MODULE 1
SPREAD SPECTRUM AND CDMA

Spread Spectrum

- spreading the bandwidth needed to transmit data.
- resistance to narrowband interference.
- the power level of the user signal can even be as low as the background noise.
- This makes it difficult to distinguish the user signal from the background noise and thus hard to detect.
- bandpass filter to cut off frequencies left and right of the narrowband signal.

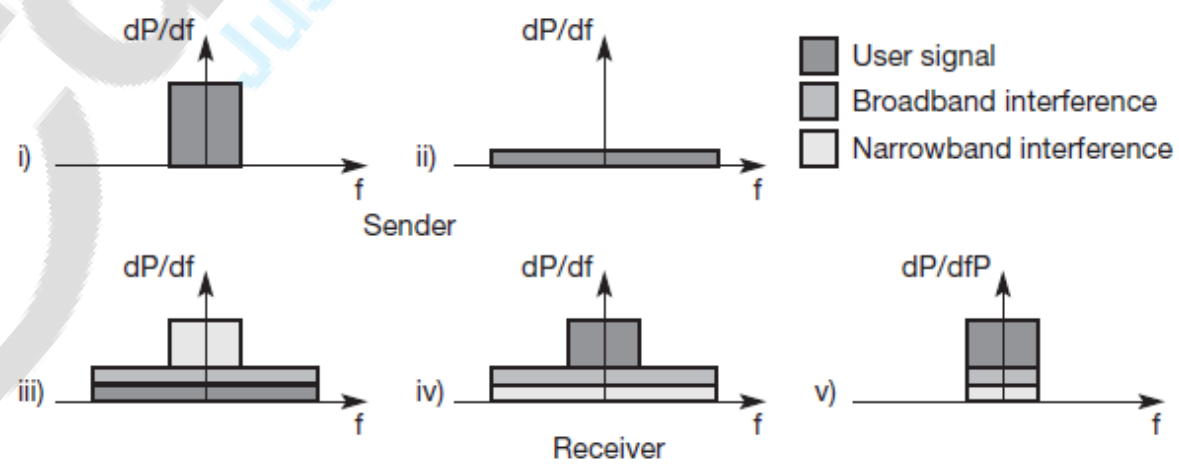


Figure 2.32
Spread spectrum: spreading and despreading

Narrowband Interference in FDM

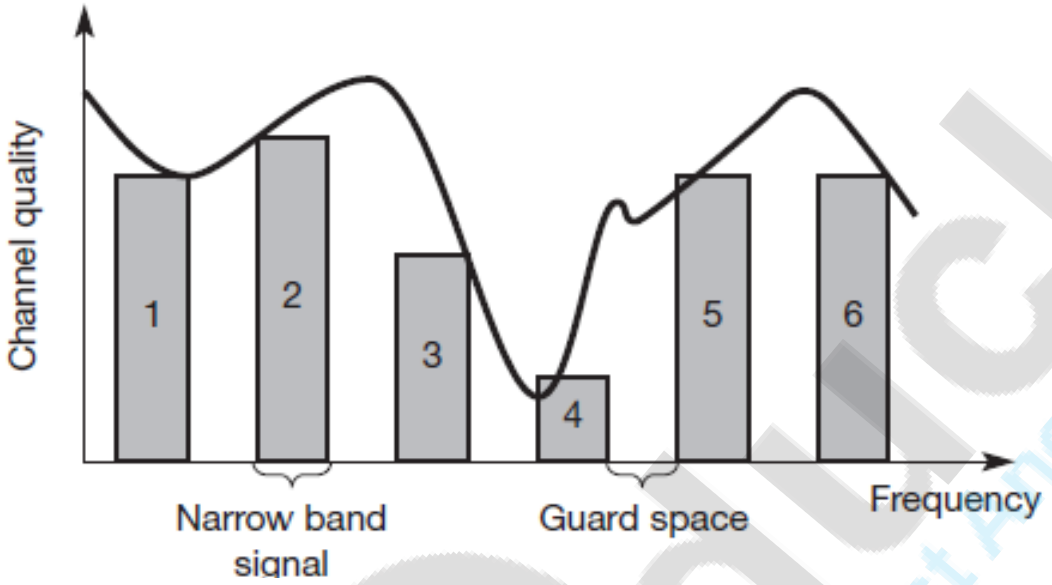


Figure 2.33
Narrowband interference without spread spectrum

- All narrowband signals are spread into broadband signals using the same frequency range.
- No more frequency planning is needed.
- all senders use the same frequency band.

