehard_operm5|   0|   1000000|     100|0.99859410|   WEAK
  diehard_rank_32x32|   0|     40000|     100|0.51382007|  PASSED
    diehard_rank_6x8|   0|    100000|     100|0.10267084|  PASSED
   diehard_bitstream|   0|   2097152|     100|0.88208024|  PASSED
        diehard_opso|   0|   2097152|     100|0.91301645|  PASSED
        diehard_oqso|   0|   2097152|     100|0.02761662|  PASSED
         diehard_dna|   0|   2097152|     100|0.45052643|  PASSED
diehard_count_1s_str|   0|    256000|     100|0.95293866|  PASSED
diehard_count_1s_byt|   0|    256000|     100|0.97542713|  PASSED
 diehard_parking_lot|   0|     12000|     100|0.08478625|  PASSED
    diehard_2dsphere|   2|      8000|     100|0.55320976|  PASSED
    diehard_3dsphere|   3|      4000|     100|0.67713221|  PASSED
     diehard_squeeze|   0|    100000|     100|0.39622256|  PASSED
        diehard_sums|   0|       100|     100|0.00055826|   WEAK
        diehard_runs|   0|    100000|     100|0.15831810|  PASSED
        diehard_runs|   0|    100000|     100|0.72414595|  PASSED
       diehard_craps|   0|    200000|     100|0.15854166|  PASSED
       diehard_craps|   0|    200000|     100|0.54455765|  PASSED
 marsaglia_tsang_gcd|   0|  10000000|     100|0.53455546|  PASSED
 marsaglia_tsang_gcd|   0|  10000000|     100|0.64239498|  PASSED
         sts_monobit|   1|    100000|     100|0.92818270|  PASSED
            sts_runs|   2|    100000|     100|0.06724033|  PASSED
          sts_serial|   1|    100000|     100|0.87600831|  PASSED
          sts_serial|   2|    100000|     100|0.56154264|  PASSED
          sts_serial|   3|    100000|     100|0.64654782|  PASSED
          sts_serial|   3|    100000|     100|0.49536253|  PASSED
          sts_serial|   4|    100000|     100|0.96794326|  PASSED
          sts_serial|   4|    100000|     100|0.21215232|  PASSED
          sts_serial|   5|    100000|     100|0.62022036|  PASSED
          sts_serial|   5|    100000|     100|0.67405245|  PASSED
          sts_serial|   6|    100000|     100|0.59645346|  PASSED
          sts_serial|   6|    100000|     100|0.11123998|  PASSED
          sts_serial|   7|    100000|     100|0.70530969|  PASSED
          sts_serial|   7|    100000|     100|0.98588862|  PASSED
          sts_serial|   8|    100000|     100|0.76323783|  PASSED
          sts_serial|   8|    100000|     100|0.63409086|  PASSED
          sts_serial|   9|    100000|     100|0.82979927|  PASSED
          sts_serial|   9|    100000|     100|0.26994653|  PASSED
          sts_serial|  10|    100000|     100|0.77875408|  PASSED
          sts_serial|  10|    100000|     100|0.83002735|  PASSED
          sts_serial|  11|    100000|     100|0.96012132|  PASSED
          sts_serial|  11|    100000|     100|0.94885291|  PASSED
          sts_serial|  12|    100000|     100|0.96963305|  PASSED
          sts_serial|  12|    100000|     100|0.86876144|  PASSED
          sts_serial|  13|    100000|     100|0.60116582|  PASSED
          sts_serial|  13|    100000|     100|0.90825798|  PASSED
          sts_serial|  14|    100000|     100|0.96992212|  PASSED
          sts_serial|  14|    100000|     100|0.08302696|  PASSED
          sts_serial|  15|    100000|     100|0.25821694|  PASSED
          sts_serial|  15|    100000|     100|0.08524629|  PASSED
          sts_serial|  16|    100000|     100|0.92167076|  PASSED
          sts_serial|  16|    100000|     100|0.64124003|  PASSED
         rgb_bitdist|   1|    100000|     100|0.99492755|  PASSED
         rgb_bitdist|   2|    100000|     100|0.37422725|  PASSED
         rgb_bitdist|   3|    100000|     100|0.25111928|  PASSED
         rgb_bitdist|   4|    100000|     100|0.99131473|  PASSED
         rgb_bitdist|   5|    100000|     100|0.50172020|  PASSED
         rgb_bitdist|   6|    100000|     100|0.08420173|  PASSED
         rgb_bitdist|   7|    100000|     100|0.02720214|  PASSED
         rgb_bitdist|   8|    100000|     100|0.98873574|  PASSED
         rgb_bitdist|   9|    100000|     100|0.78506885|  PASSED
         rgb_bitdist|  10|    100000|     100|0.69138581|  PASSED
         rgb_bitdist|  11|    100000|     100|0.24619433|  PASSED
         rgb_bitdist|  12|    100000|     100|0.76975707|  PASSED
rgb_minimum_distance|   2|     10000|    1000|0.58627042|  PASSED
rgb_minimum_distance|   3|     10000|    1000|0.39183036|  PASSED
rgb_minimum_distance|   4|     10000|    1000|0.66326334|  PASSED
rgb_minimum_distance|   5|     10000|    1000|0.11244814|  PASSED
    rgb_permutations|   2|    100000|     100|0.36235424|  PASSED
    rgb_permutations|   3|    100000|     100|0.56448535|  PASSED
    rgb_permutations|   4|    100000|     100|0.45403203|  PASSED
    rgb_permutations|   5|    100000|     100|0.44613056|  PASSED
      rgb_lagged_sum|   0|   1000000|     100|0.59273953|  PASSED
      rgb_lagged_sum|   1|   1000000|     100|0.54615979|  PASSED
      rgb_lagged_sum|   2|   1000000|     100|0.57226025|  PASSED
      rgb_lagged_sum|   3|   1000000|     100|0.56568533|  PASSED
      rgb_lagged_sum|   4|   1000000|     100|0.99379904|  PASSED
      rgb_lagged_sum|   5|   1000000|     100|0.92276883|  PASSED
      rgb_lagged_sum|   6|   1000000|     100|0.66744623|  PASSED
      rgb_lagged_sum|   7|   1000000|     100|0.99801725|   WEAK
      rgb_lagged_sum|   8|   1000000|     100|0.71690013|  PASSED
      rgb_lagged_sum|   9|   1000000|     100|0.63687697|  PASSED
      rgb_lagged_sum|  10|   1000000|     100|0.17728644|  PASSED
      rgb_lagged_sum|  11|   1000000|     100|0.93282847|  PASSED
      rgb_lagged_sum|  12|   1000000|     100|0.62586317|  PASSED
      rgb_lagged_sum|  13|   1000000|     100|0.39088813|  PASSED
      rgb_lagged_sum|  14|   1000000|     100|0.69165592|  PASSED
      rgb_lagged_sum|  15|   1000000|     100|0.05122127|  PASSED
      rgb_lagged_sum|  16|   1000000|     100|0.36057874|  PASSED
      rgb_lagged_sum|  17|   1000000|     100|0.22182933|  PASSED
      rgb_lagged_sum|  18|   1000000|     100|0.64380525|  PASSED
      rgb_lagged_sum|  19|   1000000|     100|0.59682895|  PASSED
      rgb_lagged_sum|  20|   1000000|     100|0.53549386|  PASSED
      rgb_lagged_sum|  21|   1000000|     100|0.14822566|  PASSED
      rgb_lagged_sum|  22|   1000000|     100|0.43138556|  PASSED
      rgb_lagged_sum|  23|   1000000|     100|0.05137599|  PASSED
      rgb_lagged_sum|  24|   1000000|     100|0.75091496|  PASSED
      rgb_lagged_sum|  25|   1000000|     100|0.13600277|  PASSED
      rgb_lagged_sum|  26|   1000000|     100|0.77984991|  PASSED
      rgb_lagged_sum|  27|   1000000|     100|0.03258301|  PASSED
      rgb_lagged_sum|  28|   1000000|     100|0.00168794|   WEAK
      rgb_lagged_sum|  29|   1000000|     100|0.85706626|  PASSED
      rgb_lagged_sum|  30|   1000000|     100|0.56700009|  PASSED
      rgb_lagged_sum|  31|   1000000|     100|0.03074607|  PASSED
      rgb_lagged_sum|  32|   1000000|     100|0.36619883|  PASSED
     rgb_kstest_test|   0|     10000|    1000|0.27993323|  PASSED
     dab_bytedistrib|   0|  51200000|       1|0.09171790|  PASSED
             dab_dct| 256|     50000|       1|0.33065847|  PASSED
Preparing to run test 207.  ntuple = 0
        dab_filltree|  32|  15000000|       1|0.28755577|  PASSED
        dab_filltree|  32|  15000000|       1|0.16933372|  PASSED
Preparing to run test 208.  ntuple = 0
       dab_filltree2|   0|   5000000|       1|0.95758231|  PASSED
       dab_filltree2|   1|   5000000|       1|0.13145078|  PASSED
Preparing to run test 209.  ntuple = 0
        dab_monobit2|  12|  65000000|       1|0.26835334|  PASSED
```

2.5.2 With post processor

ent report:

