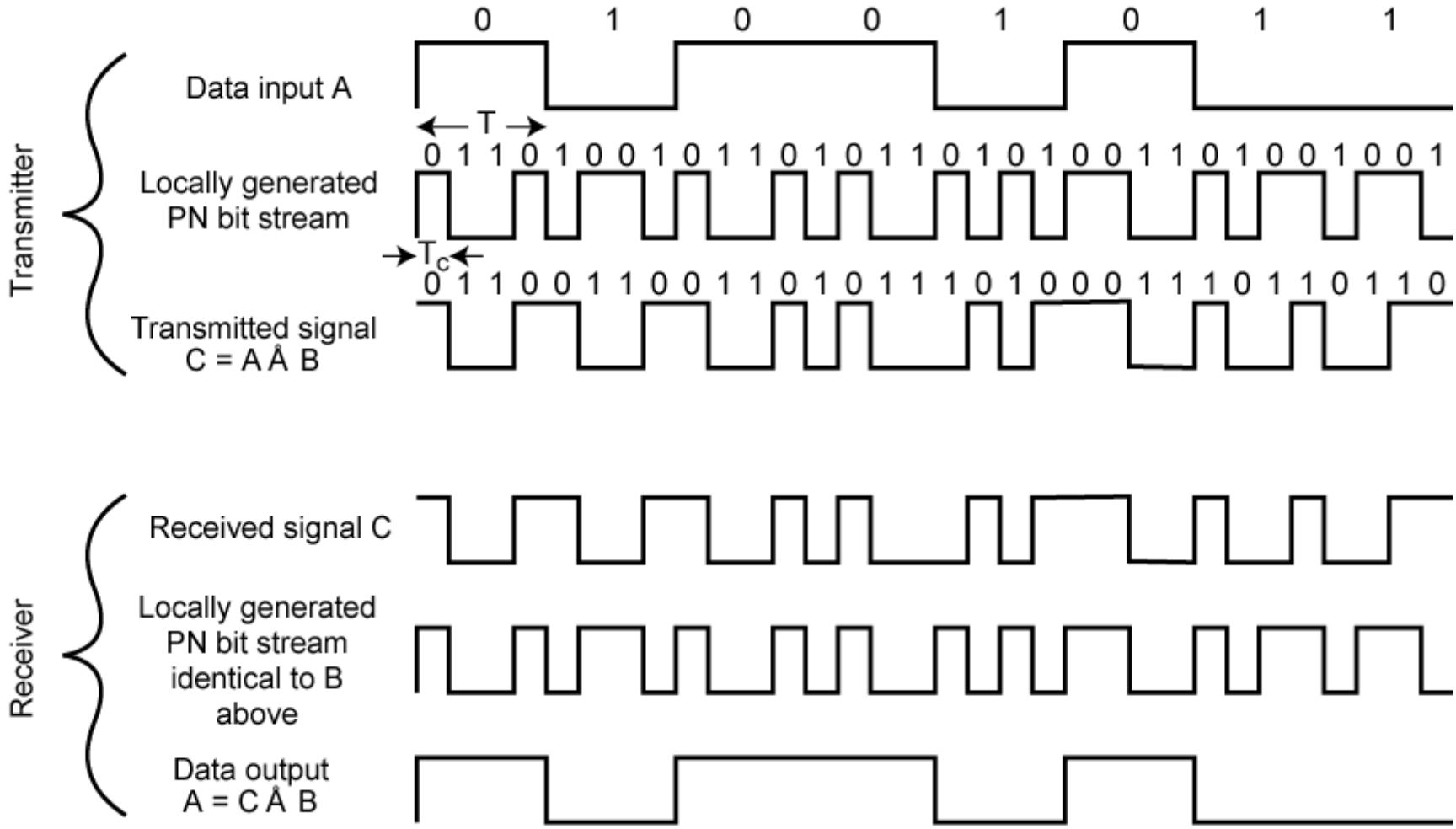
FHSS Performance Considerations

- Typically large number of frequencies used
  - —Improved resistance to jamming

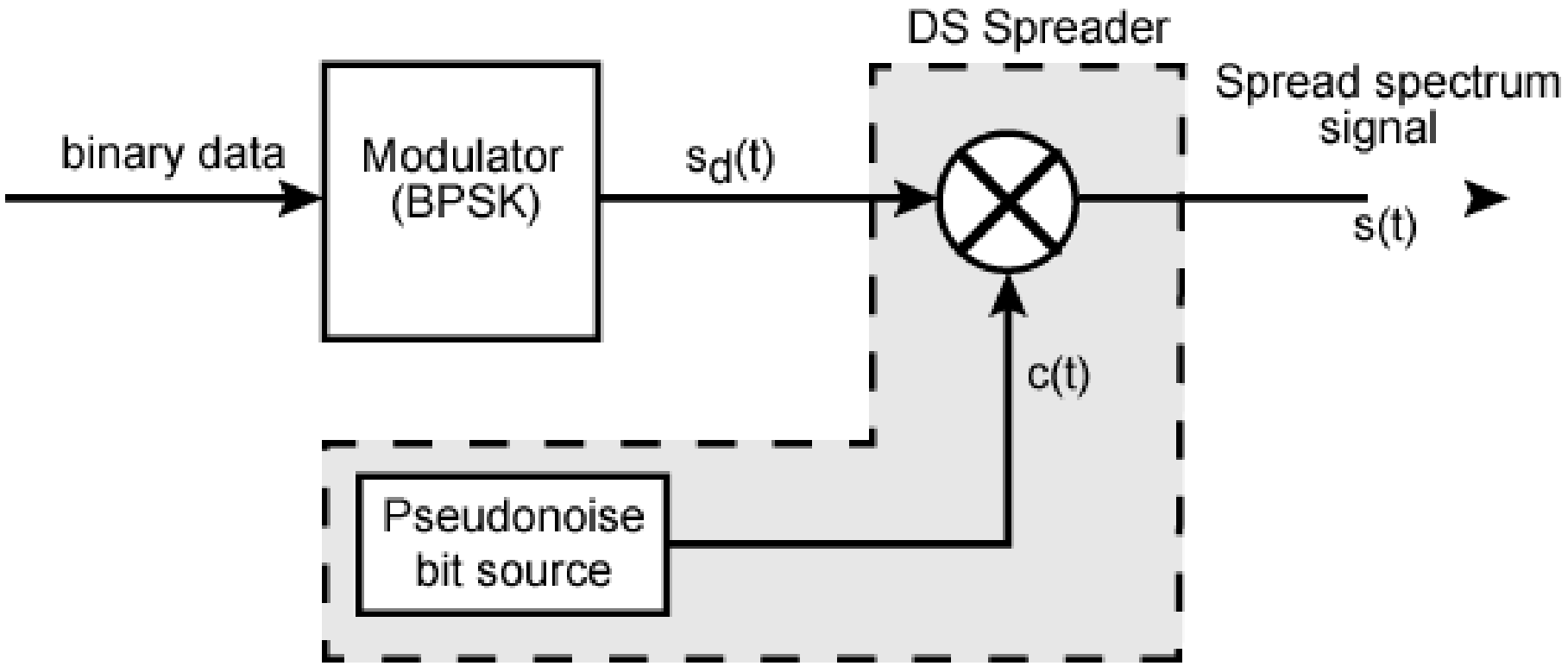
Direct Sequence Spread Spectrum (DSSS)

- Each bit represented by multiple bits using spreading code
- Spreading code spreads signal across wider frequency band
  - In proportion to number of bits used
  - 10 bit spreading code spreads signal across 10 times bandwidth of 1 bit code
- One method:
  - Combine input with spreading code using XOR
  - Input bit 1 inverts spreading code bit
  - Input zero bit doesn't alter spreading code bit
  - Data rate equal to original spreading code
- Performance similar to FHSS

