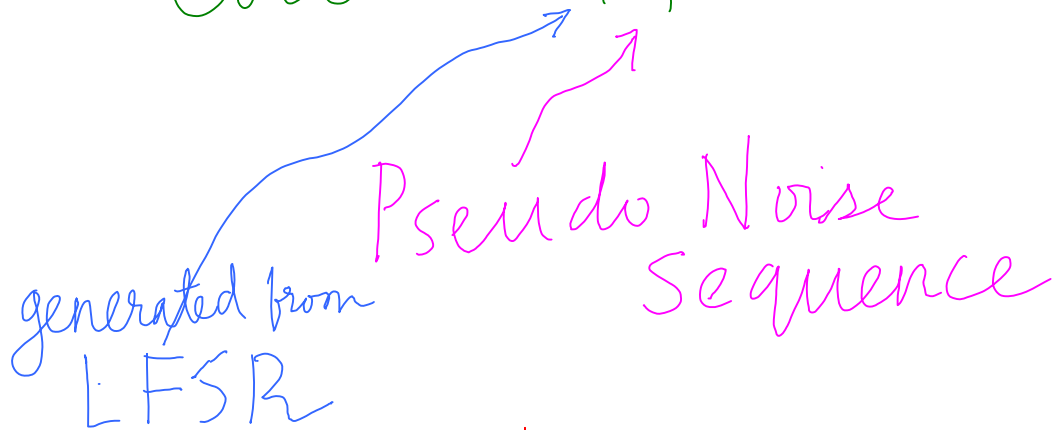


CDMA:

Code — PN

generated from
LFSR

Pseudo Noise
Sequence



Linear Feedback
Shift Register

PN Sequence From $D = 4$
LFSR

1 1 1 1 0 0 0 1 0 0 1 1 0 1 0



PN Sequence
Length = 15

$$\begin{array}{lcl}
 1 & \longrightarrow & -1 \\
 0 & \longrightarrow & +1
 \end{array}$$

1	1	1	1	0	0	0	1	0	0	1	1	0	1	0
-1	-1	-1	-1	1	1	1	-1	1	1	-1	-1	1	-1	-1

PN Sequence
after modulation

Properties of PN Sequence:

-1 -1 -1 -1 1 1 1 -1 1 1 -1 -1 1 -1 1

Total number of $(-1)s = 8$

Total number of $(+1)s = 7$

Number of (-1) 's

$$= 1 + \text{Number of } (+1)\text{'s}$$

$$\text{Number of } (-1)\text{'s} \approx \text{Number of } (+1)\text{'s}$$

Balance Property.

Property # 2 :

RUN
= String of continuous values.

$$\begin{array}{ccccccccccccccc}
 -1 & -1 & -1 & -1 & 1 & 1 & 1 & -1 & 1 & 1 & -1 & -1 & 1 & -1 & 1 \\
 \hline
 & & & & l=3 & & & l=1 & l=2 & & l=2 & & l=1 & & l=1 \\
 \hline
 & & & & & & & & & & & & & &
 \end{array}$$

$l=4$ (under the first four -1s)
 $l=3$ (under the next three 1s)
 $l=1$ (under the next -1)
 $l=2$ (under the next two 1s)
 $l=2$ (under the next two -1s)
 $l=1$ (under the next 1)
 $l=1$ (under the next -1)
 $l=1$ (under the last 1)

$$\text{Total runs} = 8$$

4 runs of length 1

$$= \frac{1}{2} \times 8 \text{ runs of length 1}$$

2 runs of length 2

$$= \frac{1}{4} \times 8 = \frac{1}{4} \times \text{Total runs are of length 2}$$

one run of length 3

$$= \frac{1}{8} \times 8 = \frac{1}{8} \times \text{Total runs are of length 3.}$$

Run Length Property:

Out of Total number of runs, $\frac{1}{2^n}$ of total runs are of length n .

Property # 3:

Auto Correlation Property:

$$\frac{1}{N} \sum_n c(n) c(n-d)$$

$N =$ length of
PN sequence.

