Data Communication

#7 Analog Transmission

Digital to Analog Conversion

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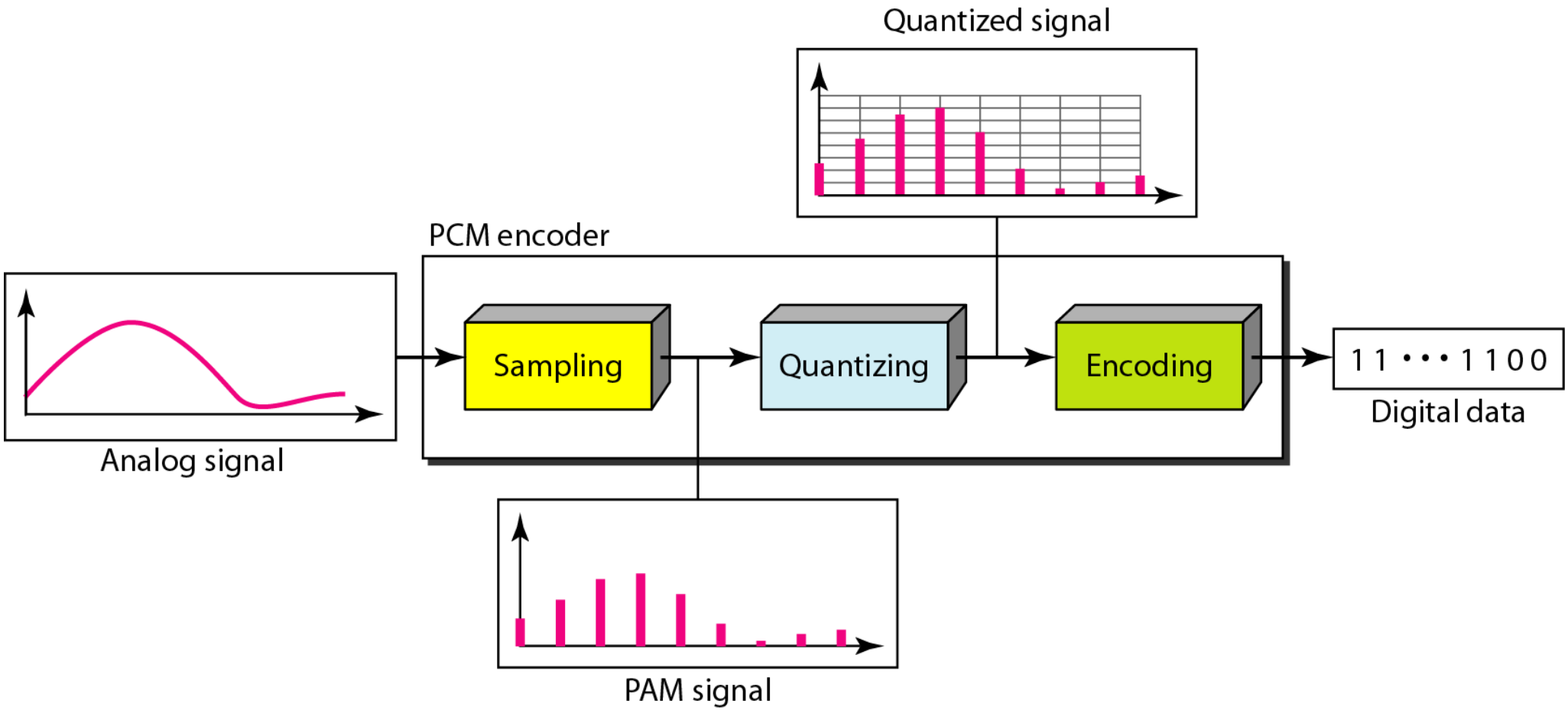
Digital Transmission

