CS698T
Wireless Networks: Principles and Practice

Topic 06
Modulation

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http://www.cse.iitk.ac.in/users/braman/courses/wless-spring2007/

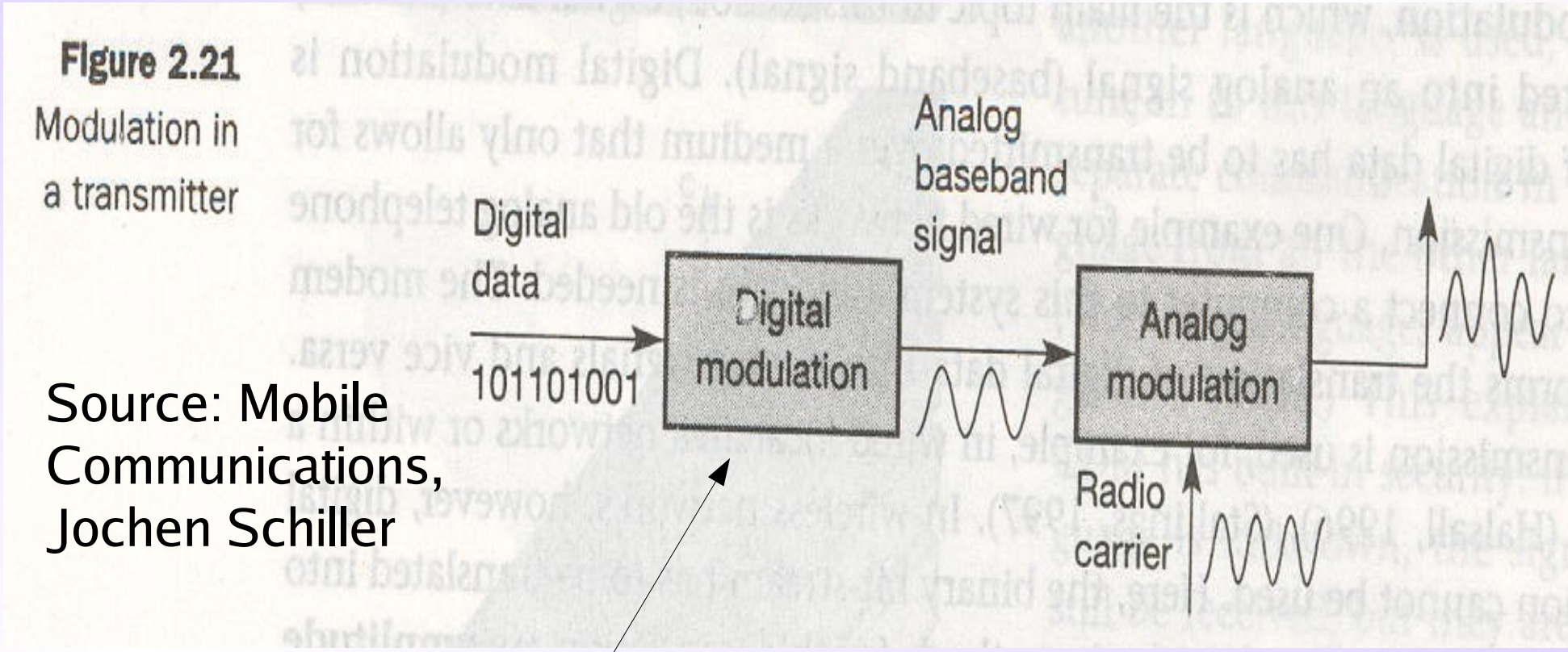
Modulation

- Modulation: the process of converting a digital signal to "ap propriate"s ignals on wire or on air (wireless)
- Wireless:
  - Digital modulation: converting the digital signal to an analog signal
  - This results in a signal with bandwidth proportional to B Hz, if the digital signal is B bits/sec

The Need for Analog Modulation

- Cannot send a signal of frequency B Hz directly:
  - Antenna size may be inappropriate
  - Propagation characteristics may not be desirable
  - Frequency Division Multiplexing (FDM) not possible
- Hence analog modulation:
  - Convert one frequency range to another
  - Using a carrier frequency