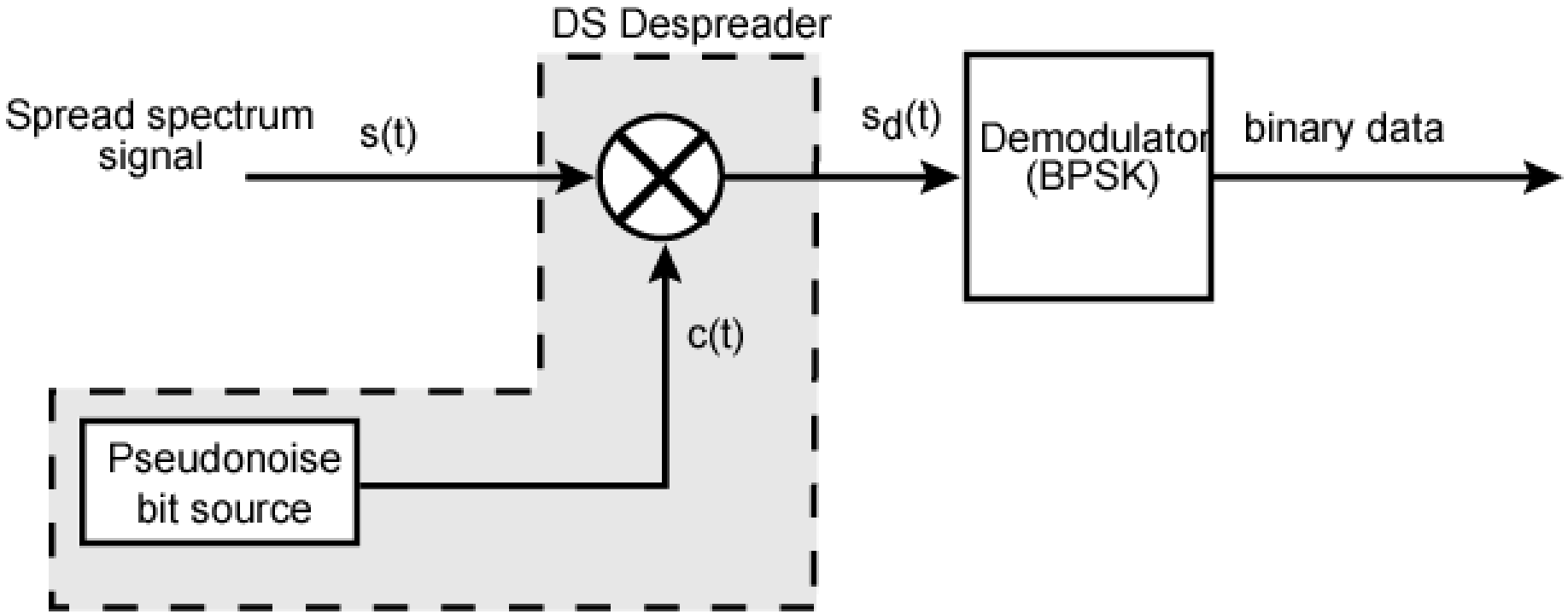
Direct Sequence Spread Spectrum Example



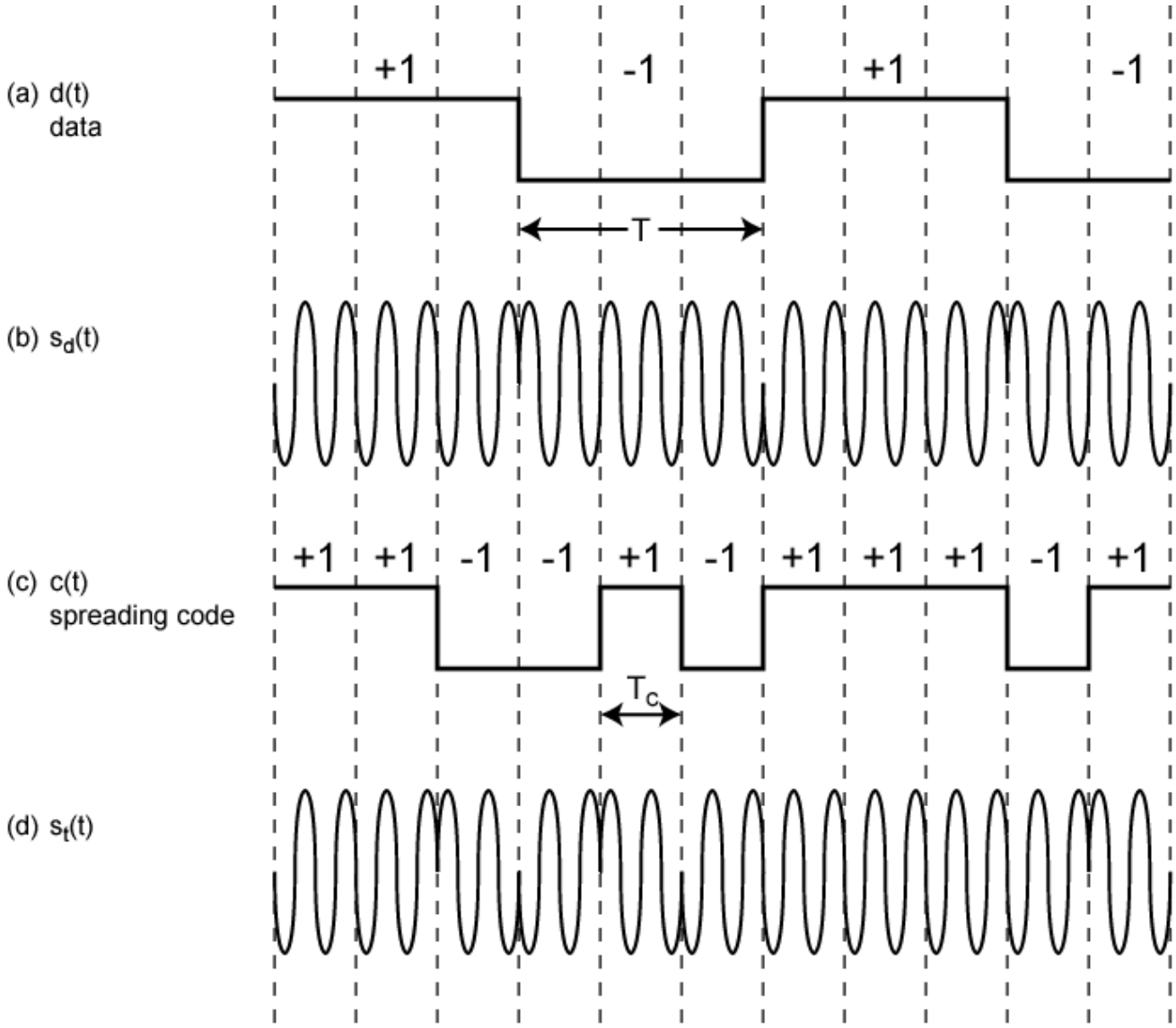
Direct Sequence Spread Spectrum Transmitter



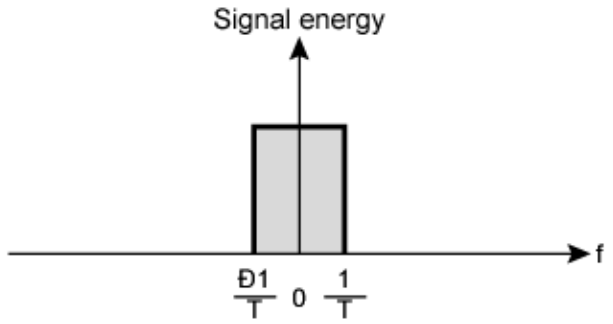
Direct Sequence Spread Spectrum Transmitter