```
Entropy = 8.000000 bits per byte.

Optimum compression would reduce the size
of this 1002438656 byte file by 0 percent.

Chi square distribution for 1002438656 samples is 265.93, and randomly
would exceed this value 30.61 percent of the times.

Arithmetic mean value of data bytes is 127.5056 (127.5 = random).
Monte Carlo value for Pi is 3.141427002 (error 0.01 percent).
Serial correlation coefficient is -0.000003 (totally uncorrelated = 0.0).
```

dat_analysis::entropy report:

```
min_entropy            7.996826369401534
shannon_entropy        7.999999606137532
frequency_test_entropy 7.976073562136397
```

LINKS TO AIS31 REPORTS:

1. TEST-SUITE: P1/T0 (passed)
2. TEST-SUITE: P1/T1-T5 (passed)
3. TEST-SUITE: P2 (passed)

STS report:

```
------------------------------------------------------------------------------
RESULTS FOR THE UNIFORMITY OF P-VALUES AND THE PROPORTION OF PASSING SEQUENCES
------------------------------------------------------------------------------
   generator is <data\kidekin_trng_aespp_room_temp.dat>
------------------------------------------------------------------------------
 C1  C2  C3  C4  C5  C6  C7  C8  C9 C10  P-VALUE  PROPORTION  STATISTICAL TEST
------------------------------------------------------------------------------
106  87  90 103  93 100 117  94 101 109  0.564639    994/1000    Frequency
 95 101 107  85  95 123  88  98 101 107  0.310049    986/1000    BlockFrequency
 95 100  84  99  97  96  99 103 113 114  0.655854    993/1000    CumulativeSums
105  83  96 112  97  93  99 104  99 112  0.643366    995/1000    CumulativeSums
 92  97 115  93  96 109 107  90 100 101  0.745908    990/1000    Runs
 96  89 105  86 110 105 116 102  85 106  0.347257    993/1000    LongestRun
111 114  96 103  73  82  99 102 118 102  0.044508    985/1000    Rank
103  97 104  94 112 106 106  92 100  86  0.792508    990/1000    FFT
114  86 111 100 107  97 103  97  86  99  0.548314    988/1000    NonOverlappingTemplate
 91 128  95  93  94 111  93  99  93 103  0.211064    990/1000    NonOverlappingTemplate
 99  93  91  97 121  94 109 103  89 104  0.490483    989/1000    NonOverlappingTemplate
 91  82  95 101  83 114  96 113 125 100  0.044797    990/1000    NonOverlappingTemplate
105 109 105  99 102 100  90  79  97 114  0.454053    993/1000    NonOverlappingTemplate
116  99 103 100  92  81 117 111  87  94  0.159910    989/1000    NonOverlappingTemplate
104 110  88 101 105 105  91  91 100 105  0.836048    991/1000    NonOverlappingTemplate
102  81  99 100 104 114 103 100 103  94  0.707513    992/1000    NonOverlappingTemplate
104 110  92  93 111 107  90 108 108  77  0.239266    989/1000    NonOverlappingTemplate
 93  95 112 115 115  95  89 106  94  86  0.288249    994/1000    NonOverlappingTemplate
119 121  80  81  87 101  94  93 106 118  0.009603    988/1000    NonOverlappingTemplate
 92  98 107  95  94  96 110  99  97 112  0.877083    991/1000    NonOverlappingTemplate
 94  96 113  87 116 104  90  94 110  96  0.424453    992/1000    NonOverlappingTemplate
 96 102  97  97  89  99 124  97  96 103  0.564639    989/1000    NonOverlappingTemplate
111 110 114  95  90  99  90 103 101  87  0.512137    989/1000    NonOverlappingTemplate
```