Modulation at the Transmitter



Source: Mobile Communications, Jochen Schiller

Also known as **keying**

Demodulation at the Receiver

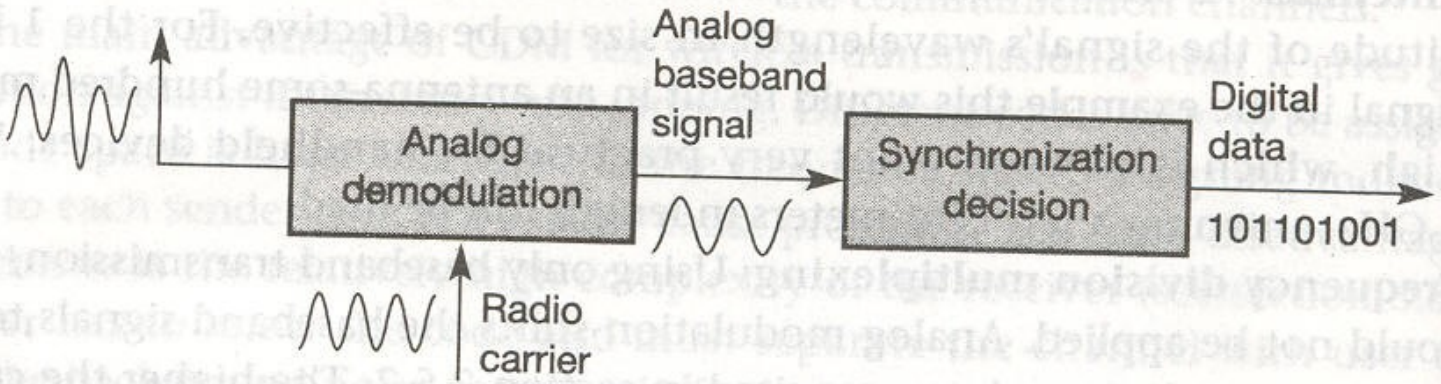


Figure 2.22 Demodulation and data reconstruction in a receiver

Source: Mobile Communications, Jochen Schiller

An RF Signal

$$g_t = A_t \sin(2 \times \pi \times f_t \times t + \phi_t)$$

- Has three components: amplitude, frequency, and phase
- Modulation/keying can be based on any of these three (or a combination)

