Error-Control Coding

The Shannon-Nyquist Sampling Theorem

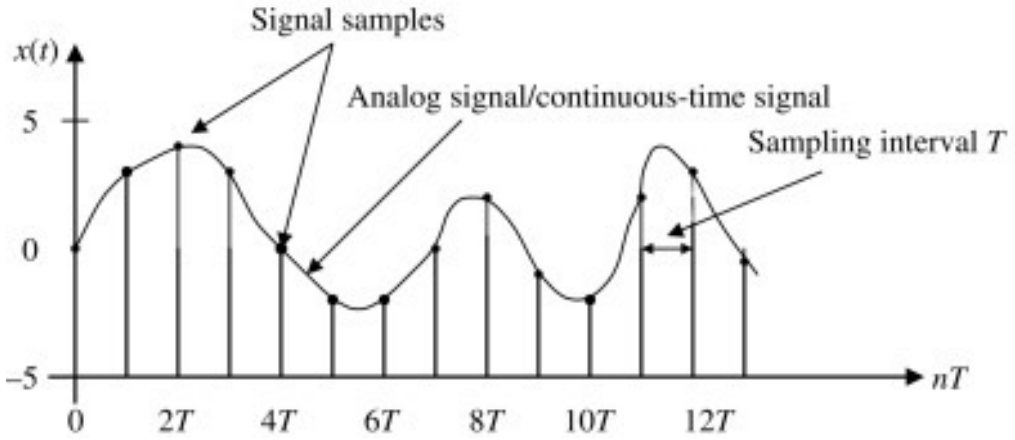
- The sampling theorem for strictly band-limited signals of finite energy can be rewritten in two equivalent parts:

1. A band-limited signal of finite energy that has no frequency components higher than B hertz is completely described by specifying the values of the signal instants of time separated by 1/2B seconds.

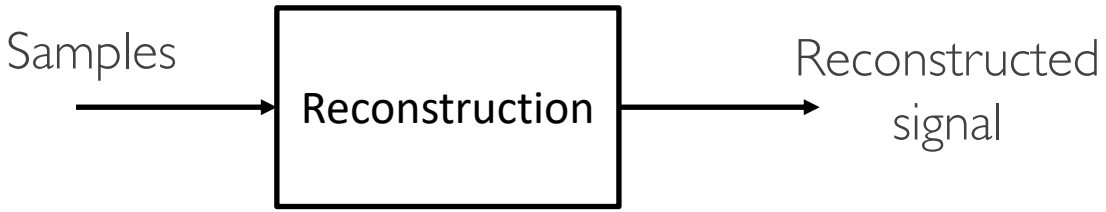
2. A band-limited signal of finite energy that has no frequency components higher than B hertz is completely recovered from a knowledge of its samples taken at the rate of 2B samples per second.

The Sampling Theorem in Communications

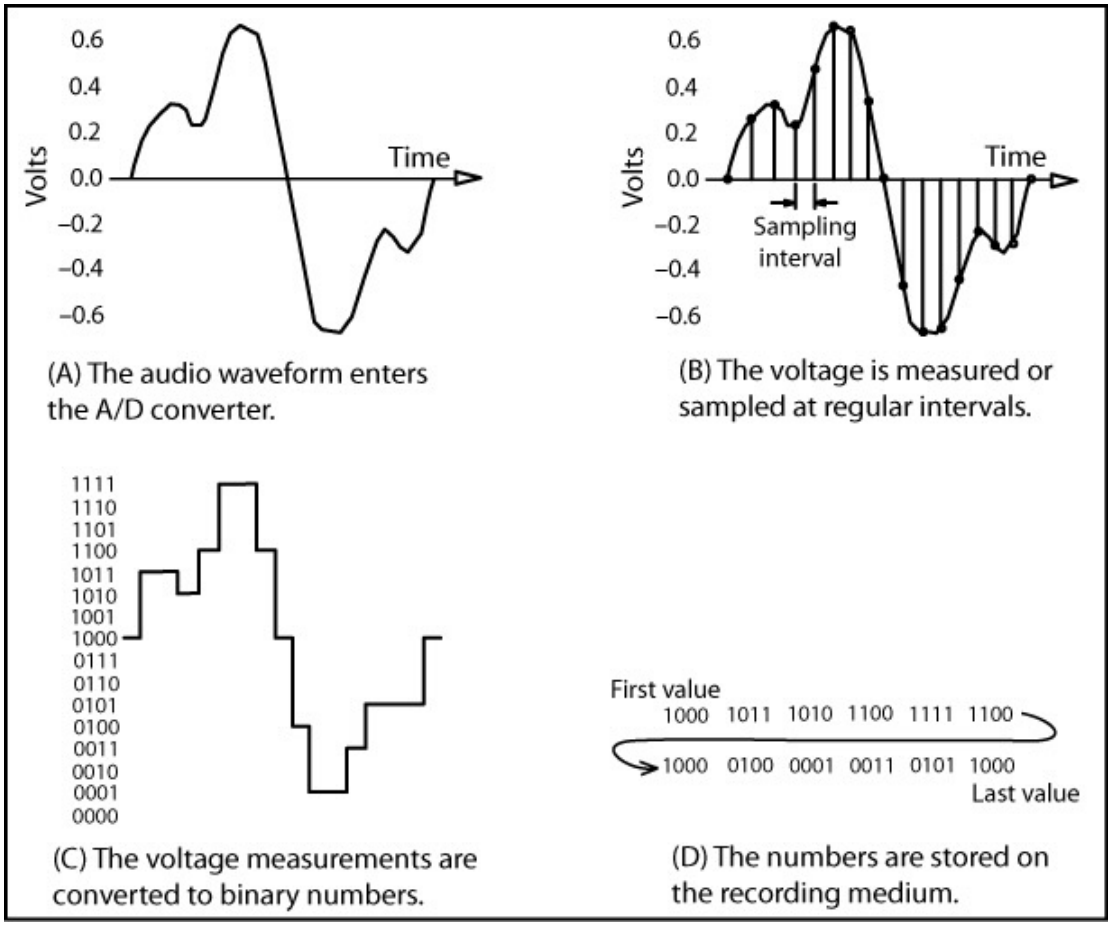
- Part 1 of the theorem is performed in the transmitter.