$d =$ shift

each $c(n) = \pm 1$

If $d = 0$

$$\begin{aligned} & \frac{1}{N} \sum_n c(n) c(n-d) \\ &= \frac{1}{N} \sum_n c(n) c(n) \\ &= \frac{1}{N} \sum_n c^2(n) \quad \text{since } c(n) = \pm 1 \\ & \quad \quad \quad c^2(n) = 1 \\ &= \frac{1}{N} \sum_n 1 = \frac{1}{N} \cdot N = 1 \end{aligned}$$

If $d = 0$

auto correlation of PN
Sequence = 1 .

$$d = 2$$

$$\begin{array}{r}
 c(n) \quad -1 \quad -1 \quad -1 \quad -1 \quad 1 \quad 1 \quad 1 \quad -1 \quad 1 \quad 1 \quad -1 \quad -1 \quad 1 \quad -1 \quad 1 \\
 c(n-2) \quad -1 \quad 1 \quad -1 \quad -1 \quad -1 \quad -1 \quad 1 \quad 1 \quad 1 \quad -1 \quad 1 \quad 1 \quad -1 \quad -1 \quad 1 \\
 \hline
 1 - 1 + 1 + 1 - 1 - 1 + 1 - 1 + 1 - 1 - 1 - 1 - 1 + 1 + 1 \\
 \hline
 = -1
 \end{array}$$

$$\text{autocorrelation} = -\frac{1}{N} = -\frac{1}{15}$$

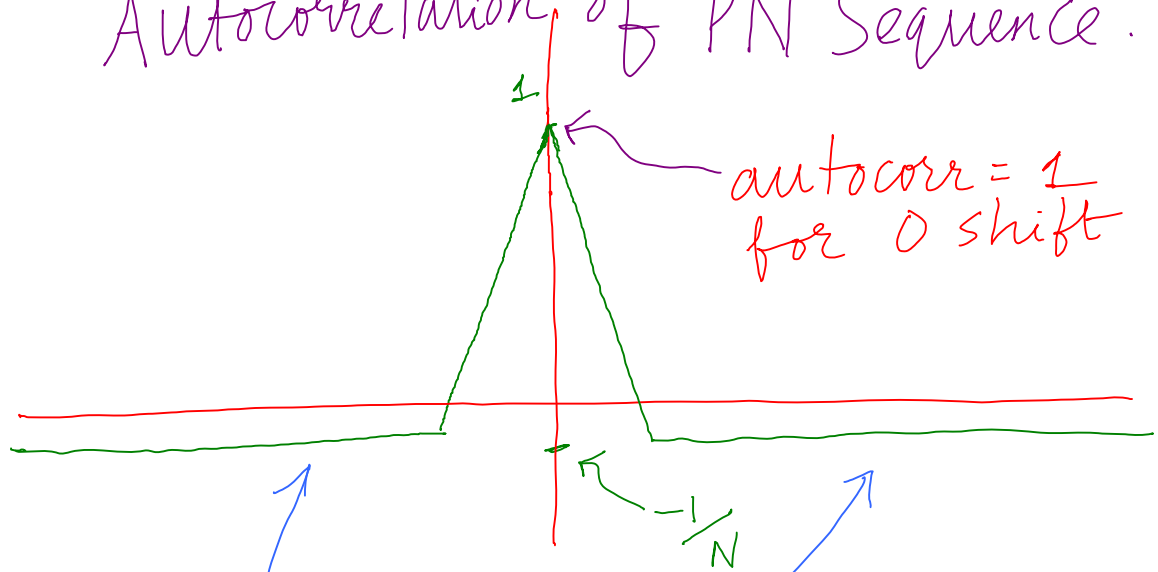
Auto correlation Property of PN Sequence.

If $d = 0$ autocorr = 1

If $d \neq 0$ autocorr = $-\frac{1}{N}$

≈ 0 for
large N .

Autocorrelation of PN Sequence.



For any non-zero shift falls to $\frac{1}{N} \approx 0$ for large N .