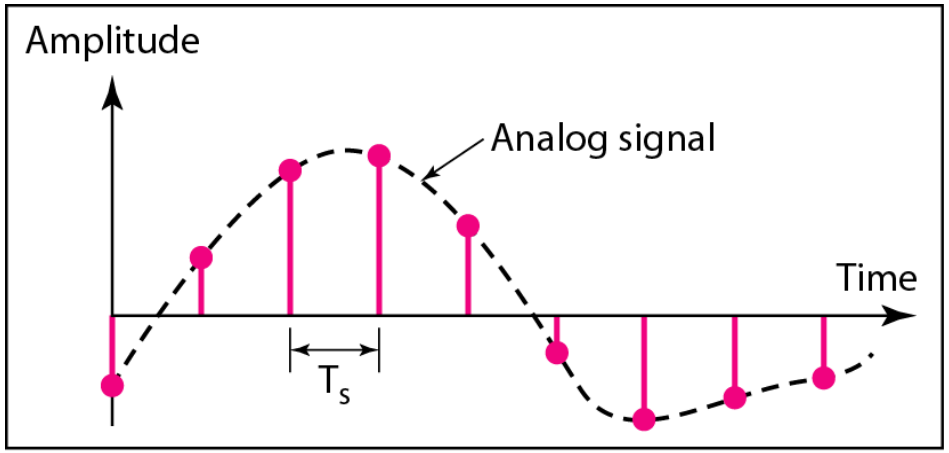
- We have seen in Chapter 3 that a digital signal is superior to an analog signal. The tendency today is to change an analog signal to digital data.
- In this section we describe two techniques, *pulse code modulation* and *delta modulation.*

Component of PCM Encoder

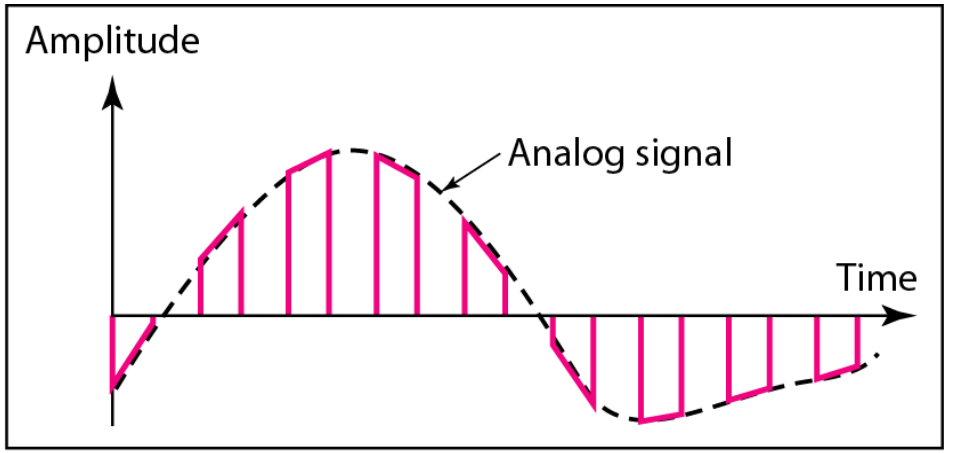


- 1. The analog signal is sampled.
  2. The sampled signal is quantized.
  3. The quantized values are encoded as streams of bits.

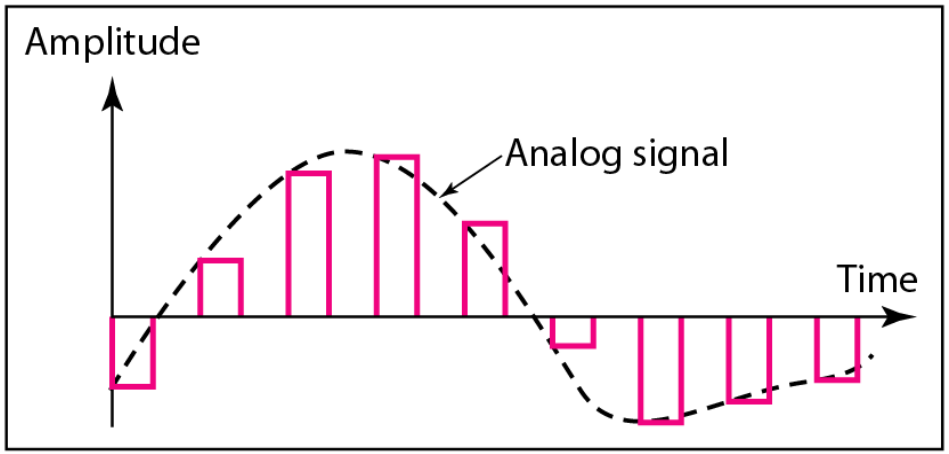
Three Different Sampling Methods for PCM