```
  89  90  88 102 100 107  92 118 109 105  0.426272    990/1000    NonOverlappingTemplate
 114  86  84  93  96  86 106 133 100 102  0.015707    985/1000    NonOverlappingTemplate
  75 110  98 103 103 101 110  95 106  99  0.428095    993/1000    NonOverlappingTemplate
 107 100 105 101  98 112  94  94  88 101  0.883171    980/1000    NonOverlappingTemplate
 104 110  98 102 106  92  96  98  92 102  0.959347    993/1000    NonOverlappingTemplate
  97  93  95 104 101  94 112 103  99 102  0.966626    993/1000    NonOverlappingTemplate
 113 115  88  98  85  98 100  99 104 100  0.546283    987/1000    NonOverlappingTemplate
  84 105 104  90  99  92  96 120 111  99  0.350485    989/1000    NonOverlappingTemplate
  97  98  97 105 118 115  97  85  90  98  0.406499    992/1000    NonOverlappingTemplate
 103 104 103 110 100 100 103  84  87 106  0.735908    989/1000    NonOverlappingTemplate
 107 113  90 112  94  94 101 102  80 107  0.360287    989/1000    NonOverlappingTemplate
 103  96 105 105  93 103 100  95 104  96  0.992952    985/1000    NonOverlappingTemplate
  91 120  98  94  96 106  97 108  87 103  0.510153    989/1000    NonOverlappingTemplate
 105  89 100  84 105  96  89 113 106 113  0.402962    994/1000    NonOverlappingTemplate
 102 122  93  92  90  94  92 109 107  99  0.408275    994/1000    NonOverlappingTemplate
  97 105  89 108  94 104  96 106 100 101  0.954015    989/1000    NonOverlappingTemplate
 113 107 110  93  86  83 100 107 101 100  0.435430    991/1000    NonOverlappingTemplate
 113  94 108  95 109  98  97  98  88 100  0.801865    988/1000    NonOverlappingTemplate
  87  98  86  95 119  94 112 110 114  85  0.103753    992/1000    NonOverlappingTemplate
 102  92 122  89 106 100 115 101  91  82  0.145326    990/1000    NonOverlappingTemplate
 100 109  94 112  95  96  97  94 101 102  0.940080    988/1000    NonOverlappingTemplate
  96 108 102  90  97  88  91 112  95 121  0.328297    991/1000    NonOverlappingTemplate
  91  85 115  90 114 101 107  84 105 108  0.201189    986/1000    NonOverlappingTemplate
 101 107 109 105  94  84 109 105  94  92  0.684890    987/1000    NonOverlappingTemplate
  93 107 101 103  97  93  98 103 103 102  0.992670    993/1000    NonOverlappingTemplate
 105  95  94  94 127  90  94  88  97 116  0.123755    991/1000    NonOverlappingTemplate
  82  93 103 122 101  96 109 112  85  97  0.144504    991/1000    NonOverlappingTemplate
 112  91 107  94 112  90  99 101  98  96  0.763677    988/1000    NonOverlappingTemplate
  90 112 104 114  90 111  84 101  98  96  0.388990    990/1000    NonOverlappingTemplate
 101 112  95 108 110  99  89  86 111  89  0.442831    987/1000    NonOverlappingTemplate
  88  92 112 102 110  97  86 103  88 122  0.163513    988/1000    NonOverlappingTemplate
 105 102  95 103  98 107  97  99  92 102  0.992381    990/1000    NonOverlappingTemplate
  96  98  95 102 115 114  97  93  99  91  0.729870    992/1000    NonOverlappingTemplate
 100  98 109  89 101 105  90 100  95 113  0.811080    986/1000    NonOverlappingTemplate
 123  96  99  88  86 104  96 101 123  84  0.048093    990/1000    NonOverlappingTemplate
 104 103 102 120  97 103  97 104  75  95  0.260930    990/1000    NonOverlappingTemplate
  98 103 109  91  87 115  78 107 110 102  0.209948    989/1000    NonOverlappingTemplate
  89 100  91  99 110  80 123 116  88 104  0.057510    992/1000    NonOverlappingTemplate
 101  97 106  89 106 102 114  97 103  85  0.693142    995/1000    NonOverlappingTemplate
  98  99  95  90 111 110  96 106  94 101  0.883171    990/1000    NonOverlappingTemplate
 113  84 108 102  85 111  90 100  99 108  0.347257    989/1000    NonOverlappingTemplate
 104  97  91 103  99 104 106  97 104  95  0.988291    990/1000    NonOverlappingTemplate
  80 103 101 103  98 110 118  86 111  90  0.179584    988/1000    NonOverlappingTemplate
  88 104 102  96  91 103 105 101 103 107  0.939005    994/1000    NonOverlappingTemplate
 106  92 121 114  90 103  93 106  86  89  0.187581    996/1000    NonOverlappingTemplate
 118 101 106 106  89 114  86  89  93  98  0.286836    987/1000    NonOverlappingTemplate
  96  83 104  95 104  88 101  96 117 116  0.298282    988/1000    NonOverlappingTemplate
  94  87  94  94 103  89 126 103 101 109  0.228367    986/1000    NonOverlappingTemplate
  90  89 106 111 100 101 101  92 113  97  0.717714    992/1000    NonOverlappingTemplate
 113 124  82 113 102  90 105  92  91  88  0.056069    988/1000    NonOverlappingTemplate
 103  94  96 105  81 109 107 104 106  95  0.684890    984/1000    NonOverlappingTemplate
  89  90  93  96  96 115 105 113  95 108  0.524101    991/1000    NonOverlappingTemplate
  86  86 101  87  94  90  99 114 105 138  0.004908    994/1000    NonOverlappingTemplate
 104  87 112  95  99 108 108 108  89  90  0.566688    990/1000    NonOverlappingTemplate
 104 114 120  83  90  82 101  91 127  88  0.006661    990/1000    NonOverlappingTemplate
  77  90 105 113 109 109 100 100 110  87  0.184549    989/1000    NonOverlappingTemplate
 106  98 106 109 104  96  93 101  97  90  0.942198    990/1000    NonOverlappingTemplate
  98  93 107  99  88  87  98 114  92 124  0.183547    993/1000    NonOverlappingTemplate
  97  90  83 103 106 106 108 103  96 108  0.707513    989/1000    NonOverlappingTemplate
 114  86 110 100 109  96 103  97  86  99  0.530120    988/1000    NonOverlappingTemplate
  99 114 123  96  82  93 102  90 101 100  0.202268    990/1000    NonOverlappingTemplate
  97  99  97 104  87  98 106 106  98 108  0.942198    989/1000    NonOverlappingTemplate
 97 108 114 105 104  84 101 101  91  95  0.664168    991/1000    NonOverlappingTemplate
107 106  92 108  89  90 122  83 101 102  0.206629    988/1000    NonOverlappingTemplate
115 107  78 107  96 114 106  88  97  92  0.175691    983/1000    NonOverlappingTemplate
 98 110  93 105 113 103 102  75 105  96  0.329850    990/1000    NonOverlappingTemplate
 87 103 122  86 101  97  92 114  99  99  0.255705    994/1000    NonOverlappingTemplate
 93 107  93  99  85 114 106  93 117  93  0.357000    992/1000    NonOverlappingTemplate
114  91 103 117  99 111  95  93  81  96  0.244236    993/1000    NonOverlappingTemplate
109 108 103  89  90  95  99 100  93 114  0.693142    985/1000    NonOverlappingTemplate
104  99  89  88  93  93 111 103 114 106  0.593478    990/1000    NonOverlappingTemplate
 87 113  88 109 105 109  99 114  89  87  0.239266    990/1000    NonOverlappingTemplate
 98  90 116 109  81  99 119  78 107 103  0.047785    989/1000    NonOverlappingTemplate
115  99  92  95 104  91 101  97 102 104  0.881662    985/1000    NonOverlappingTemplate
105  96  92 100  77 106 107 108  94 115  0.316052    987/1000    NonOverlappingTemplate
 95 126  96 109  94  92 105 103  92  88  0.249284    989/1000    NonOverlappingTemplate
 98  81  97  97  96 105 116 116  96  98  0.387264    985/1000    NonOverlappingTemplate
105 100  90  96 108 118 102  82 102  97  0.465415    989/1000    NonOverlappingTemplate
 95 106 109  95  99 120  88  97 103  88  0.461612    986/1000    NonOverlappingTemplate
 88  83 112 103  93 129 106  80  96 110  0.016261    989/1000    NonOverlappingTemplate
123  90 110  88 101  93 113  82  94 106  0.094285    982/1000    NonOverlappingTemplate
 89 104 102 105  98  98 111 105 103  85  0.784927    991/1000    NonOverlappingTemplate
