A Study of the Complex Helicity Patterns of the Generator

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- Helicity Generator data for the **Octet, Hexo-Quad, Octo-Quad, m64, 16q, 32p** helicity patterns were recorded using the Helicity Decoder in *test mode.*

- In *test mode* the Decoder records helicity data after the start of each stable period.

- Data is recorded once per helicity window; the entire helicity sequence can be reconstructed.

- The Decoder also measures the duration of all stable and settling periods so we can confirm that they are fixed values.

- These patterns contain many helicity windows (8, 24, 32, 64) and so are difficult to confirm on a scope.

- Data from 32K helicity windows was collected for each pattern run.

- The analysis program discovers all patterns in the run and confirms that the starting helicity of the patterns is consistent with the generator seeds recorded by the Decoder (for earlier patterns).

- **Pages 3 – 8** shows the results from the analysis of the data runs.

- Two complementary versions of the pattern were found for each pattern type. The **Octet, Hexo-Quad**, and **Octo-Quad** patterns were confirmed to match the documentation for the Generator (6/23/2014) as well as the HDL code of its design. The **m64, 16q, 32p** patterns were confirmed to match the HDL code.

- The stable and settling periods for all patterns were found to have the proper (default) values of the Generator. Very small variations were measured that are consistent with the 8 ns sampling period of the Decoder.

- The frequencies of the complementary patterns were measured and an asymmetry computed for each pattern type. For the longer patterns (24, 32, 64 windows) this asymmetry was 3 – 8%. For the Octet (8 windows) it was < 1%.

- The non-trivial asymmetry may be due to the reduced statistics of the longer patterns. With 32K windows collected a 64-window pattern will present only 500 total patterns for analysis.

- The asymmetry is both + and -, which reinforces the reduced statistics argument.

- Longer data runs will be taken to confirm that there are no other things happening.

- In addition, the data acquisition program that recorded this data is being modified to do the above analysis in real time. In this way runs of many hours may be taken without having to deal with storing large amounts of data.

Data input file name = octet_test1.txt

HELICITY COMPARE: Prediction of helicity at next pattern to actual next pattern helicity
       number = 4000   match = 4000
HELICITY COMPARE: Capture seed at point - advance sequence to compare helicity for all future patterns
       number = 3993   match = 3993

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 2 Helicity patterns found in data
 0110 1001
 1001 0110

Octet

Length of patterns
 8
 8

***** The 2 patterns are complements *****

frequency of patterns in data
 1994
 2004   n(1)-n(0) / n(1)+n(0) = 0.00250

number helicity 1 = 16000   number helicity 0 = 16000

At pattern sync: number helicity 1 = 2006   number helicity 0 = 1994

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stable duration (8 ns units)
   AVG = 4166254.154 SIG = 0.6187 min = 4166253 max = 4166255 diff = 2 (num = 32000)
   stable duration = 33330.035 us

settle duration (8 ns units)
   AVG = 62498.842 SIG = 0.3647 min = 62498 max = 62499 diff = 1 (num = 32000)
   settle duration = 499.991 us

Data input file name = hex_test1.txt

HELICITY COMPARE: Prediction of helicity at next pattern to actual next pattern helicity
        number = 1315   match = 1315
HELICITY COMPARE: Capture seed at point - advance sequence to compare helicity for all future patterns
        number = 1305   match = 1305

----

 2 Helicity patterns found in data
 1001 1001 1001 0110 0110 0110
 0110 0110 0110 1001 1001 1001

Hexo-Quad

Length of patterns
 24
 24

***** The 2 patterns are complements *****

frequency of patterns in data
 688
 643   n(1)-n(0) / n(1)+n(0) = 0.03381

number helicity 1 = 16000   number helicity 0 = 16000

At pattern sync: number helicity 1 = 689   number helicity 0 = 644
----
stable duration (8 ns units)
    AVG = 4166254.442 SIG = 0.4677 min = 4166254 max = 4166255 diff = 1 (num = 32000)
    stable duration = 33330.035 us

settle duration (8 ns units)
    AVG = 62498.845 SIG = 0.3621 min = 62498 max = 62499 diff = 1 (num = 32000)
    settle duration = 499.991 us

Data input file name = ocq_test1.txt

HELICITY COMPARE: Prediction of helicity at next pattern to actual next pattern helicity
        number = 976   match = 976
HELICITY COMPARE: Capture seed at point - advance sequence to compare helicity for all future patterns
        number = 966   match = 966