Recovery of the signal:

- To separate different channels, CDM is used.
- Spreading of a narrowband signal is achieved using a special code.

Advantage:

- Without knowing the code, the signal cannot be recovered and behaves like background noise - security effect of spread spectrum.
- coexistence of several signals without coordination.
- Robustness against narrowband interference.
- relative high security.

Drawbacks:

- **increased complexity of receivers** that have to despread a signal.
- **large frequency band** that is needed due to the spreading of the signal.

Techniques:

- Direct Sequence Spread Spectrum.
- Frequency Hopping Spread Spectrum.

Direct Sequence Spread Spectrum (DSSS)

- User bit stream and perform an (XOR) with a chipping sequence.
- **Chipping sequence**- pseudo-noise Sequence.
- The **spreading factor** s = tb/tc determines the bandwidth of the resulting signal.
- If the original signal needs a bandwidth w, the resulting signal needs s·w after spreading.
- Normal spreading factor= 7

civil applications = between 10 and 100

military applications= upto 10,000.

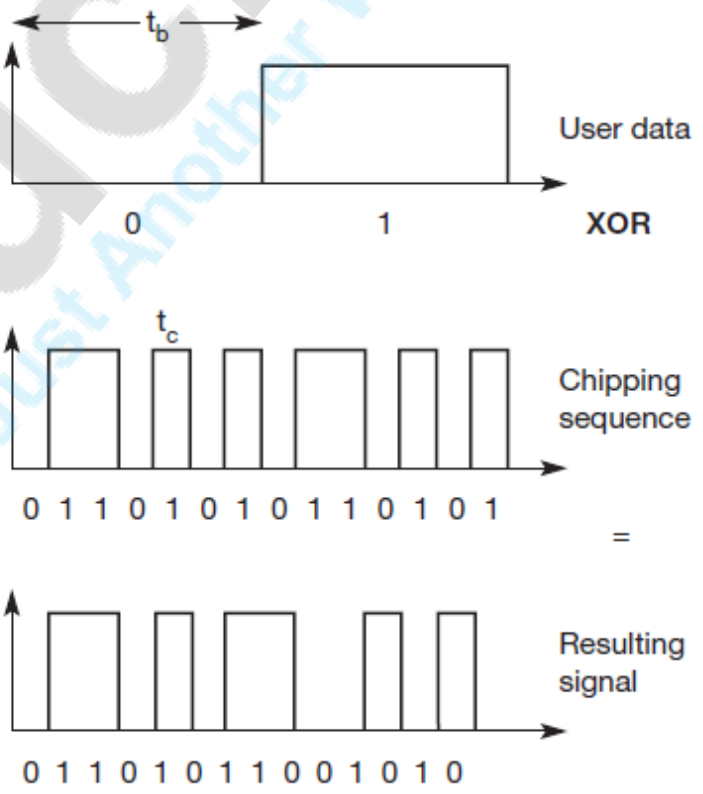


Figure 2.35
Spreading with DSSS

