EXPERIMENT NO. 01

TITLE: Design PN sequence generator using Linear Feedback Shift Register

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PROBLEM STATEMENT: Design a 4-bit PN sequence generator using Linear Feedback Shift Register. The generated circuitry should avoid lockout condition. Also find the correlation function of the generated PN sequence with a delayed version of itself.

KEY COMPONENTS: IC7418(AND gate), IC7432(OR gate), IC7486(XOR gate), IC7495(4-bit shift register), digital oscilloscope, function generator, breadboard, connecting wires, power supply.

BRIEF THEORY:

The experiment aims to generation of random PN sequence using Linear Shift Feedback Register (LFSR). An LFSR can generate random number sequence which acts as cipher in cryptography. Pseudo-Noise (PN) sequences are commonly used to generate noise that is approximately white. It is also commonly referred to as the Pseudo-Random Binary Sequence (PRBS). The term "pseudo" implies that the sequence is not truly random. Actually, it is periodic with a (possibly large) period, and exhibits some characteristics of a random white sequence within that period. Pseudo random binary sequences (PRBSs), also known as pseudo noise (PN). A linear feedback shift register (LFSR) is assembled by N number of flip flops connected in series and a combinational logic generally XOR gate. At every rising edge of the clock pulse the contents of the registers are moved one bit position towards right. With each clock pulse the logic circuit computes a Boolean function of the states of the flip-flops. The result is then fed back as the input to the first flip-flop, thereby preventing the shift register from emptying. The PN sequence thus generated depends upon the number of flip flops used, the logic used for feedback circuit and initial state. A general block diagram of PN sequence is shown below:

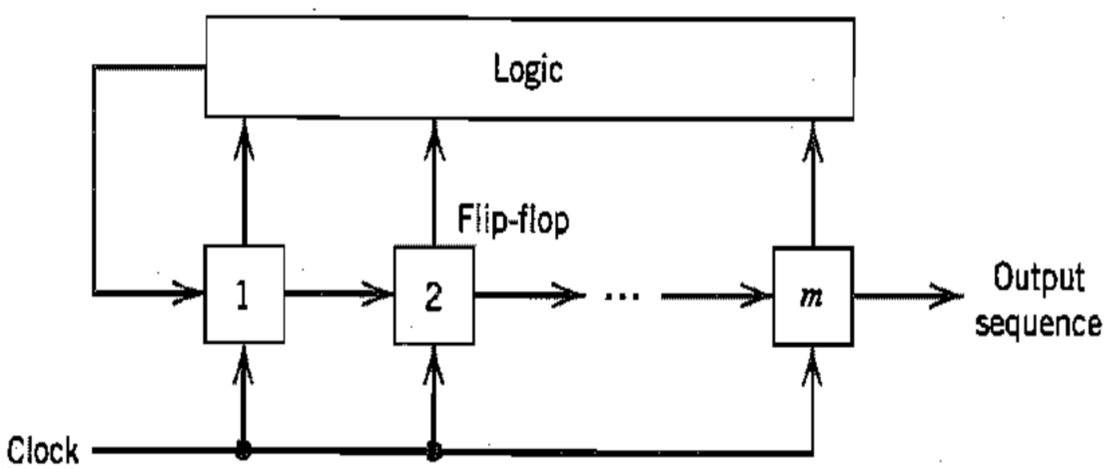

Figure 1: Feedback Shift Register

Properties of PN sequences:

The properties which make pseudorandom signal truly appears to be random are listed below:

1. **Balance Property:** In each period of a maximum length sequence, the number of 1s is always one more than the number of 0s.
2. **Run Property:** Among the runs of 1s and 0s in each period of a maximum length sequence, one half the runs of each kind are of length one-fourth are of length two, one eighth are of length three, and so on as long as these fractions represent meaningful numbers of runs.

3. **Correlation Property:** Correlation is a measure of similarity between two sequences. When the two sequences compared are different it is the ‘cross correlation’ and when they are the same it is the ‘autocorrelation’.

Applications of PN sequence in communication systems:

1. **RAKE Receiver:** It is a method of resolving multipath problems using PN sequences. Here autocorrelation property of PN sequence is used i.e., time shifted versions of itself are almost zero. Thus, a signal that propagates from Tx to Rx over multiple paths (hence having different time delays) is cross-correlated with time shifted versions PN sequence. It uses multiple correlators to separately detect strongest multipath components.
2. **Searcher Receiver:** It performs detection and measurements of multipath components in IS-95 CDMA system. It is programmed to compare incoming signal with I and Q channel PN codes. Multipath arrivals at the receiver unit manifest themselves as correlation peaks occurring at different times. Searcher receiver table maintains time of arrival of signal, signal strength, and the corresponding PN code offset. All base stations use same I and Q PN codes, differing only in code phase offset, which enables detecting base stations by correlation.

Expected Outcome:

With the help of 4-bit linear feedback shift register a PN sequence of length 15 bits will be generated which will follow the properties of PN sequence such as run length property, balance property and correlation property. Output plot should contain the clock and the generated PN sequence. The autocorrelation function should be maximum only when the shift is zero or some integer times the period of the generated PN sequence. In other cases, the correlation function is constant and minimum i.e., the generated PN sequence should offer high autocorrelation and low cross correlation.

Software Part:

1. Export the DSO data i.e., time series in .csv format and plot it in MATLAB.
2. Plot the autocorrelation function for the above data and comment on the generated function.
3. Generate a PN sequence with 6-stage Linear Feedback Shift Register using the following polynomial and plot the autocorrelation function:

   $$x^6 + x + 1$$
4. Similarly do the same for the following polynomial:

   $$x^6 + x^5 + x^4 + x^3 + x^2 + x + 1$$
5. Comment on the difference in the plots.

Note: Both hardware and software should be included in the report.