Amplitude Shift Keying

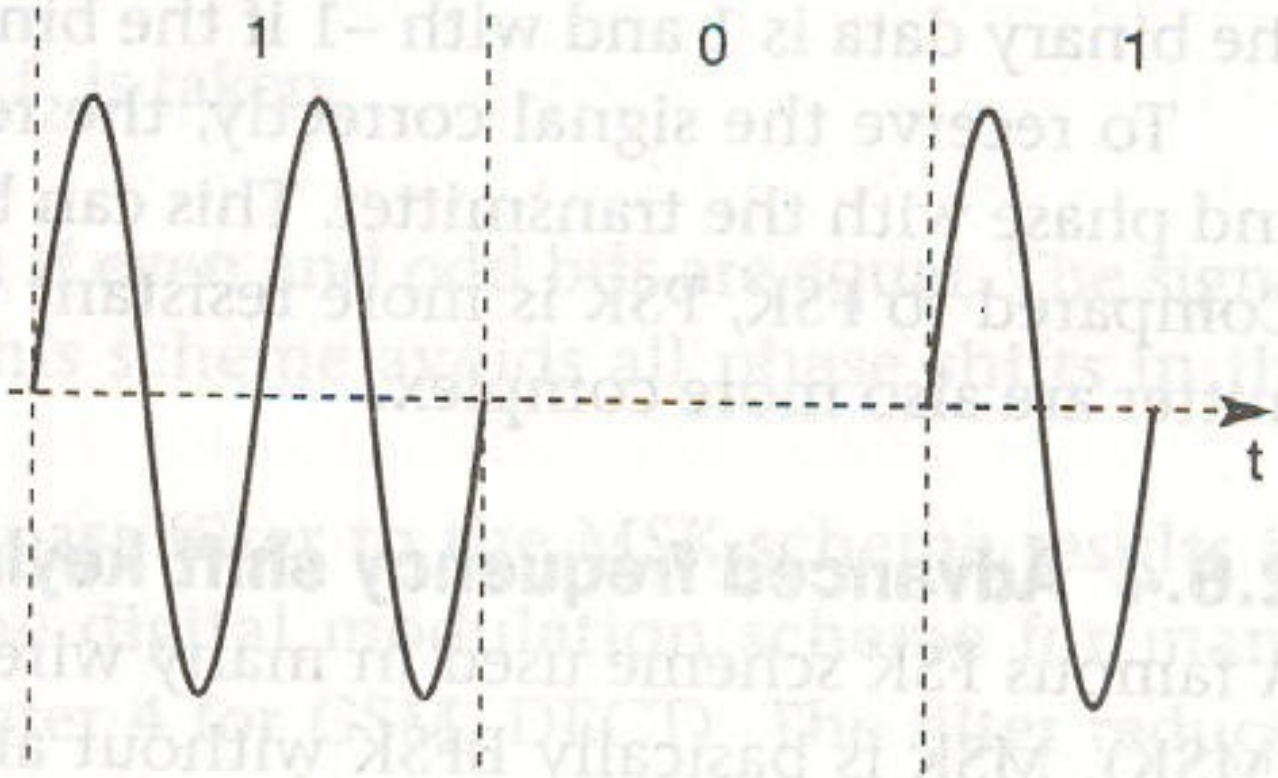


Figure 2.23
Amplitude shift keying (ASK)