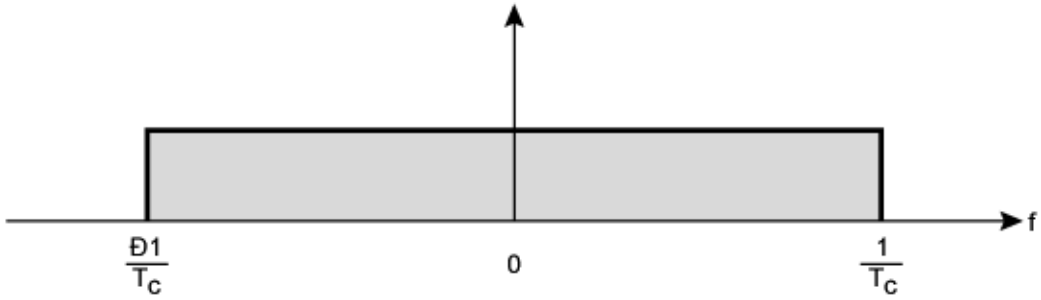
Direct Sequence Spread Spectrum Using BPSK Example



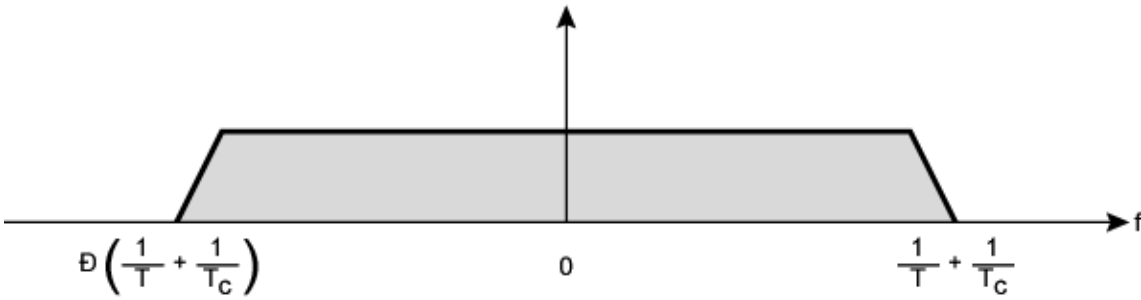
Approximate Spectrum of DSSS Signal



(a) Spectrum of data signal



(b) Spectrum of pseudonoise signal

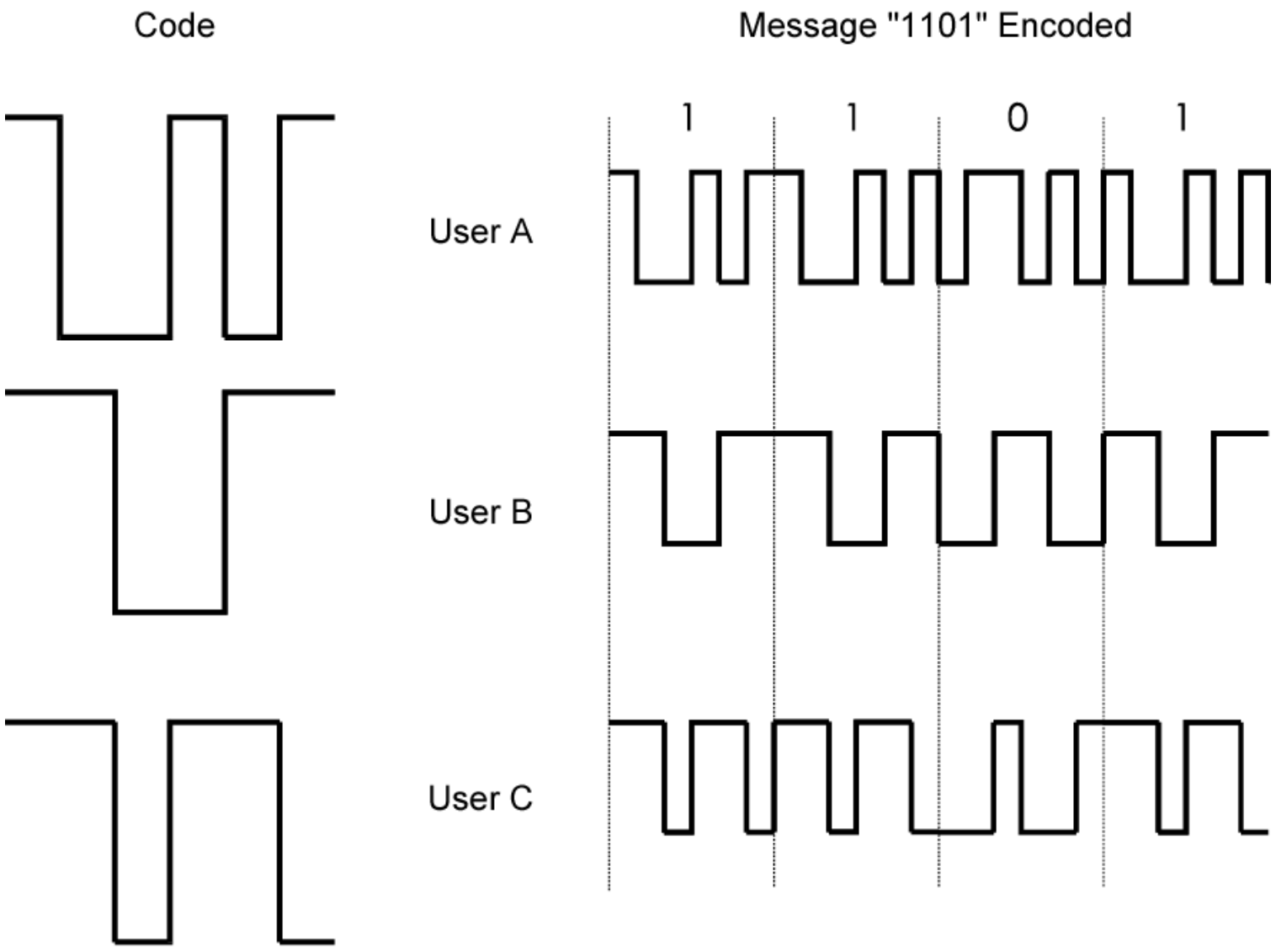


(c) Spectrum of combined signal

Code Division Multiple Access (CDMA)

- Multiplexing Technique used with spread spectrum
- Start with data signal rate *D*
  - Called bit data rate
- Break each bit into *k* chips according to fixed pattern specific to each user
  - User's code
- New channel has chip data rate *kD* chips per second
- E.g. *k*=6, three users (A,B,C) communicating with base receiver R
- Code for A = <1,-1,-1,1,-1,1>
- Code for B = <1,1,-1,-1,1,1>
- Code for C = <1,1,-1,1,1,-1>