----

 2 Helicity patterns found in data
 0110 0110 0110 0110 1001 1001 1001 1001
 1001 1001 1001 1001 0110 0110 0110 0110

Octo-Quad

Length of patterns
 32
 32

***** The 2 patterns are complements *****

frequency of patterns in data
 517
 481   n(1)-n(0) / n(1)+n(0) = -0.03607

number helicity 1 = 16000   number helicity 0 = 16000

At pattern sync: number helicity 1 = 482   number helicity 0 = 518
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stable duration (8 ns units)
   AVG = 4166254.596 SIG = 0.7539 min = 4166254 max = 4166256 diff = 2 (num = 32000)
   stable duration = 33330.035 us

settle duration (8 ns units)
   AVG = 62498.848 SIG = 0.3592 min = 62498 max = 62499 diff = 1 (num = 32000)
   settle duration = 499.991 us

Data input file name = m64_test1.txt

HELICITY COMPARE: Prediction of helicity at next pattern to actual next pattern helicity

      number = 474   match = 474

HELICITY COMPARE: Capture seed at point - advance sequence to compare helicity for all future patterns

      number = 464   match = 464

----

 2 Helicity patterns found in data

 0110 1001 1001 0110 1001 0110 0110 1001 1001 0110 0110 1001 0110 1001 1001 0110

 1001 0110 0110 1001 0110 1001 1001 0110 0110 1001 1001 0110 1001 0110 0110 1001

m64

Length of patterns

 64

 64

***** The 2 patterns are complements *****

frequency of patterns in data

 235

 263      $n(1)-n(0) / n(1)+n(0) = 0.05622$

number helicity 1 = 16001   number helicity 0 = 15999

At pattern sync: number helicity 1 = 264   number helicity 0 = 236

----

stable duration (8 ns units)

   AVG = 4166255.540 SIG = 0.7342 min = 4166254 max = 4166257 diff = 3 (num = 32000)

   stable duration = 33330.043 us

settle duration (8 ns units)

   AVG = 62498.863 SIG = 0.3435 min = 62498 max = 62499 diff = 1 (num = 32000)

   settle duration = 499.991 us

Data input file name = a16q_test1.txt

HELICITY COMPARE: Prediction of helicity at next pattern to actual next pattern helicity

          number = 474   match = 474

HELICITY COMPARE: Capture seed at point - advance sequence to compare helicity for all future patterns

          number = 464   match = 464

----

 2 Helicity patterns found in data

 1001 1001 0110 0110 1001 1001 0110 0110 1001 1001 0110 0110 1001 1001 0110 0110

 0110 0110 1001 1001 0110 0110 1001 1001 0110 0110 1001 1001 0110 0110 1001 1001

16q

Length of patterns

 64

 64

***** The 2 patterns are complements *****

frequency of patterns in data

 229

 269      $n(1)-n(0) / n(1)+n(0) = -0.08032$

number helicity 1 = 16000   number helicity 0 = 16000

At pattern sync: number helicity 1 = 230   number helicity 0 = 270

----

stable duration (8 ns units)

    AVG = 4166255.312 SIG = 0.5078 min = 4166254 max = 4166257 diff = 3 (num = 32000)

    stable duration = 33330.043 us

settle duration (8 ns units)

    AVG = 62498.859 SIG = 0.3485 min = 62498 max = 62499 diff = 1 (num = 32000)

    settle duration = 499.991 us

Data input file name = a32p_test1.txt

HELICITY COMPARE: Prediction of helicity at next pattern to actual next pattern helicity
        number = 474   match = 474
HELICITY COMPARE: Capture seed at point - advance sequence to compare helicity for all future patterns
        number = 464   match = 464

----

 2 Helicity patterns found in data
 0101 0101 0101 0101 0101 0101 0101 0101 0101 0101 0101 0101 0101 0101 0101 0101
 1010 1010 1010 1010 1010 1010 1010 1010 1010 1010 1010 1010 1010 1010 1010 1010

Length of patterns   **32p**
 64
 64

***** The 2 patterns are complements *****

frequency of patterns in data
 257
 241   n(1)-n(0) / n(1)+n(0) = -0.03213

number helicity 1 = 16000   number helicity 0 = 16000

At pattern sync: number helicity 1 = 242   number helicity 0 = 258

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stable duration (8 ns units)
    AVG = 4166255.392 SIG = 0.7262 min = 4166254 max = 4166256 diff = 2 (num = 32000)
    stable duration = 33330.043 us

settle duration (8 ns units)
    AVG = 62498.860 SIG = 0.3474 min = 62498 max = 62499 diff = 1 (num = 32000)
    settle duration = 499.991 us