DSSS Transmitter and Receiver

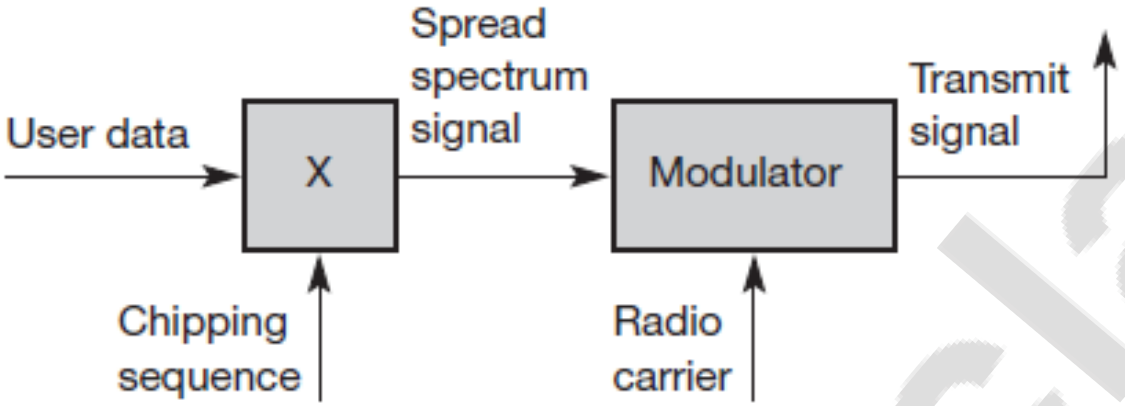
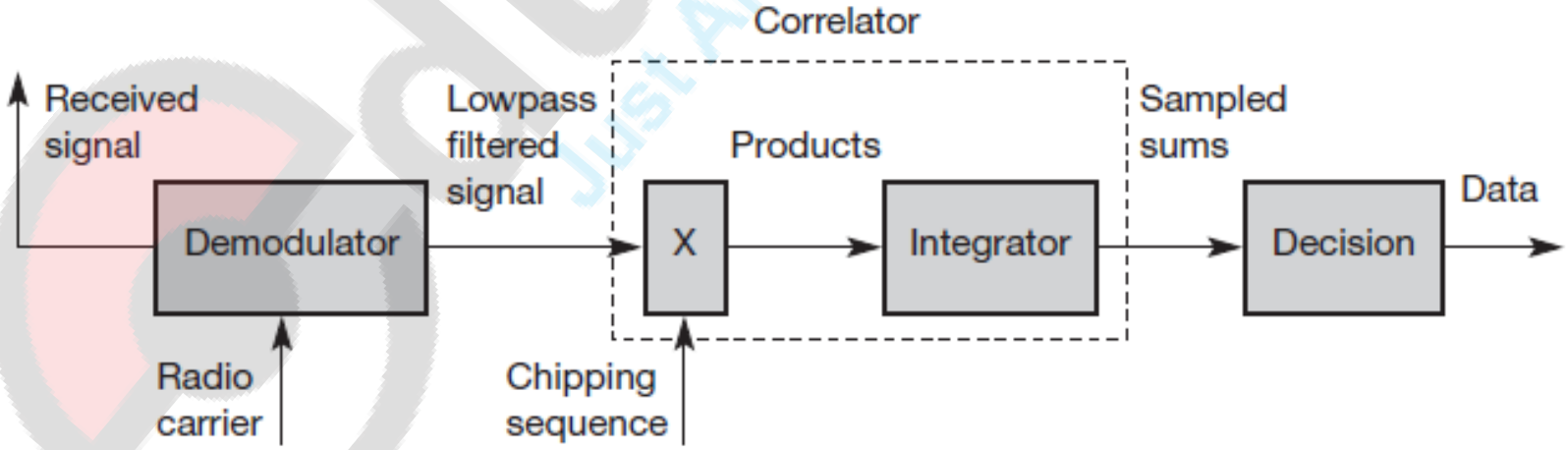


Figure 2.36
DSSS transmitter

Figure 2.37
DSSS receiver



Rake Receivers for DSSS

- Useful in case of Multi-path propagation.
- Uses n correlators for the n strongest paths.
- Each correlator is synchronized to the transmitter plus the delay on that specific path.
- As soon as the receiver detects a new path which is stronger than the currently weakest path, it assigns this new path to the correlator with the weakest path.
- Takes advantage of the multi-path propagation by combining the different paths in a constructive way.

Frequency hopping spread spectrum (FHSS)

- Total available bandwidth is split into many channels of **smaller bandwidth** plus **guard spaces** between the channels.
- Transmitter and receiver stay on one of these channels for a certain time and then hop to another channel.
- FDM+TDM.
- The pattern of channel usage- **hopping sequence.**
- The time spend on a channel with a certain frequency- **dwell time.**
- **two variants- slow and fast hopping.**
- **Fast hopping-** overcoming the effects of narrowband interference and frequency selective fading.

