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Chapter 12 Pseudo Noise Sequences

Section 12.2, pages 728-732

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Experimental BER

➤ Monte Carlo estimation of BER

☐ Matlab simulations

- o generate bits
- o simulate system
- o count errors

☐ Experimental simulations

- o generate bits
- o pass through a system
- o count errors

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Experimental BER

➤ Monte Carlo estimation of BER

❑ Matlab simulations

- o generate bits
 - o simulate system
 - o count errors
- you know what was sent
- 

❑ Experimental simulations

- o generate bits
 - o pass through a system
 - o count errors
- you know what was sent
- 

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Experimental BER

➤ Monte Carlo estimation of BER

❑ Matlab simulations

- o generate bits
 - o simulate system
 - o count errors
- perfect synchronization
- 

❑ Experimental simulations

- o generate bits
 - o pass through a system
 - o count errors
- how do we synchronize?
- 

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Experimental BER

➤ Monte Carlo estimation of BER

❑ Matlab simulations

- o generate bits
- o simulate system
- o count errors

one frame examined

❑ Experimental simulations

- o generate bits
- o pass through a system
- o count errors

continuous repetition

how do we synchronize?

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Experimental BER

➤ Monte Carlo estimation of BER

❑ Matlab simulations

- o generate bits
- o simulate system
- o count errors

random data

❑ Experimental simulations

- o generate bits
- o pass through a system
- o count errors

*continuous repetition
need special properties*

how do we synchronize?

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“Random” data

pseudo-noise sequences
(PN)

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Pseudo-noise sequences

➤ **balance**

- ❑ number of "1" in the sequence is equal to the number of "0"

“looks” random even if it is not ... pseudo-random

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Pseudo-noise sequences

➤ **balance**

- ❑ number of "1" in the sequence is equal to the number of "0"

➤ **no long sub-sequences**

- ❑ the length of sub-sequences with all the same bit (i.e., 0 or 1) is limited

"looks" random even if it is not ... pseudo-random

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Pseudo-noise sequences

➤ **balance**

- ❑ number of "1" in the sequence is equal to the number of "0"

➤ **no long sub-sequences**

- ❑ the length of sub-sequences with all the same bit (i.e., 0 or 1) is limited

➤ **constrained cross-correlation**

- ❑ correlation of a sequence with a cyclical shift of itself is very small

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Sequences

➤ PRBS

- ❑ Pseudo random bit sequence

➤ PN sequences

- ❑ Pseudo noise
- ❑ "delta function" autocorrelation is like AWGN!

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LFSR

- How do we get a sequence with thewe properties?