117 107  99  98  95  86 106  90  93 109  0.504219    989/1000    NonOverlappingTemplate
109  95 100  87  94  97 100  92 116 110  0.595549    985/1000    NonOverlappingTemplate
105  91  99 108  92 120  90 100  92 103  0.526105    990/1000    NonOverlappingTemplate
106 114 110 111  93  84  91 105 105  81  0.186566    991/1000    NonOverlappingTemplate
103  90 110 100 110 110  97  82 102  96  0.572847    989/1000    NonOverlappingTemplate
 97 105 101 100 108  98 101 118  79  93  0.420827    987/1000    NonOverlappingTemplate
 90  95 105  99  94 137 104  88  86 102  0.023866    996/1000    NonOverlappingTemplate
107 124 101  85 110  96  93  91  92 101  0.235589    991/1000    NonOverlappingTemplate
105 111  92  92  81  98 117  92  97 115  0.199045    987/1000    NonOverlappingTemplate
 95  87  93 114  86 118 113  94 114  86  0.076658    989/1000    NonOverlappingTemplate
112  89  98  89  87 116 100  95 119  95  0.199045    987/1000    NonOverlappingTemplate
 88  98  97 100  94 108 107 102 103 103  0.952152    994/1000    NonOverlappingTemplate
 87  96 105  85 107 106 125  87  95 107  0.126658    993/1000    NonOverlappingTemplate
 92 100 105  88  80 110 108 119  95 103  0.217857    989/1000    NonOverlappingTemplate
 97 111 102 114  96  88  99 103  89 101  0.717714    995/1000    NonOverlappingTemplate
105 100  64 104  98 104  87 128 100 110  0.004146    988/1000    NonOverlappingTemplate
103  97  94  96 101  97  94 119  99 100  0.853049    991/1000    NonOverlappingTemplate
 99 101 121 108 105  95  94  80  95 102  0.332970    991/1000    NonOverlappingTemplate
 99 104 104  96  98  95  97 102 111  94  0.981417    990/1000    NonOverlappingTemplate
105 110  89  96  97 110  95 107  91 100  0.811080    982/1000    NonOverlappingTemplate
103 109 107  99  95 111 105  96  84  91  0.674543    989/1000    NonOverlappingTemplate
 97 106 105  99  96  96  88  94 113 106  0.844641    990/1000    NonOverlappingTemplate
105  96  90  91 104 111 107 101 100  95  0.887645    990/1000    NonOverlappingTemplate
106 112 111  90  73  95 105  98 114  96  0.123755    995/1000    NonOverlappingTemplate
116 111  82 117 102  86  89  99 104  94  0.135720    985/1000    NonOverlappingTemplate
113  90  92 100  98 105  89 106 110  97  0.711601    990/1000    NonOverlappingTemplate
109  99 107 100 101  90  99  99 107  89  0.908760    993/1000    NonOverlappingTemplate
124  90 112  94  86  89  81 115 104 105  0.035174    980/1000    NonOverlappingTemplate
 82 114 116 106  96  92 112  87 105  90  0.149495    995/1000    NonOverlappingTemplate
 95  96  98 103  95  92 113 102 100 106  0.940080    986/1000    NonOverlappingTemplate
 96  84 109 112  80 101  94 111 109 104  0.241741    990/1000    NonOverlappingTemplate
107  97  98 103 102  93  81 112  99 108  0.643366    992/1000    NonOverlappingTemplate
101  90 103 106  88 110  96 103 107  96  0.851383    987/1000    NonOverlappingTemplate
101 112  99  85 106  73 112 100 116  96  0.077607    989/1000    NonOverlappingTemplate
102  89 100 111  98 100 114  81 104 101  0.510153    988/1000    NonOverlappingTemplate
110  94  97 105 105  92 107 106  93  91  0.856359    987/1000    NonOverlappingTemplate
111 119  80 100 107  98  98  95  94  98  0.347257    987/1000    NonOverlappingTemplate
106 119 114  74  99  93 110  88 105  92  0.056785    987/1000    NonOverlappingTemplate
113 105 100  97  97  86  98 109  94 101  0.807412    990/1000    NonOverlappingTemplate
 90  98 107  91  96  99  99 112 101 107  0.878618    984/1000    NonOverlappingTemplate
105  96 120 104  91  90 104  90 106  94  0.508172    990/1000    NonOverlappingTemplate
 93  99  86 106 103 106  94 116  88 109  0.490483    995/1000    NonOverlappingTemplate
 87  97 104 103  98  99 102 110 105  95  0.934599    991/1000    NonOverlappingTemplate
 98  95  90 115 103  92 113  93 113  88  0.385543    988/1000    NonOverlappingTemplate
 86 111  99  86 118 101  98  92  98 111  0.325206    993/1000    NonOverlappingTemplate
 81  89  97 101 108  99  95 102 123 105  0.249284    992/1000    NonOverlappingTemplate
107  91  91 103  96 115  96  94 100 107  0.777265    988/1000    NonOverlappingTemplate
 99 105 114  86  91 104 101 106  94 100  0.751866    990/1000    NonOverlappingTemplate
 89  91 114 104  98 105  99 112  94  94  0.678686    993/1000    NonOverlappingTemplate
104  98 102 102 102  98 112 109  96  77  0.528111    988/1000    NonOverlappingTemplate
 98  88  84 103 106 106 108 103  96 108  0.701366    989/1000    NonOverlappingTemplate
108 116 100 112  87  96  96 102  89  94  0.508172    984/1000    OverlappingTemplate
118 110  97  99 110  92  91  88 101  94  0.474986    984/1000    Universal
 90 105 106 106 101 107  74 107 113  91  0.201189    989/1000    ApproximateEntropy
 60  72  79  55  56  58  65  56  64  59  0.446255    620/624     RandomExcursions
 65  52  70  64  61  59  63  61  64  65  0.953179    617/624     RandomExcursions
 52  65  70  65  68  50  67  66  61  60  0.680688    619/624     RandomExcursions
 50  55  64  58  71  59  72  74  49  72  0.155443    616/624     RandomExcursions
 54  68  62  59  63  66  61  60  50  81  0.330000    618/624     RandomExcursions
 59  52  63  50  58  72  70  54  69  77  0.189030    614/624     RandomExcursions
 64  67  52  58  69  59  70  71  68  46  0.325007    612/624     RandomExcursions
 60  62  79  64  56  70  57  52  61  63  0.489351    616/624     RandomExcursions
 54  64  65  67  62  56  65  63  64  64  0.980447    618/624     RandomExcursionsVariant
 53  60  76  63  64  52  68  51  62  75  0.243993    620/624     RandomExcursionsVariant
 55  68  65  65  64  64  56  65  45  77  0.289209    619/624     RandomExcursionsVariant
 52  71  57  57  69  61  61  55  66  75  0.501993    619/624     RandomExcursionsVariant
 52  62  60  63  64  73  59  62  53  76  0.501993    617/624     RandomExcursionsVariant
 58  50  55  74  60  77  54  68  59  69  0.216971    617/624     RandomExcursionsVariant
 54  64  59  63  51  73  56  67  70  67  0.576895    619/624     RandomExcursionsVariant
 50  61  55  71  65  54  72  60  61  75  0.347880    619/624     RandomExcursionsVariant
 53  44  55  72  67  61  54  82  69  67  0.034801    622/624     RandomExcursionsVariant
 67  44  57  58  75  53  71  63  73  63  0.136777    617/624     RandomExcursionsVariant
 66  50  63  56  64  69  52  72  72  60  0.443251    615/624     RandomExcursionsVariant
 74  56  64  59  61  56  70  61  72  51  0.501993    612/624     RandomExcursionsVariant
 72  49  79  62  64  66  56  52  67  57  0.195729    617/624     RandomExcursionsVariant
 60  65  68  58  55  64  66  64  59  65  0.980447    617/624     RandomExcursionsVariant
 61  50  50  74  63  63  61  64  52  86  0.035174    617/624     RandomExcursionsVariant
 57  46  61  65  52  77  55  59  70  82  0.031273    618/624     RandomExcursionsVariant
 60  45  62  74  53  57  63  69  71  70  0.218820    618/624     RandomExcursionsVariant
 59  56  59  74  50  62  58  65  69  72  0.501993    618/624     RandomExcursionsVariant
 95  86 102 111  99 107 104  97  99 100  0.896345    989/1000    Serial
107  98  92  92 112  91  92 122  98  96  0.371941    988/1000    Serial
 96 105  89 104  85 108 118  96 105  94  0.467322    988/1000    LinearComplexity


- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
The minimum pass rate for each statistical test with the exception of the
random excursion (variant) test is approximately = 980 for a
sample size = 1000 binary sequences.

The minimum pass rate for the random excursion (variant) test
is approximately = 610 for a sample size = 624 binary sequences.

For further guidelines construct a probability table using the MAPLE program
provided in the addendum section of the documentation.
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

Diehardar report:

```
#=============================================================================#
#            dieharder version 3.31.1 Copyright 2003 Robert G. Brown          #
#=============================================================================#
   rng_name    |           filename             |rands/second|
 file_input_raw|kidekin_trng_aespp_room_temp2.dat|  1.54e+07  |
#=============================================================================#
        test_name   |ntup| tsamples |psamples|  p-value |Assessment
#=============================================================================#
   diehard_birthdays|   0|       100|     100|0.06690462|  PASSED
      diehard_operm5|   0|   1000000|     100|0.96256527|  PASSED
  diehard_rank_32x32|   0|     40000|     100|0.86968772|  PASSED
    diehard_rank_6x8|   0|    100000|     100|0.58061967|  PASSED
   diehard_bitstream|   0|   2097152|     100|0.43973508|  PASSED
        diehard_opso|   0|   2097152|     100|0.04087902|  PASSED
        diehard_oqso|   0|   2097152|     100|0.09108243|  PASSED
         diehard_dna|   0|   2097152|     100|0.26593410|  PASSED
diehard_count_1s_str|   0|    256000|     100|0.14926226|  PASSED
diehard_count_1s_byt|   0|    256000|     100|0.86543829|  PASSED
 diehard_parking_lot|   0|     12000|     100|0.30644186|  PASSED
    diehard_2dsphere|   2|      8000|     100|0.45678363|  PASSED
    diehard_3dsphere|   3|      4000|     100|0.69106203|  PASSED
     diehard_squeeze|   0|    100000|     100|0.32883107|  PASSED
        diehard_sums|   0|       100|     100|0.00551459|  PASSED
        diehard_runs|   0|    100000|     100|0.23977400|  PASSED
        diehard_runs|   0|    100000|     100|0.99458350|  PASSED
       diehard_craps|   0|    200000|     100|0.14557669|  PASSED
       diehard_craps|   0|    200000|     100|0.96679653|  PASSED
 marsaglia_tsang_gcd|   0|  10000000|     100|0.81763467|  PASSED
 marsaglia_tsang_gcd|   0|  10000000|     100|0.14778603|  PASSED
         sts_monobit|   1|    100000|     100|0.09356876|  PASSED
            sts_runs|   2|    100000|     100|0.96152550|  PASSED
          sts_serial|   1|    100000|     100|0.06413064|  PASSED
          sts_serial|   2|    100000|     100|0.99520218|   WEAK
          sts_serial|   3|    100000|     100|0.41817663|  PASSED
          sts_serial|   3|    100000|     100|0.19713108|  PASSED
          sts_serial|   4|    100000|     100|0.43306108|  PASSED
          sts_serial|   4|    100000|     100|0.49425335|  PASSED
          sts_serial|   5|    100000|     100|0.48045877|  PASSED
          sts_serial|   5|    100000|     100|0.89728331|  PASSED
          sts_serial|   6|    100000|     100|0.89441164|  PASSED
          sts_serial|   6|    100000|     100|0.70870484|  PASSED
          sts_serial|   7|    100000|     100|0.87999775|  PASSED
          sts_serial|   7|    100000|     100|0.29340040|  PASSED
          sts_serial|   8|    100000|     100|0.48574863|  PASSED
          sts_serial|   8|    100000|     100|0.86999729|  PASSED
          sts_serial|   9|    100000|     100|0.85848036|  PASSED
          sts_serial|   9|    100000|     100|0.83023230|  PASSED
          sts_serial|  10|    100000|     100|0.45085625|  PASSED
          sts_serial|  10|    100000|     100|0.43870266|  PASSED
          sts_serial|  11|    100000|     100|0.09289715|  PASSED
          sts_serial|  11|    100000|     100|0.44233151|  PASSED
          sts_serial|  12|    100000|     100|0.74228831|  PASSED
          sts_serial|  12|    100000|     100|0.85785136|  PASSED
          sts_serial|  13|    100000|     100|0.16030108|  PASSED
          sts_serial|  13|    100000|     100|0.00323771|   WEAK
          sts_serial|  14|    100000|     100|0.58852039|  PASSED
          sts_serial|  14|    100000|     100|0.70323868|  PASSED
          sts_serial|  15|    100000|     100|0.03894230|  PASSED
          sts_serial|  15|    100000|     100|0.85451769|  PASSED
          sts_serial|  16|    100000|     100|0.29495284|  PASSED
          sts_serial|  16|    100000|     100|0.79662203|  PASSED
         rgb_bitdist|   1|    100000|     100|0.93478498|  PASSED
         rgb_bitdist|   2|    100000|     100|0.97950233|  PASSED
         rgb_bitdist|   3|    100000|     100|0.56044386|  PASSED
         rgb_bitdist|   4|    100000|     100|0.71018219|  PASSED
         rgb_bitdist|   5|    100000|     100|0.88729679|  PASSED
         rgb_bitdist|   6|    100000|     100|0.88606663|  PASSED
         rgb_bitdist|   7|    100000|       100|0.31777796|  PASSED
         rgb_bitdist|   8|    100000|       100|0.11847800|  PASSED
         rgb_bitdist|   9|    100000|       100|0.87424589|  PASSED
         rgb_bitdist|  10|    100000|       100|0.26387810|  PASSED
         rgb_bitdist|  11|    100000|       100|0.76563788|  PASSED
         rgb_bitdist|  12|    100000|       100|0.62314345|  PASSED
rgb_minimum_distance|   2|     10000|      1000|0.41188670|  PASSED
rgb_minimum_distance|   3|     10000|      1000|0.96139716|  PASSED
rgb_minimum_distance|   4|     10000|      1000|0.15209409|  PASSED
rgb_minimum_distance|   5|     10000|      1000|0.85756423|  PASSED
    rgb_permutations|   2|    100000|       100|0.43798937|  PASSED
    rgb_permutations|   3|    100000|       100|0.79582362|  PASSED
    rgb_permutations|   4|    100000|       100|0.84482179|  PASSED
    rgb_permutations|   5|    100000|       100|0.56754987|  PASSED
      rgb_lagged_sum|   0|   1000000|       100|0.56893688|  PASSED
      rgb_lagged_sum|   1|   1000000|       100|0.71710618|  PASSED
      rgb_lagged_sum|   2|   1000000|       100|0.04322438|  PASSED
      rgb_lagged_sum|   3|   1000000|       100|0.70410450|  PASSED
      rgb_lagged_sum|   4|   1000000|       100|0.61294046|  PASSED
      rgb_lagged_sum|   5|   1000000|       100|0.00937777|  PASSED
      rgb_lagged_sum|   6|   1000000|       100|0.01499892|  PASSED
      rgb_lagged_sum|   7|   1000000|       100|0.41323462|  PASSED
      rgb_lagged_sum|   8|   1000000|       100|0.17986284|  PASSED
      rgb_lagged_sum|   9|   1000000|       100|0.77422598|  PASSED
      rgb_lagged_sum|  10|   1000000|       100|0.84668703|  PASSED
      rgb_lagged_sum|  11|   1000000|       100|0.31899411|  PASSED
      rgb_lagged_sum|  12|   1000000|       100|0.18327849|  PASSED
      rgb_lagged_sum|  13|   1000000|       100|0.04663125|  PASSED
      rgb_lagged_sum|  14|   1000000|       100|0.95238594|  PASSED
      rgb_lagged_sum|  15|   1000000|       100|0.65816179|  PASSED
      rgb_lagged_sum|  16|   1000000|       100|0.93352674|  PASSED
      rgb_lagged_sum|  17|   1000000|       100|0.42125495|  PASSED
      rgb_lagged_sum|  18|   1000000|       100|0.90269614|  PASSED
      rgb_lagged_sum|  19|   1000000|       100|0.79005020|  PASSED
      rgb_lagged_sum|  20|   1000000|       100|0.08941778|  PASSED
      rgb_lagged_sum|  21|   1000000|       100|0.97545103|  PASSED
      rgb_lagged_sum|  22|   1000000|       100|0.47051601|  PASSED
      rgb_lagged_sum|  23|   1000000|       100|0.01421599|  PASSED
      rgb_lagged_sum|  24|   1000000|       100|0.02382046|  PASSED
      rgb_lagged_sum|  25|   1000000|       100|0.38335456|  PASSED
      rgb_lagged_sum|  26|   1000000|       100|0.69167158|  PASSED
      rgb_lagged_sum|  27|   1000000|       100|0.00906137|  PASSED
      rgb_lagged_sum|  28|   1000000|       100|0.22708952|  PASSED
      rgb_lagged_sum|  29|   1000000|       100|0.49280591|  PASSED
      rgb_lagged_sum|  30|   1000000|       100|0.31680872|  PASSED
      rgb_lagged_sum|  31|   1000000|       100|0.90355605|  PASSED
      rgb_lagged_sum|  32|   1000000|       100|0.20762492|  PASSED
     rgb_kstest_test|   0|     10000|      1000|0.55959373|  PASSED
     dab_bytedistrib|   0|  51200000|         1|0.63968869|  PASSED
             dab_dct| 256|     50000|         1|0.50086423|  PASSED
Preparing to run test 207.  ntuple = 0
        dab_filltree|  32|  15000000|         1|0.91557618|  PASSED
        dab_filltree|  32|  15000000|         1|0.05590965|  PASSED
Preparing to run test 208.  ntuple = 0
       dab_filltree2|   0|   5000000|         1|0.69303511|  PASSED
       dab_filltree2|   1|   5000000|         1|0.70893420|  PASSED
Preparing to run test 209.  ntuple = 0
        dab_monobit2|  12|  65000000|         1|0.07691978|  PASSED
```