Source: Mobile Communications, Jochen Schiller

Frequency Shift Keying

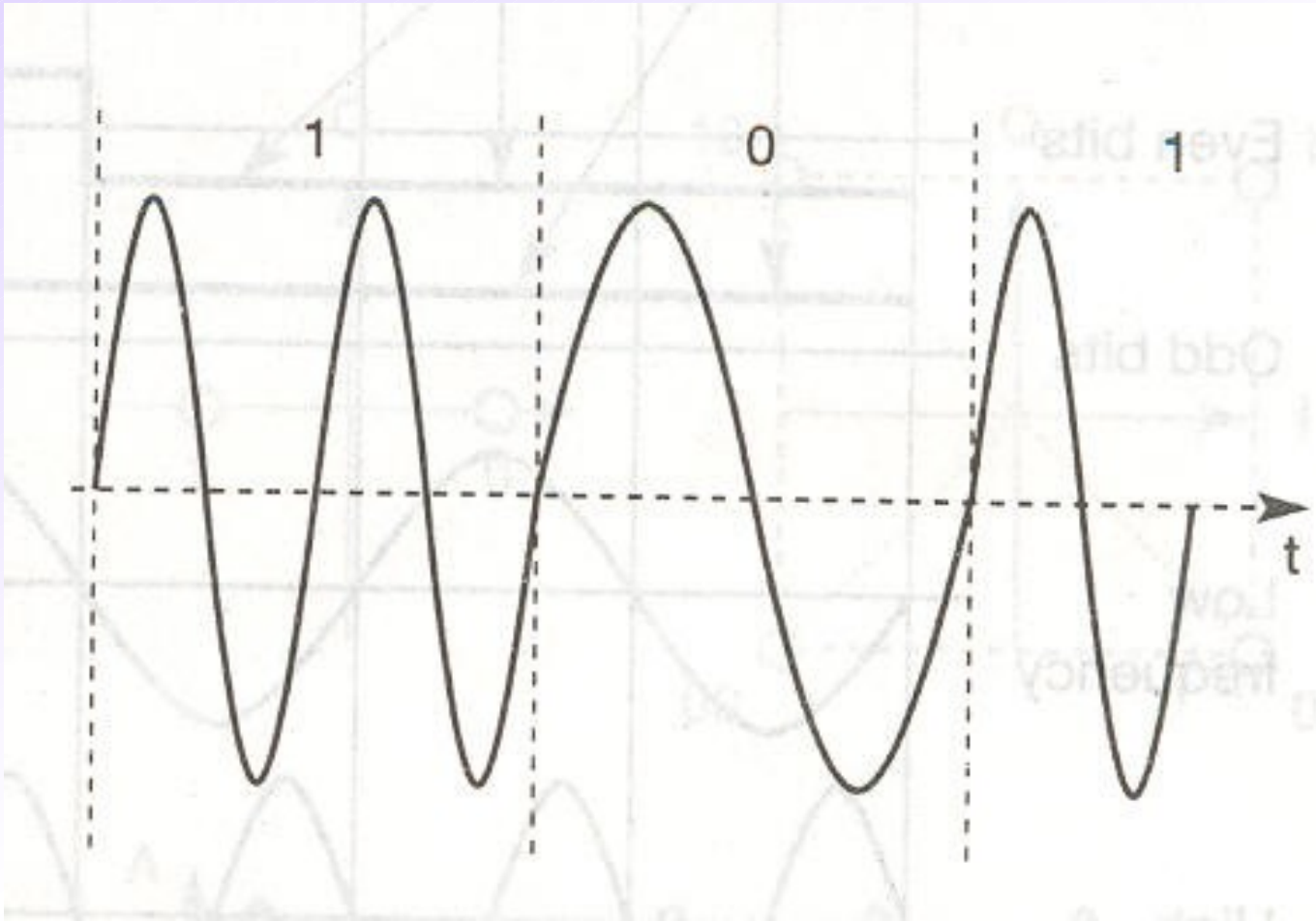


Figure 2.24
Frequency shift keying (FSK)