a. Ideal sampling



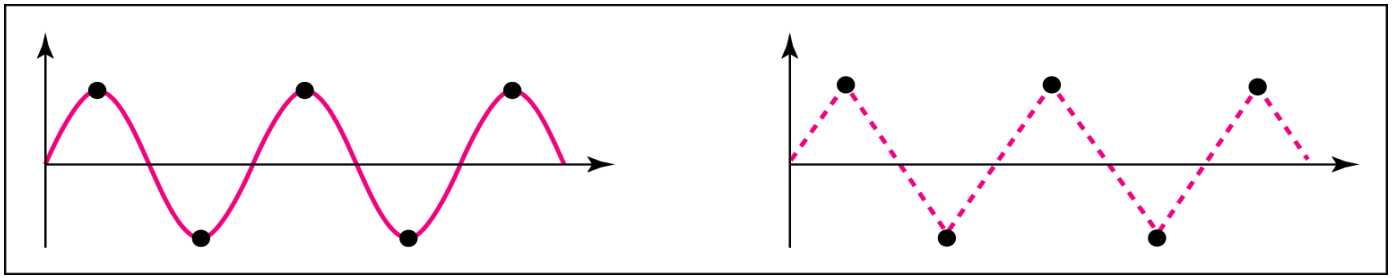
b. Natural sampling



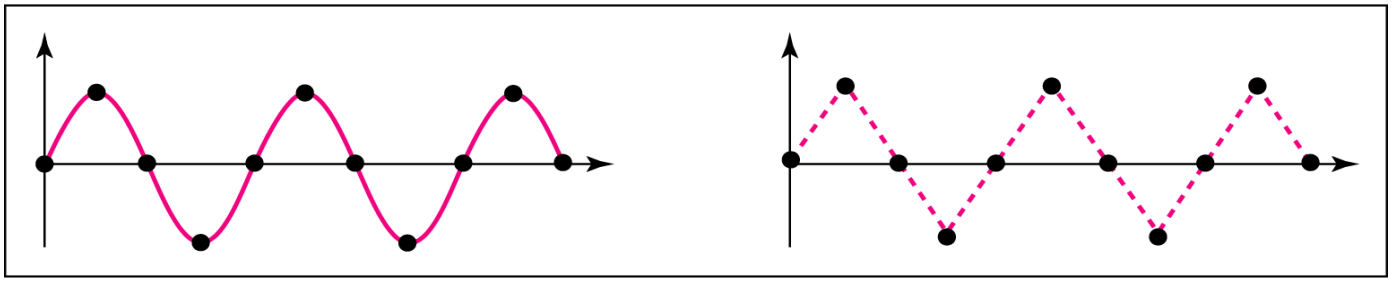
c. Flat-top sampling

According to the Nyquist theorem, the sampling rate must be at least 2 times the highest frequency contained in the signal.

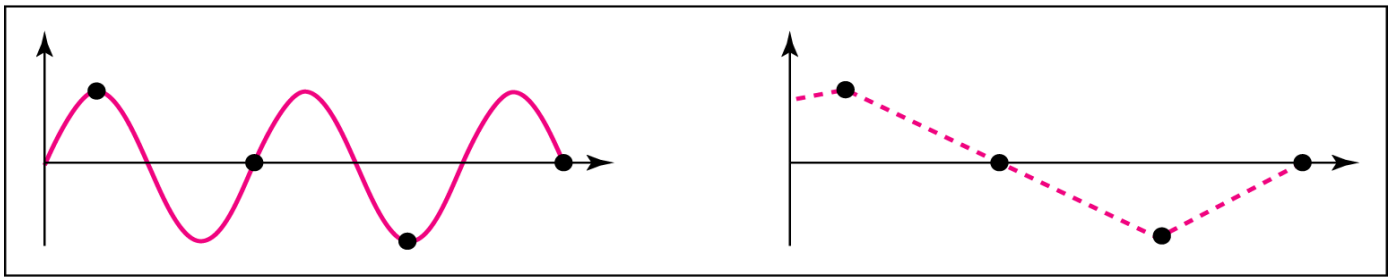
Recovery of a Sampled Sine Wave for Different Sampling Rate