2.6 Supported OS

The TRNG has no control commands, so it just output random numbers as long as the host ask for it. The USB communication is done via an FTDI chip, so your favorite OS is supported as long as an FTDI driver exist for it.

SUPPORTED OS ACCORDING TO FTDI'S WEBSITE:

1. Windows 8.1
2. Windows 8.1 x64
3. Windows 8
4. Windows 8 x64
5. Windows Server2012
6. Windows Server 2008 R2
7. Windows 7
8. Windows 7 x64
9. Windows Server 2008
10. Windows Server 2008 x64
11. Windows Vista
12. Windows Vista x64
13. Windows Server 2003
14. Windows Server 2003 x64
15. Windows XP
16. Windows XP x64
17. Windows ME
18. Windows 98
19. Linux
20. Mac OS X
21. Mac OS 9
22. Mac OS 8
23. Windows CE.NET (Version 4.2 and greater)
24. Android
25. Windows RT

FTDI D2XX driver download page: http://www.ftdichip.com/Drivers/D2XX.htm (Note: the VCP driver is not needed).

KIDEKIN TRNG IS TESTED ON THE FOLLOWING OS ONLY:

1. Windows 8.1 x64
2. Windows 7 x64
3. Debian x64 (running inside VirtualBox)
4. Ubuntu 14LTS

Chapter 3

Kidekin TRNG software package

This is a zip file bundling all documentation and software examples for Kidekin TRNG. The latest version and previous ones are available on kidekin's website.

Click this link for direct download of latest version.

3.1 Installation tips for Windows users

Most of the time Kidekin TRNG is recognized correctly by Windows which automatically download the right driver. The document trng_tips_windows present some tips if the automatic detection fails or you simply want to do the installation off-line.

3.2 Cross platform application notes

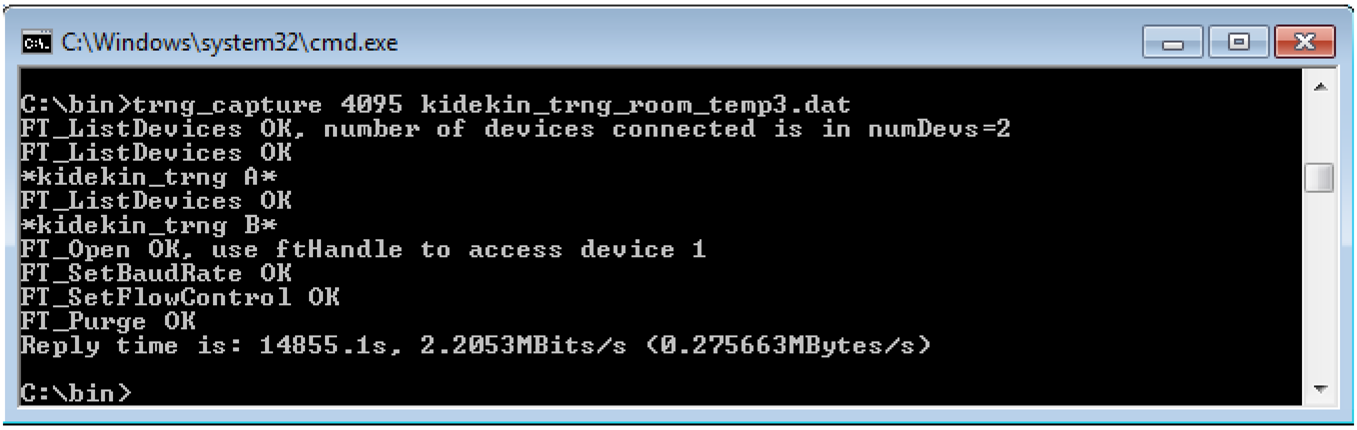
The software presented in this section have been tested on Windows and Linux and should be able to run on any supported OS with minimal porting effort. They are located in the directory "application_notes_software\ftdi_d2xx". Each application note has a dedicated directory containing build script for windows (build.bat) and linux (build.sh). Those script creates a sub-directory to store intermediate object files and the executables, they therefore need write permission. The directory "common" contain things which are needed in several application notes.