Slow and fast frequency hopping

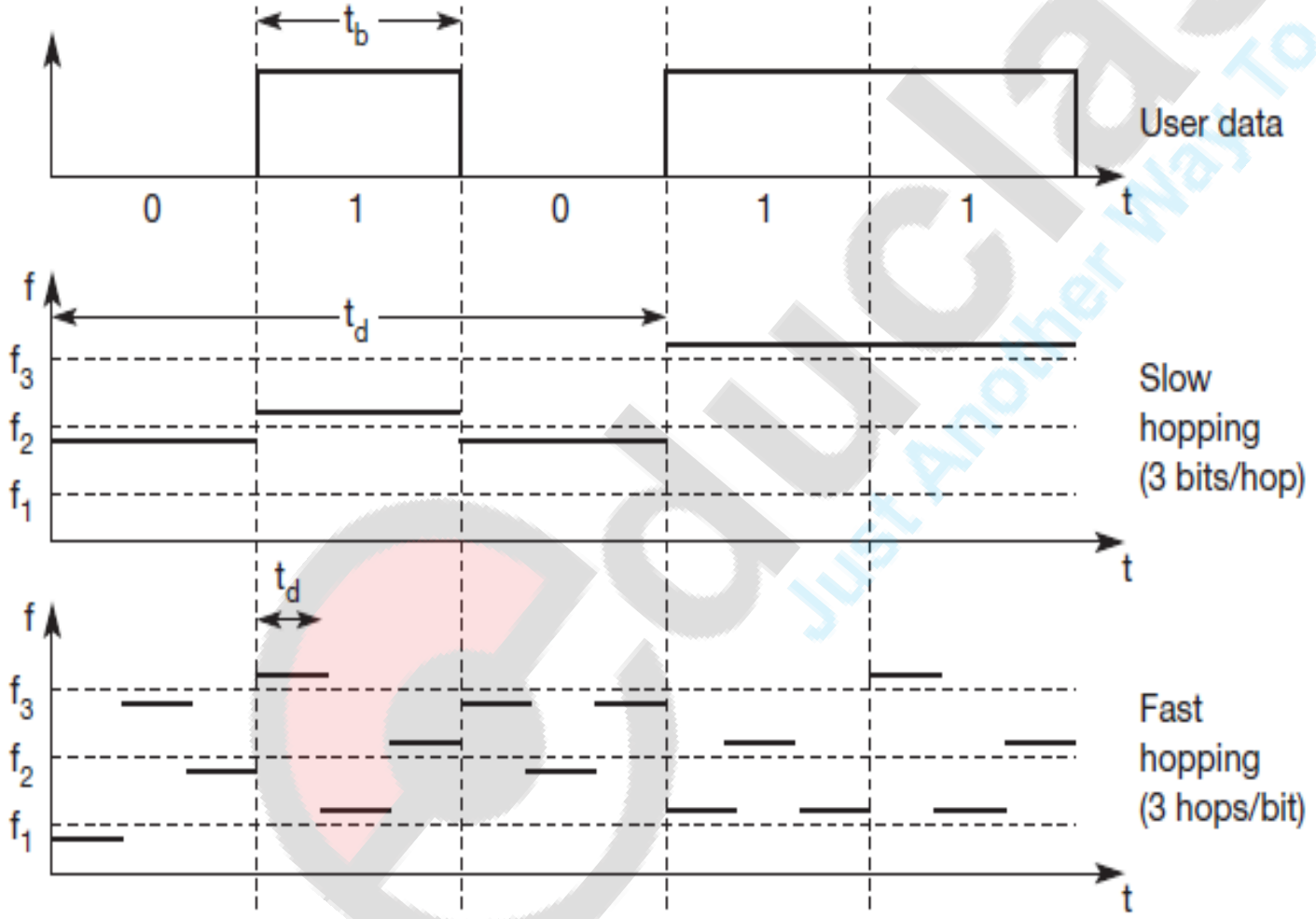


Figure 2.38
Slow and fast frequency hopping

FHSS Transmitter and Receiver

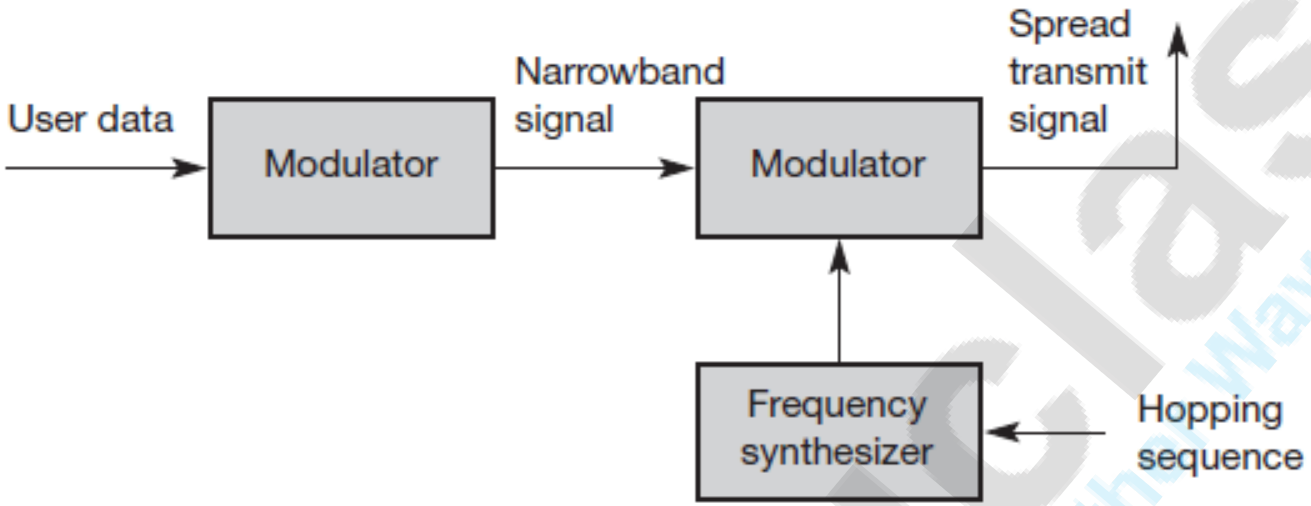


Figure 2.39
FHSS transmitter

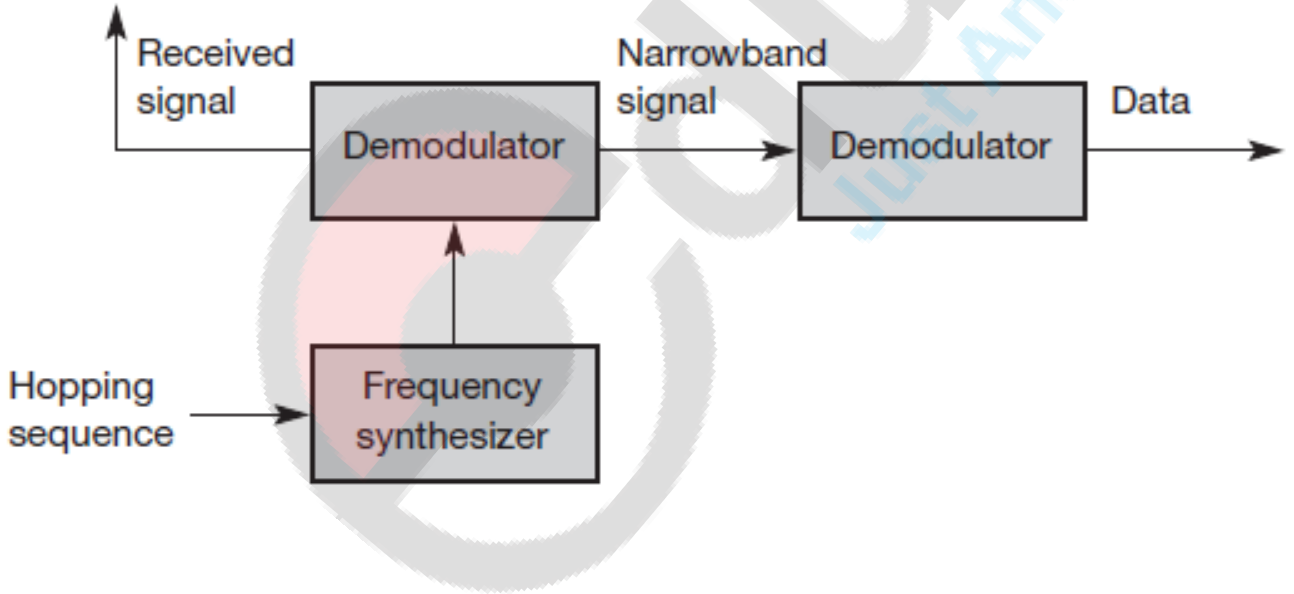


Figure 2.40
FHSS receiver

CDMA

- codes with certain characteristics can be applied to the transmission.
- use exactly these codes to separate different users in code space and to enable access to a shared medium without interference.
- The main problem is how to find “good” codes and how to separate the signal from noise generated by other signals and the environment.
- Orthogonality and Auto-correlation.

Orthogonality and Auto-correlation

Orthogonality:

- Two vectors are called orthogonal if their inner product is 0.
  - e. g.
    - vectors (2, 5, 0) and (0, 0, 17): (2, 5, 0)*(0, 0, 17) = 0 + 0 + 0 = 0.
    - (3, –2, 4) and (–2, 3, 3) are orthogonal: (3, –2, 4)*(–2, 3, 3) = –6 – 6 + 12 = 0.

good auto-correlation:

- The code (+1, –1, +1, +1, –1, +1, +1, +1, –1, –1, –1)
- has a good auto-correlation, i. e., the inner product with itself is large, the result is 11.