Source: Mobile Communications, Jochen Schiller

Phase Shift Keying

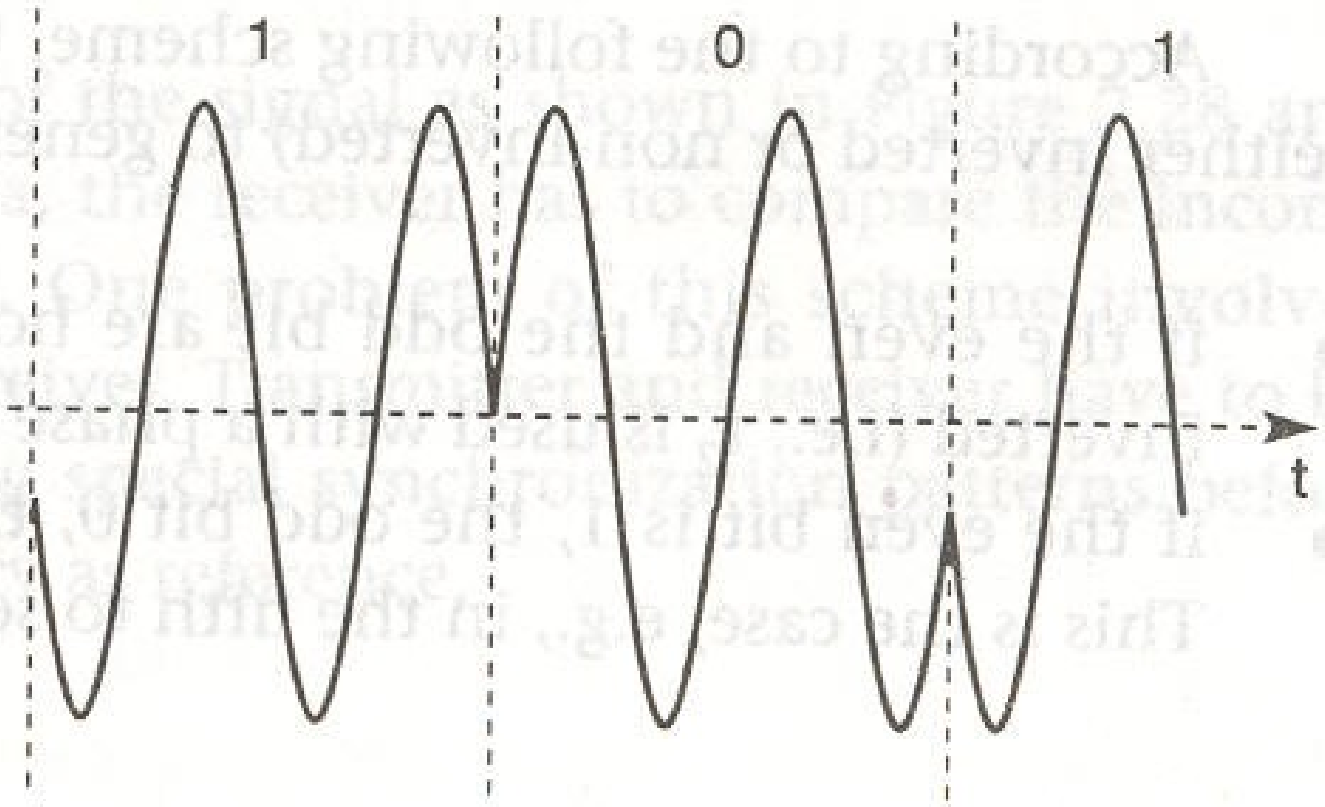


Figure 2.25 Phase shift keying (PSK)

Source: Mobile Communications, Jochen Schiller

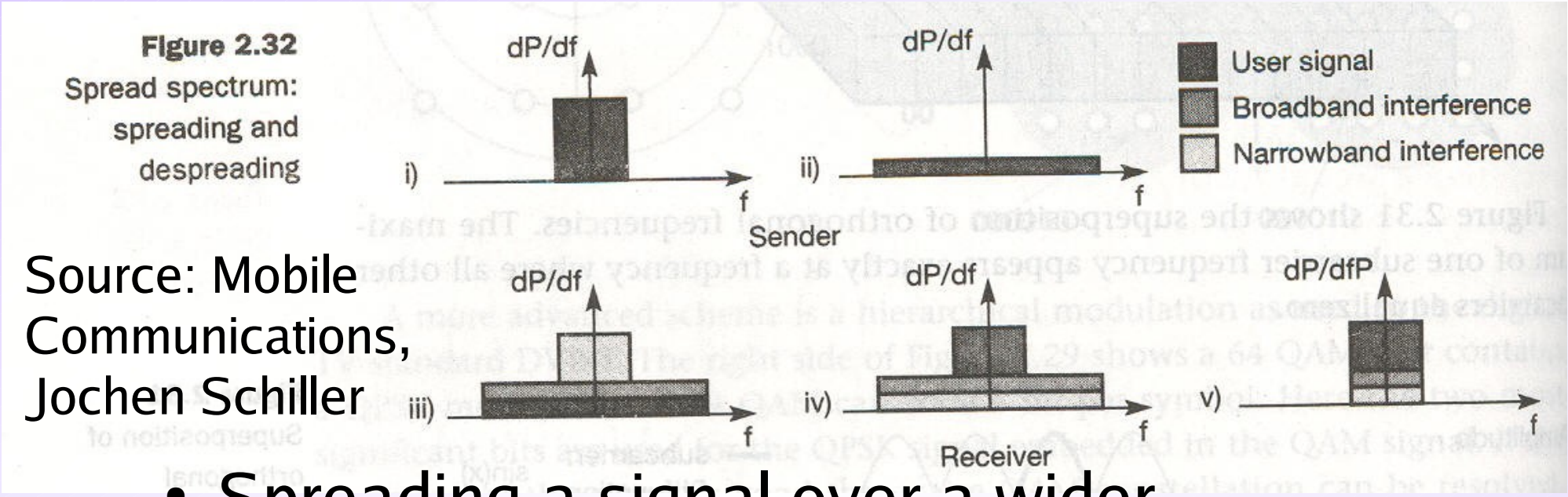
Some Remarks

- Phase Shift Keying: binary, quadrature, etc.
  - 802.11b uses BPSK, QPSK, CCK
- Metrics in modulation:
  - Spectral efficiency: bits/sec/hz
  - Power efficiency
  - Robustness to noise

BER vs. SNR

- For a given modulation:
  - Bit-Error-Rate (BER) is a function of the Signal-to-Noise-Ratio (SNR)
- Thermal noise: k x T x B
  - k: Boltzmann's constant = 1.38 x 10^-23
  - T: temperature in Kelvin
  - B: bandwidth in Hz
- Strictly, Signal-to-Interference-and-Noise-Ratio (SINR) must be used

Spread Spectrum



Source: Mobile Communications, Jochen Schiller

- Spreading a signal over a wider frequency range
  - Avoids narrow-band interference
  - E.g. 802.11b Barker code: 10110111000
- Two techniques for spread-spectrum
  - Direct Sequence, Frequency Hopping