CDMA Example



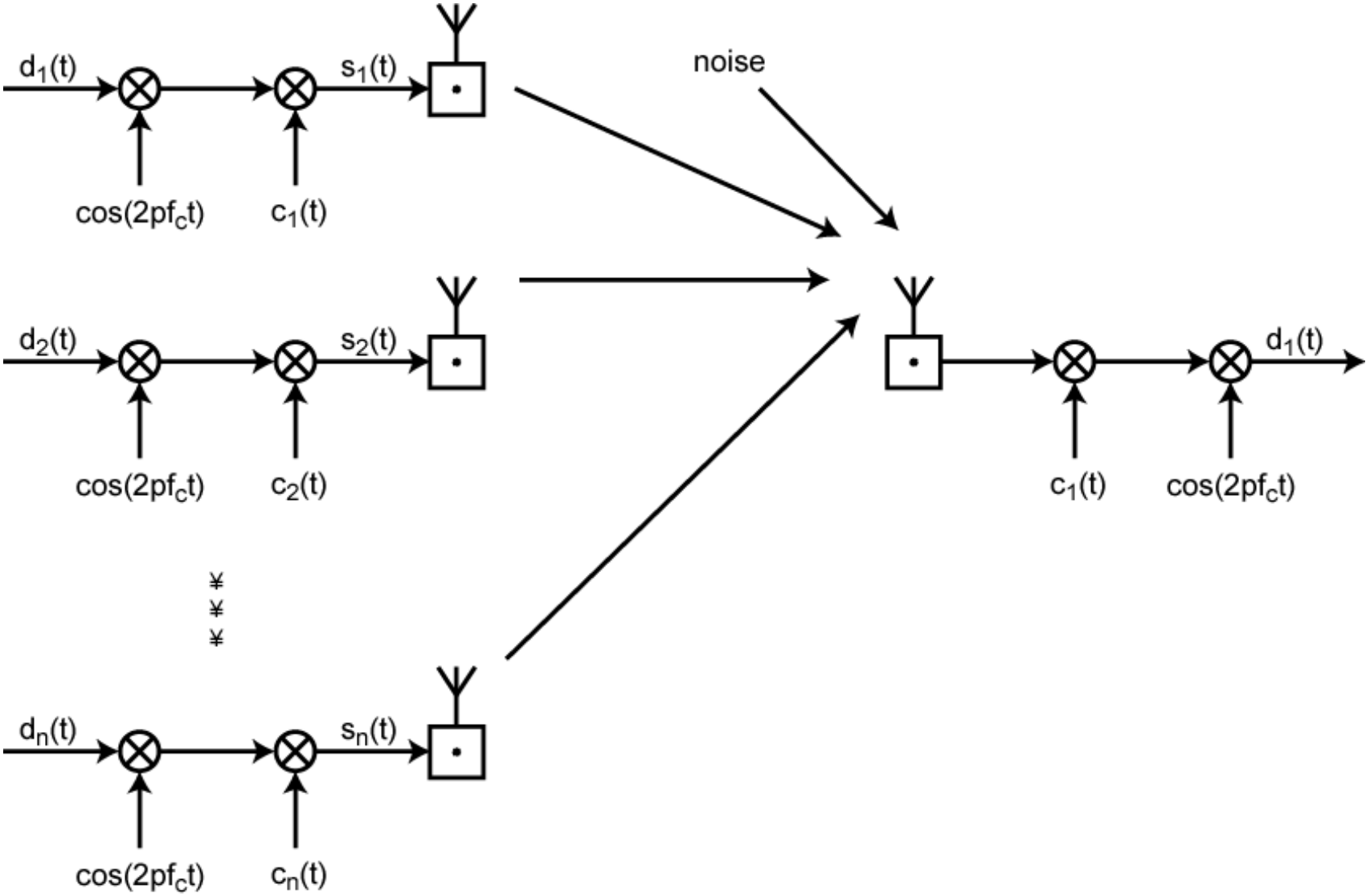
CDMA Explanation

- Consider A communicating with base
- Base knows A's code
- Assume communication already synchronized
- A wants to send a 1
  - Send chip pattern <1,-1,-1,1,-1,1>
    - A's code
- A wants to send 0
  - Send chip[pattern <-1,1,1,-1,1,-1>
    - Complement of A's code
- Decoder ignores other sources when using A's code to decode
  - Orthogonal codes

CDMA for DSSS

- n users each using different orthogonal PN sequence
- Modulate each users data stream
  - Using BPSK
- Multiply by spreading code of user

CDMA in a DSSS Environment



Seven Channel CDMA Encoding and Decoding