CONTENT OF THE "COMMON" DIRECTORY

1. generic: this directory contain the C++ code of a thin wrapper around FTDI's FTD2XX driver. It provides a straight forward interface to access Kidekin TRNG.
2. linux: linux port of FTDI's FTD2XX driver.
3. windows: windows port of FTDI's FTD2XX driver, including executable installer.

3.2.1 trng_capture: Direct access in C++

The program trng_capture allows to write random data to a file or the standard output. The standard output is a convenient way to directly feed random numbers to another software. That makes Kidekin TRNG accessible to virtually any programming language without resorting to write dedicated code in the target language. Binaries for windows and linux are provided as well as the C++ sources and simple build batch files and documentation (trng_capture.pdf). trng_capture allows to choose between binary or text output mode, in text mode the output is the conversion of random numbers to hexadecimal, so it looks like "A3BCFD67..." without any white space character.



```
C:\bin>trng_capture 4095 kidekin_trng_room_temp3.dat
FT_ListDevices OK, number of devices connected is in numDevs=2
FT_ListDevices OK
*kidekin_trng A*
FT_ListDevices OK
*kidekin_trng B*
FT_Open OK, use ftHandle to access device 1
FT_SetBaudRate OK
FT_SetFlowControl OK
FT_Purge OK
Reply time is: 14855.1s, 2.2053MBits/s (0.275663MBytes/s)

C:\bin>
```

Figure 3.1: trng_capture output after creating a file of almost 4GB

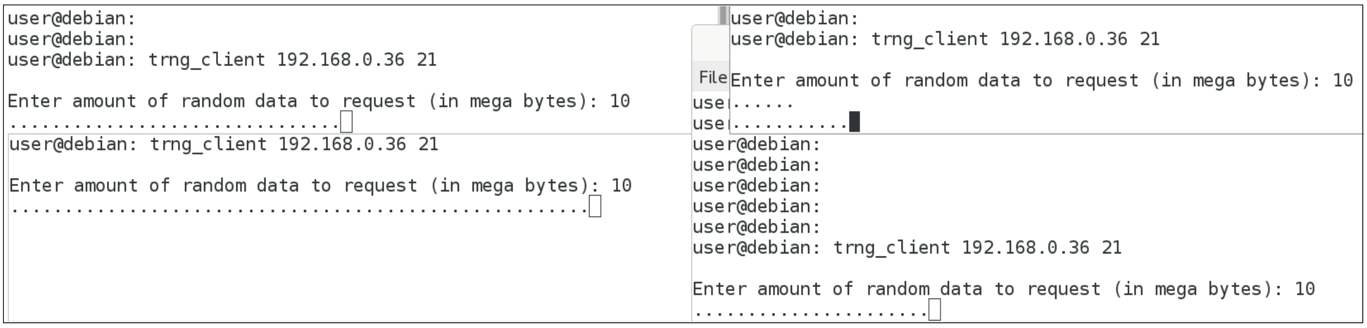
3.2.2 trng_client_server: Client-server in C++ and java

This application note consist of two programs.

PROGRAMS:

1. The program trng_server allows to send random data to another program running on another computer (or the same one).
2. The program trng_client demonstrate how to connect to trng_server and writes random data to a file.

The client-server architecture is a way to easily access the TRNG with any programming language, all you need is to connect to a socket and request data. This is demonstrated with a java implementation of trng_client. Like in the capture application note, sources (C++ and java), binaries and documentation are provided (trng_server.pdf, trng_client.pdf). In addition, a step by step guide is provided to get both programs working together.



```
user@debian:
user@debian:
user@debian: trng_client 192.168.0.36 21

Enter amount of random data to request (in mega bytes): 10
..............................
```

```
user@debian: trng_client 192.168.0.36 21

Enter amount of random data to request (in mega bytes): 10
...................................................
```

```
user@debian:
user@debian: trng_client 192.168.0.36 21

Enter amount of random data to request (in mega bytes): 10
......
..........
```

```
user@debian:
user@debian:
user@debian:
user@debian:
user@debian:
user@debian: trng_client 192.168.0.36 21

Enter amount of random data to request (in mega bytes): 10
.....................
```

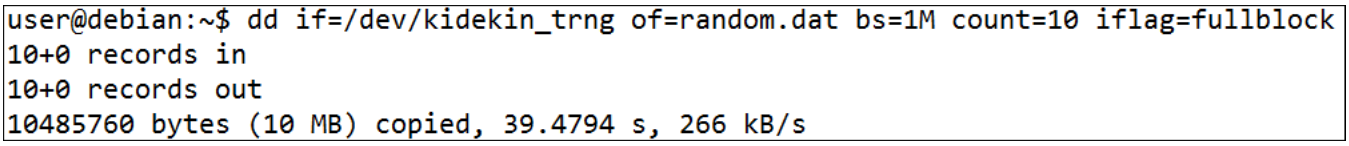
Figure 3.2: Several trng_client instances accessing the same trng_server in parallel

3.3 Linux specific application notes

Linux provides convenient mechanisms to integrate hardware random generators, the application notes in this section show how to use them with Kidekin TRNG.

3.3.1 TRNG as a character device: /dev/kidekin_trng

This application note show how to mound the TRNG as a Linux special device similar to /dev/random. After running an instal script, each time the TRNG is plugged-in, the device /dev/kidekin_trng will be mounted and ready for read operation in user mode. This is the most natural way to use the TRNG on linux: just read from the device as you would from /dev/random. Since the device has a specific name, it does not interfere with existing applications and your application can have exclusive use of it. The install script just copy a file containing udev rules, this works out of the box without installing any other software or packages.