- Part 2 of the theorem, is performed in the receiver.



Analog-to-Digital Conversion



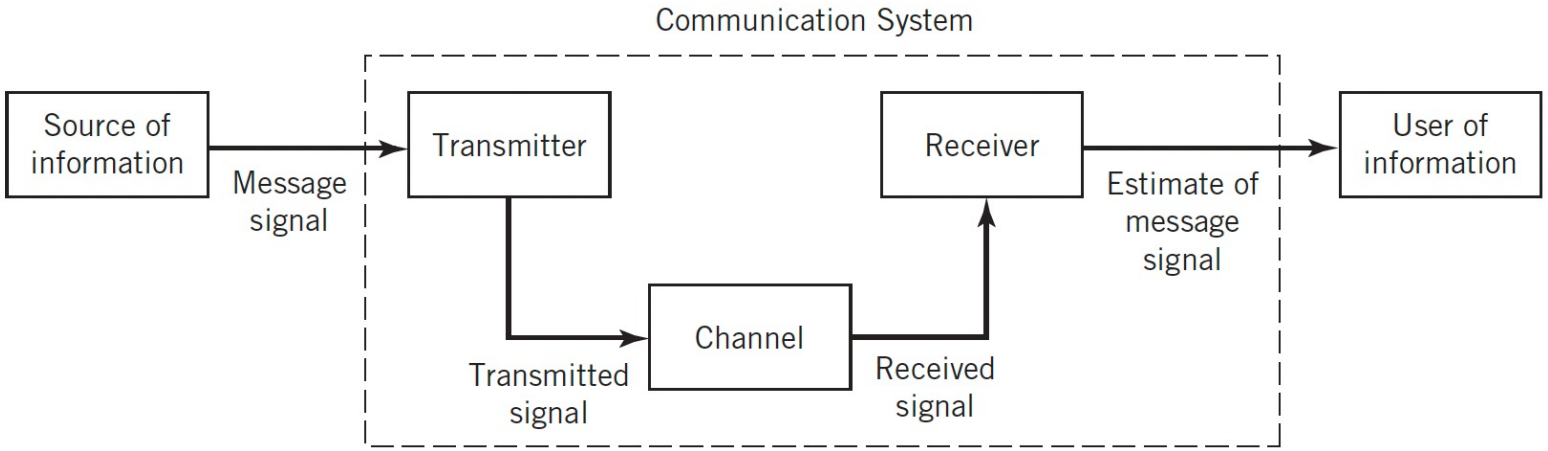
(A) The audio waveform enters the A/D converter.

(B) The voltage is measured or sampled at regular intervals.