Coding and Spreading using CDMA

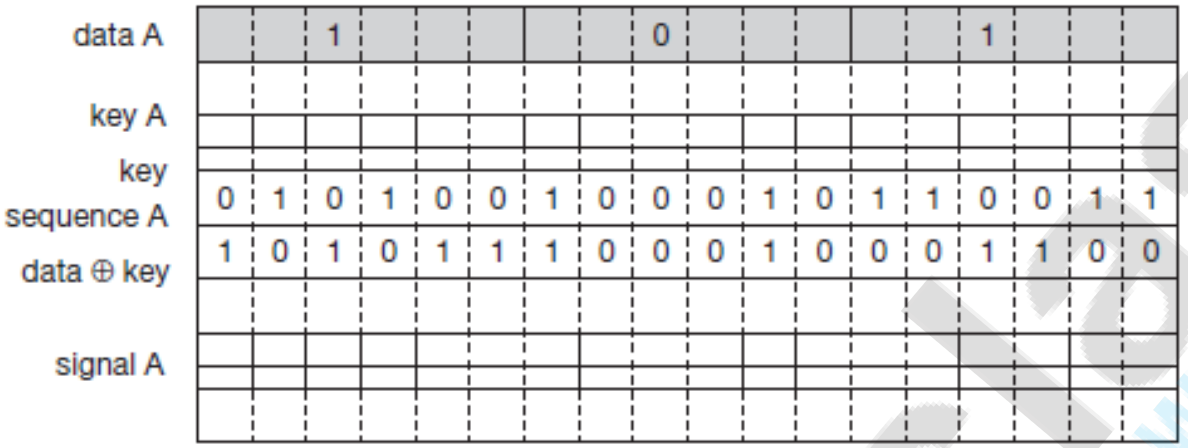


Figure 3.14
Coding and spreading of data from sender A

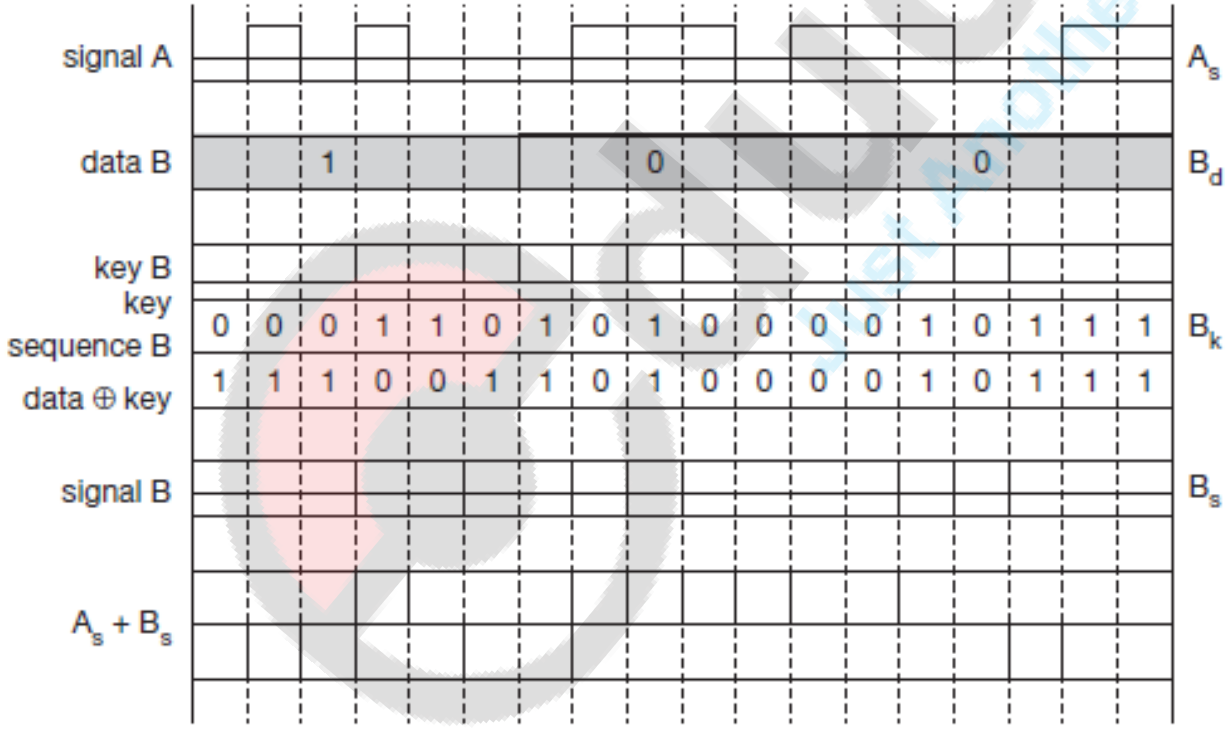


Figure 3.15
Coding and spreading of data from sender B