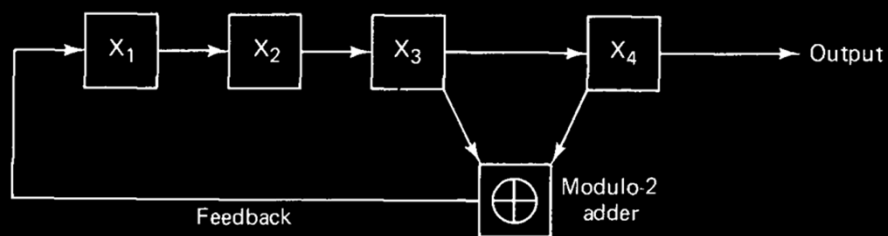
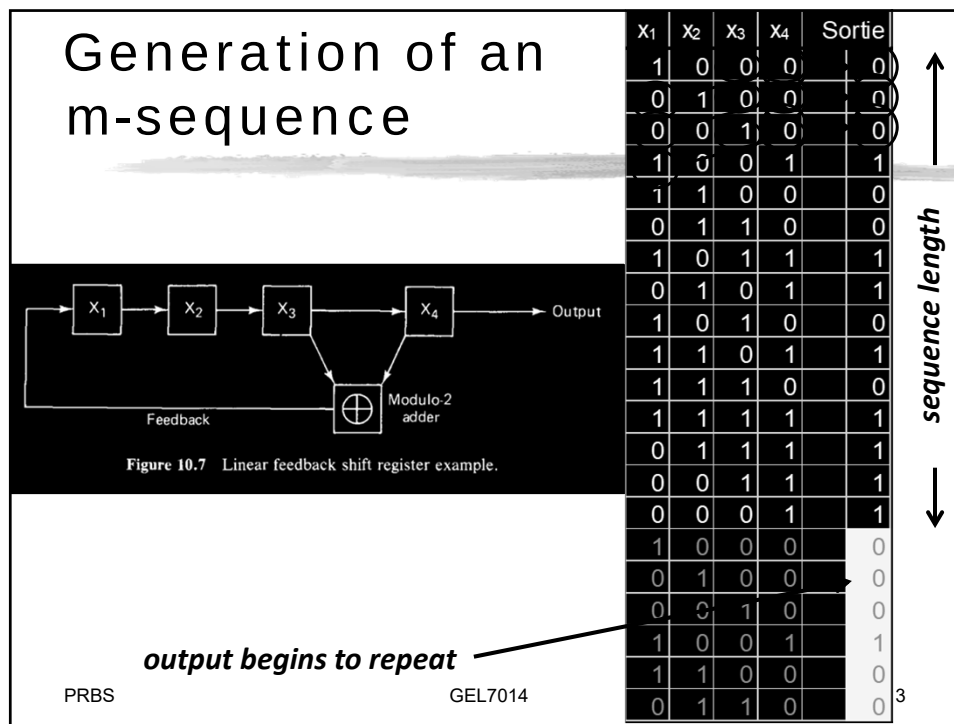


Figure 10.7 Linear feedback shift register example.

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m is for maximal

- Given m registers in LSFR
 - ☐ possible states
 - ☐ zero state is unallowed; why?
 - ☐ maximal length we can generate is

m-sequence

X ₁	X ₂	X ₃	X ₄	Sortie
1	0	0	0	0
0	1	0	0	0
0	0	1	0	0
1	0	0	1	1
1	1	0	0	0
0	1	1	0	0
1	0	1	1	1
0	1	0	1	1
1	0	1	0	0
1	1	0	1	1
1	1	1	0	0
1	1	1	1	1
0	1	1	1	1
0	0	1	1	1
0	0	0	1	1

➤ balance

- ☐ 8 ones
- ☐ 7 zeros

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m-sequence

X ₁	X ₂	X ₃	X ₄	Sortie
1	0	0	0	0
0	1	0	0	0
0	0	1	0	0
1	0	0	1	1
1	1	0	0	0
0	1	1	0	0
1	0	1	1	1
0	1	0	1	1
1	0	1	0	0
1	1	0	1	1
1	1	1	0	0
1	1	1	1	1
0	1	1	1	1
0	0	1	1	1
0	0	0	1	1

➤ No long sub-sequences

- ☐ One sequence of 4 ones
- ☐ One sequence of 3 zeros
- ☐ Two sequences of length 2
 - o One of zeros
 - o One of ones
- ☐ Four sequences of length 1

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Definition

➤ Autocorrelation function

$$R_x(\tau) = \frac{1}{K} \frac{1}{T_0} \int_{-T_0/2}^{T_0/2} x(t) x(t+\tau) dt$$

➤ Normalization factor

$$K = \frac{1}{T_0} \int_{-T_0/2}^{T_0/2} x^2(t) dt$$

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Autocorrelation of m-sequences