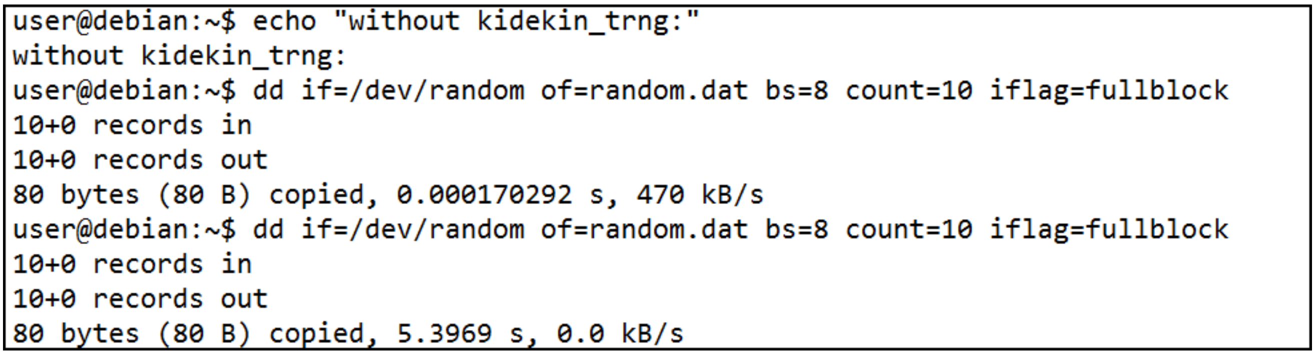


```
user@debian:~$ dd if=/dev/kidekin_trng of=random.dat bs=1M count=10 iflag=fullblock
10+0 records in
10+0 records out
10485760 bytes (10 MB) copied, 39.4794 s, 266 kB/s
```

Figure 3.3: /dev/kidekin_trng typical performances: about 40 seconds to generate 10 mega bytes.

3.3.2 Feeding the /dev/random device

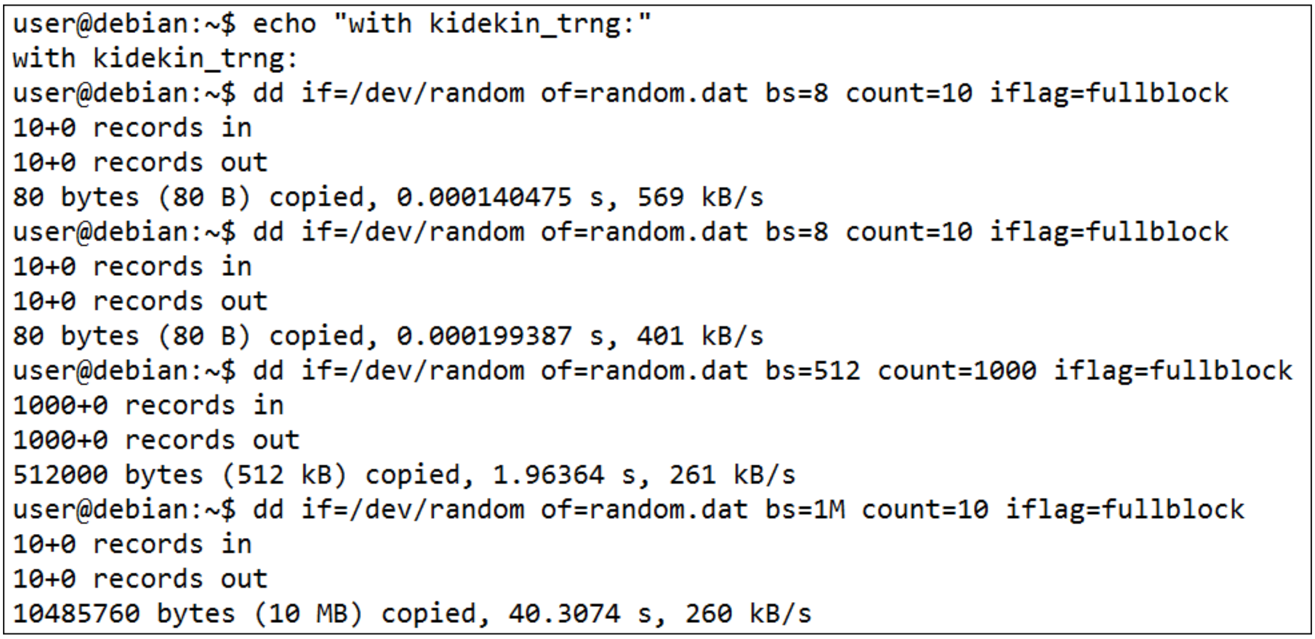
This application note show how to feed Linux's /dev/random with the TRNG. This way any program using /dev/random is seamlessly accelerated. This is especially useful on gaming servers or web servers which need to generate cryptographic keys. This is just some udev rules however it does require an additional package (rng-tools). An installer shell script is provided to copy the right files at the right places with minimal user effort.



```
user@debian:~$ echo "without kidekin_trng:"
without kidekin_trng:
user@debian:~$ dd if=/dev/random of=random.dat bs=8 count=10 iflag=fullblock
10+0 records in
10+0 records out
80 bytes (80 B) copied, 0.000170292 s, 470 kB/s
user@debian:~$ dd if=/dev/random of=random.dat bs=8 count=10 iflag=fullblock
10+0 records in
10+0 records out
80 bytes (80 B) copied, 5.3969 s, 0.0 kB/s
```

Figure 3.4: /dev/random typical performances

First call to /dev/random is very fast because it just read buffered data, second call is way slower as the system is waiting to gather enough fresh entropy.



```
user@debian:~$ echo "with kidekin_trng:"
with kidekin_trng:
user@debian:~$ dd if=/dev/random of=random.dat bs=8 count=10 iflag=fullblock
10+0 records in
10+0 records out
80 bytes (80 B) copied, 0.000140475 s, 569 kB/s
user@debian:~$ dd if=/dev/random of=random.dat bs=8 count=10 iflag=fullblock
10+0 records in
10+0 records out
80 bytes (80 B) copied, 0.000199387 s, 401 kB/s
user@debian:~$ dd if=/dev/random of=random.dat bs=512 count=1000 iflag=fullblock
1000+0 records in
1000+0 records out
512000 bytes (512 kB) copied, 1.96364 s, 261 kB/s
user@debian:~$ dd if=/dev/random of=random.dat bs=1M count=10 iflag=fullblock
10+0 records in
10+0 records out
10485760 bytes (10 MB) copied, 40.3074 s, 260 kB/s
```

Figure 3.5: /dev/random with Kidekin TRNG typical performances

With Kidekin TRNG, first and subsequent calls to /dev/random are beyond 2MBits/s. In that experiment the last call read 10 mega bytes to minimize the effect of buffering on the performance measurement. Such request is possible only with Kidekin TRNG, without it /dev/random would take an unreasonable time. The performance achieved with /dev/random is slightly lower than reading directly /dev/kidekin_trng or using dedicated software however it allows to use standard software.

Chapter 4

Glossary

The definitions given here focus on the context of Kidekin TRNG, please refer to other sources to get an encyclopaedic definition.

AES

Advanced Encryption Standard, as described in FIPS PUB 197

CBC-MAC

Cipher Block Chaining Message Authentication Code. An algorithm originaly designed to authenticate data. In the context of Kidekin TRNG, it is used as post processing algorithm, as recommended in NIST’s SP800-90B.

TRNG

True Random Number Generator, as opposed to Pseudo Random Number Generator (PRNG). A TRNG is a device whose output is unpredictable no matter how long one observe it. It is often desired that the output is also uniformly distributed, this is the case for Kidekin TRNG, with or without post processor.