Reconstruction of Data using CDMA

Figure 3.16
Reconstruction of A's data

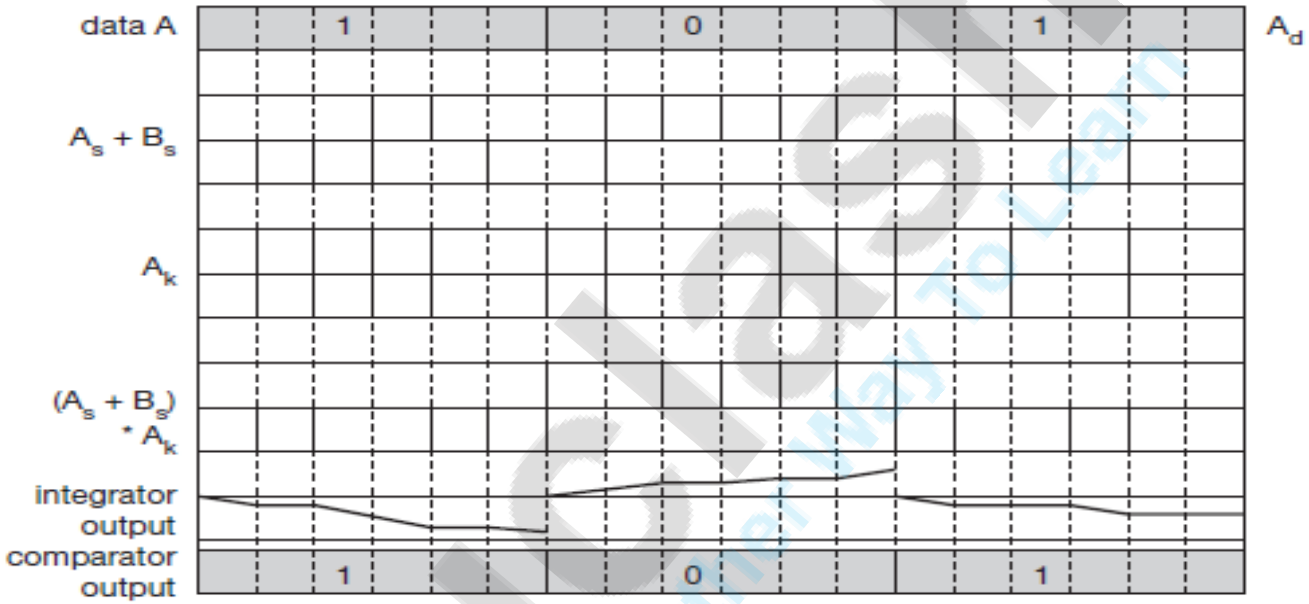
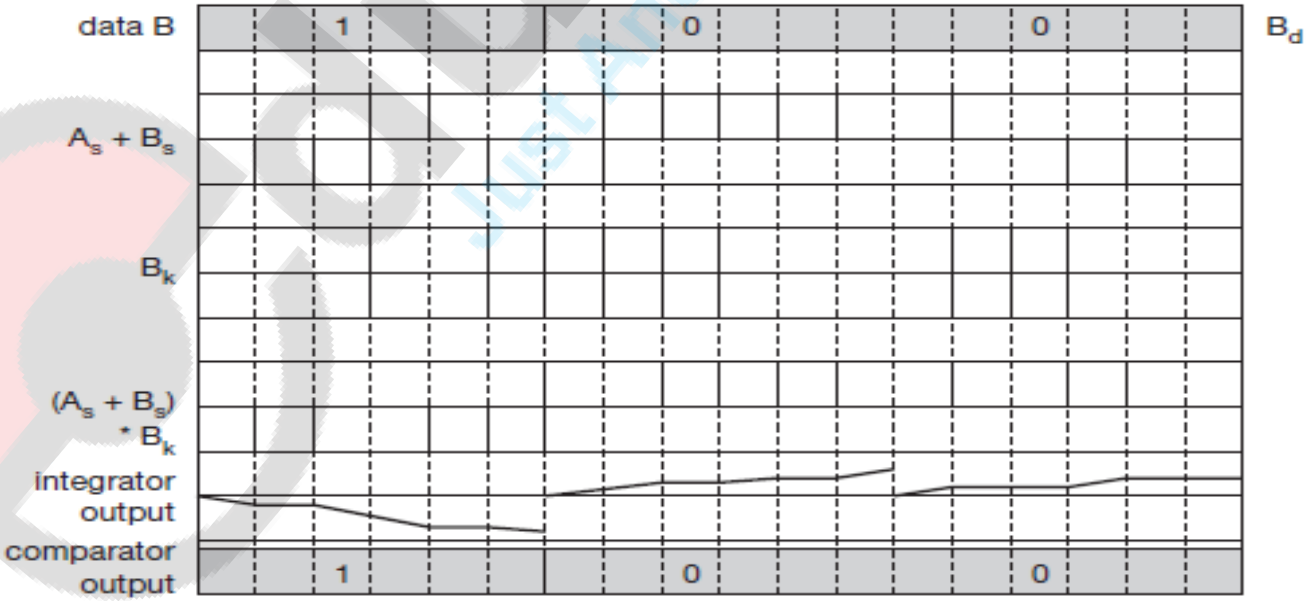


Figure 3.17
Reconstruction of B's data



References

Mobile Communications, Second Edition, Jochen Schiller, Pearson Education- Chapter 2.

University Questions

1. What is FHSS? List the benefits of using it.- May 16- 10M
2. What is spread spectrum? Explain DSSS.- Nov 16- 8M