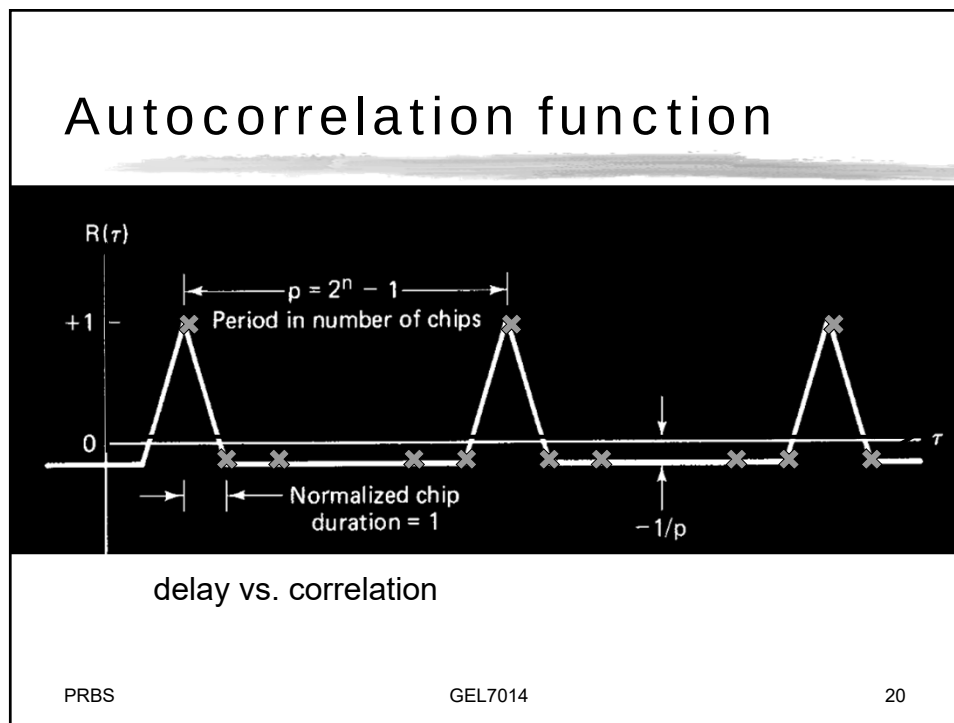
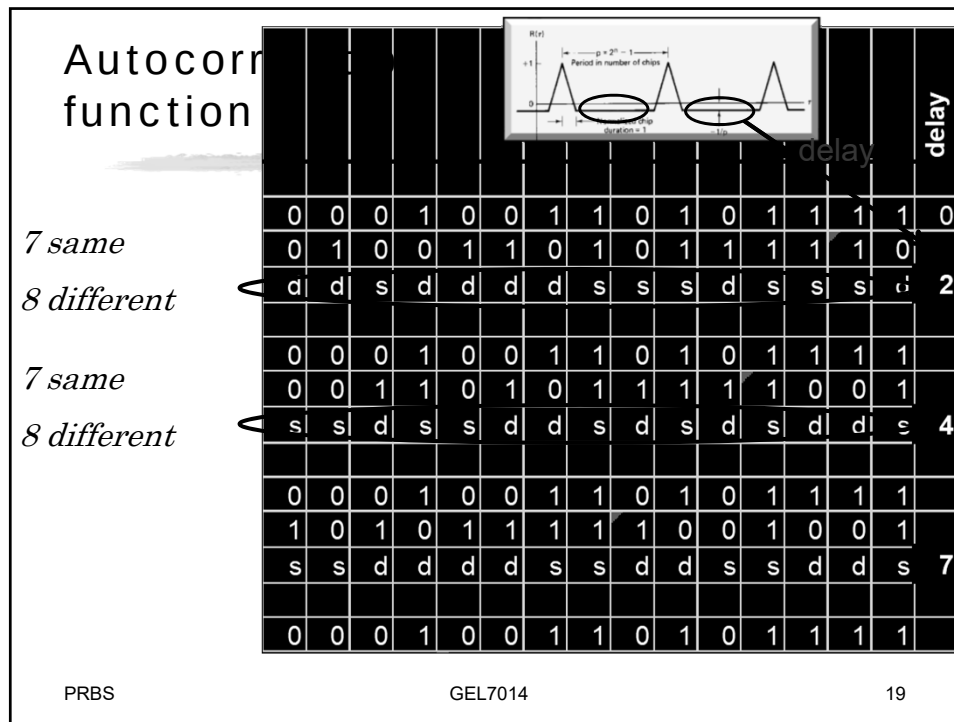
$$R_x(\tau) = \frac{\text{nombre de chips pareils} - \text{nombre differents}}{\text{longueur de code}}$$