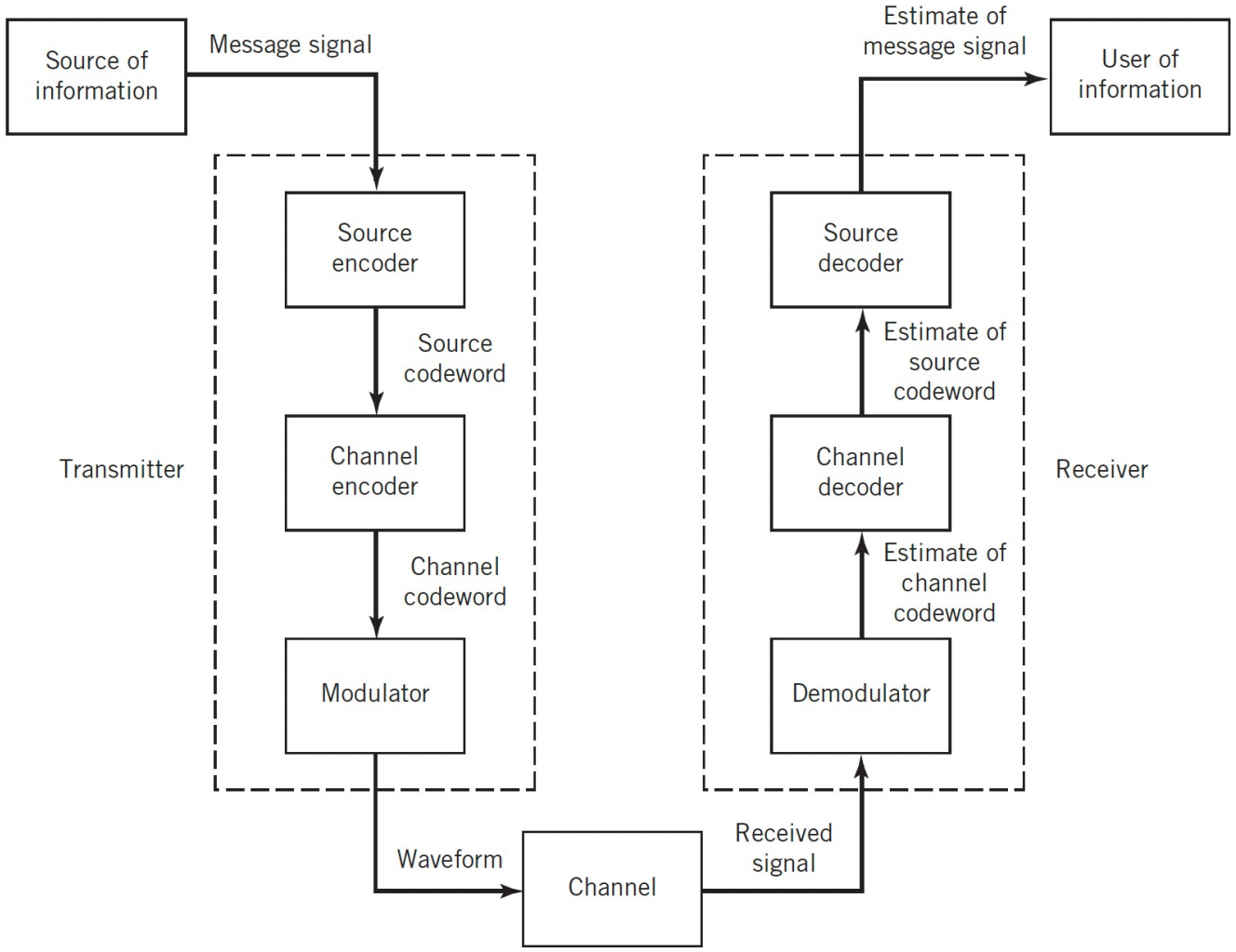
(C) The voltage measurements are converted to binary numbers.

(D) The numbers are stored on the recording medium.