for discrete time

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Autocorrelation function

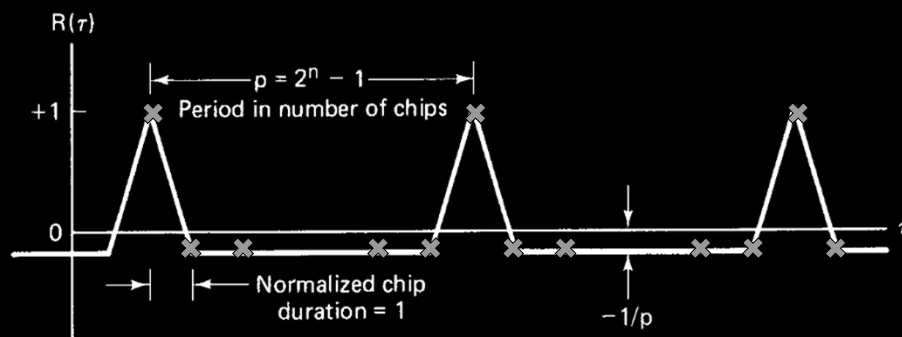
- For zero delay
 - ❑ All bits are identical
 - ❑ Spike with height = code length
- For any other delay
 - ❑ Half the bits are identical
 - ❑ Autocorrelation of less than one

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Autocorrelation function



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Autocorrelation & synchronization

- Sharp autocorrelation solves our synchronization requirement

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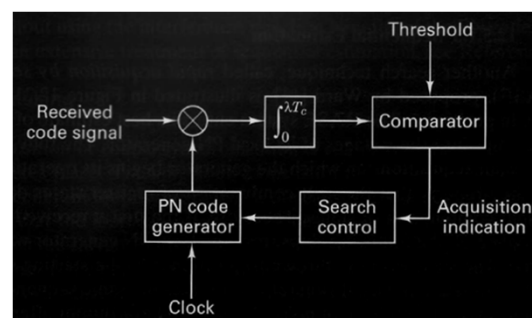
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Synchronisation

- The sharper the autocorrelation peak
 - ❑ the better the synchronization

**sliding
correlator**

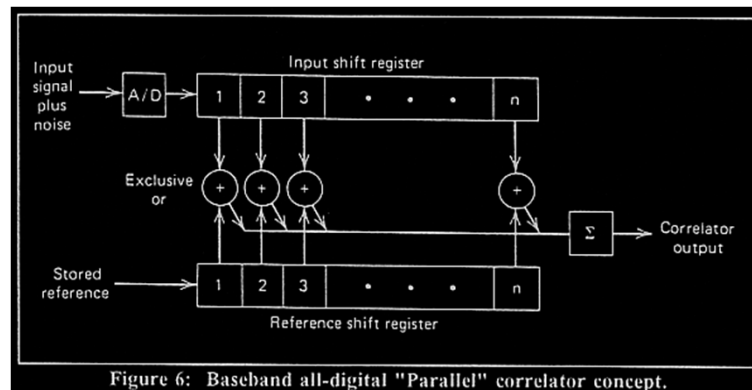


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Synchronisation



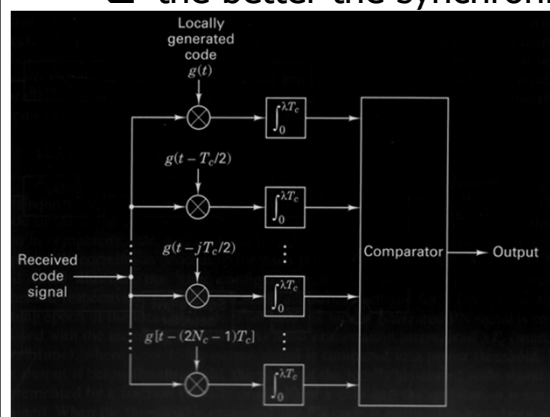
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Synchronisation

- The sharper the autocorrelation peak
- ☐ the better the synchronization



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Offline synchronization

- If implementation was not an issue, how would we do it?
- Matlab implementations can simply use a convolution
- Convolve your received signal with the transmitted PRBS
- Practice with Equalization assignment