Elements of a Communication System



Block Diagram of a Communication System



Error Control Using FEC

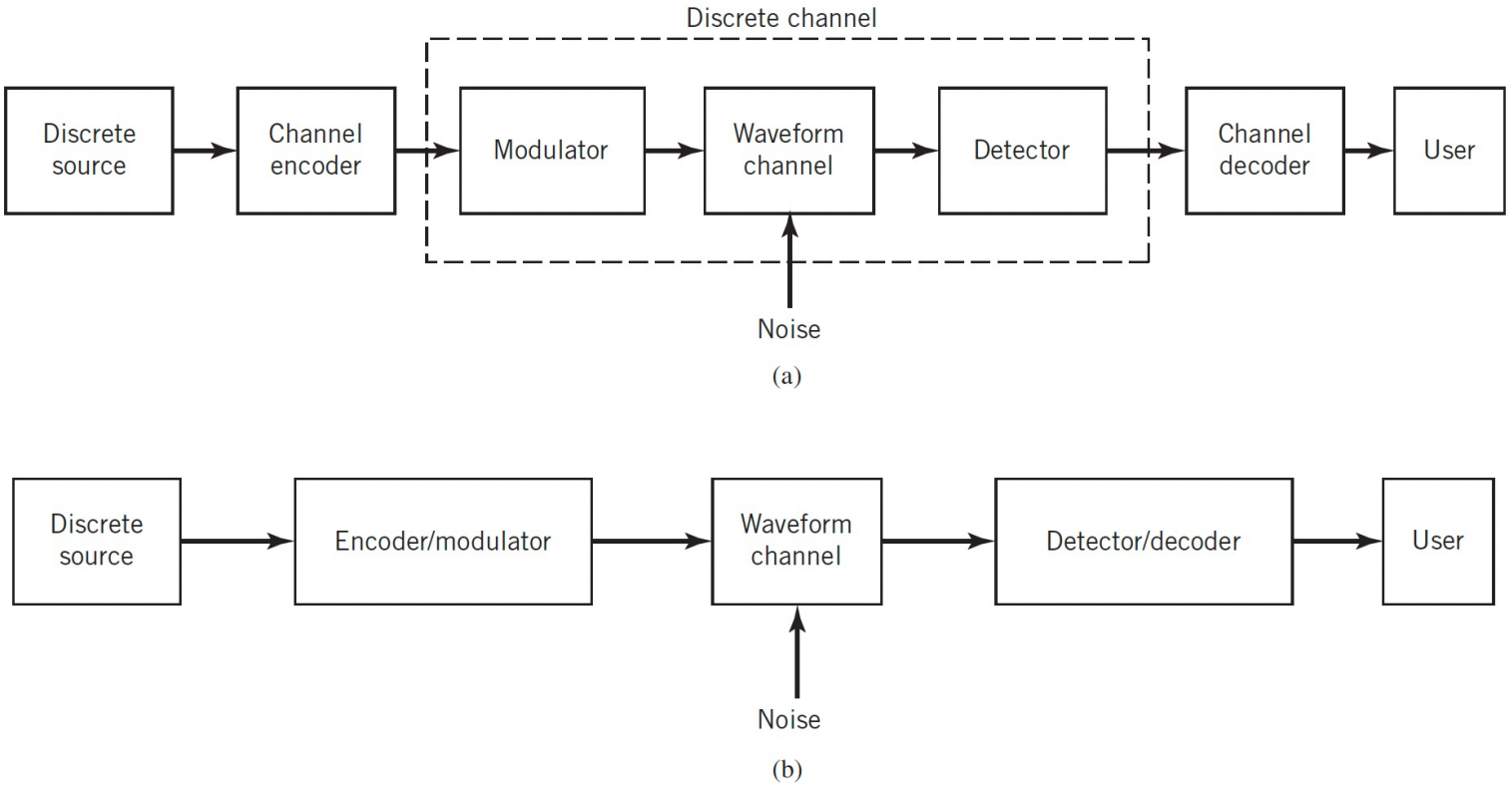


Figure 10.1 Simplified models of a digital communication system. (a) Coding and modulation performed separately. (b) Coding and modulation combined.

Discrete Memoryless Channels

- The discrete channel is memoryless if in each interval:
  - the detector output depends only on the encoder input in the interval
- The simplest discrete memoryless channel is the binary symmetric channel (BSC)

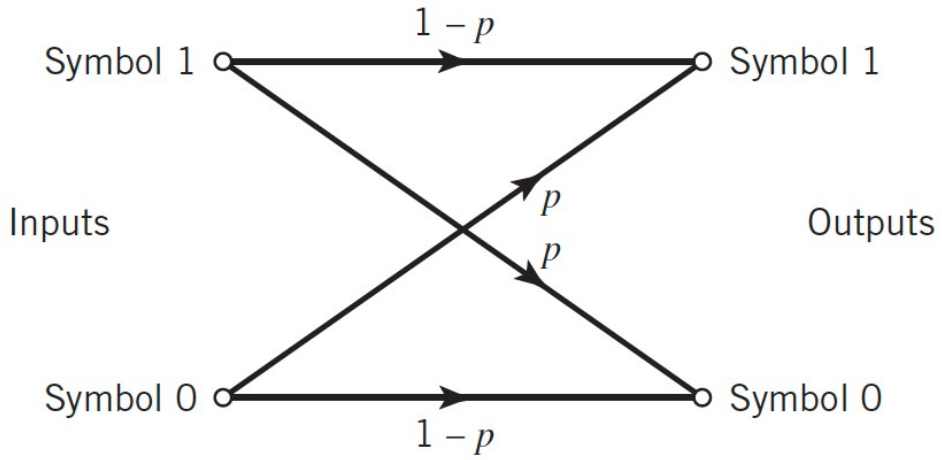


Figure 10.2 Transition probability diagram of binary symmetric channel.

Error-correcting codes

- 1948 Shannon Article '[The Mathematical Theory of Information]'
- 1950 Hamming codes
- 1960 Reed-Solomon codes
- 1960 Low-density Parity Check (LDPC) codes
- 1967 Convolutional codes (Viterbi algorithm)
- 1993 Turbo codes
- …
- 2009 Polar codes