a. Nyquist rate sampling: $f_s = 2\ f$



b. Oversampling: $f_s = 4\ f$



c. Undersampling: $f_s = f$

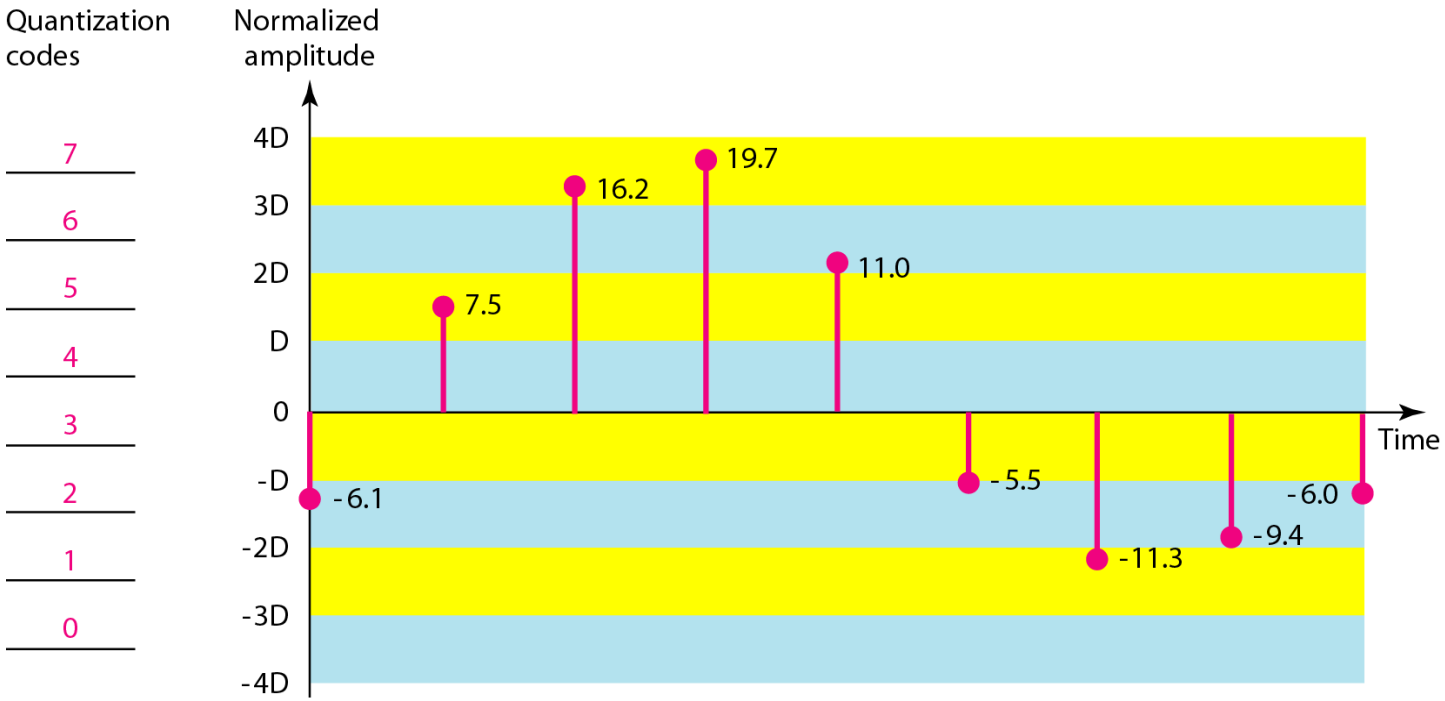
Quantization

- The result of sampling is a series of pulses with amplitude values between the maximum and minimum amplitudes of the signal. The set of amplitudes can be infinite with non integral values between the two limits. These values cannot be used in the encoding process.
- The following are the steps in quantization:
    1. We assume that the original analog signal has instantaneous amplitudes between Vmin and Vmax.
    2. We divide the range into *L* zones, each of height Δ (delta).

$$\Delta = \frac{Vmax - Vmin}{L}$$

    3. We assign quantized values of 0 to L - 1 to the midpoint of each zone.
    4. We approximate the value of the sample amplitude to the quantized values.
- As a simple example, assume that we have a sampled signal and the sample amplitudes are between -20 and +20 V. We decide to have eight levels (L = 8). This means that =5 V.

Quantisation and Encoding of a sampled signal

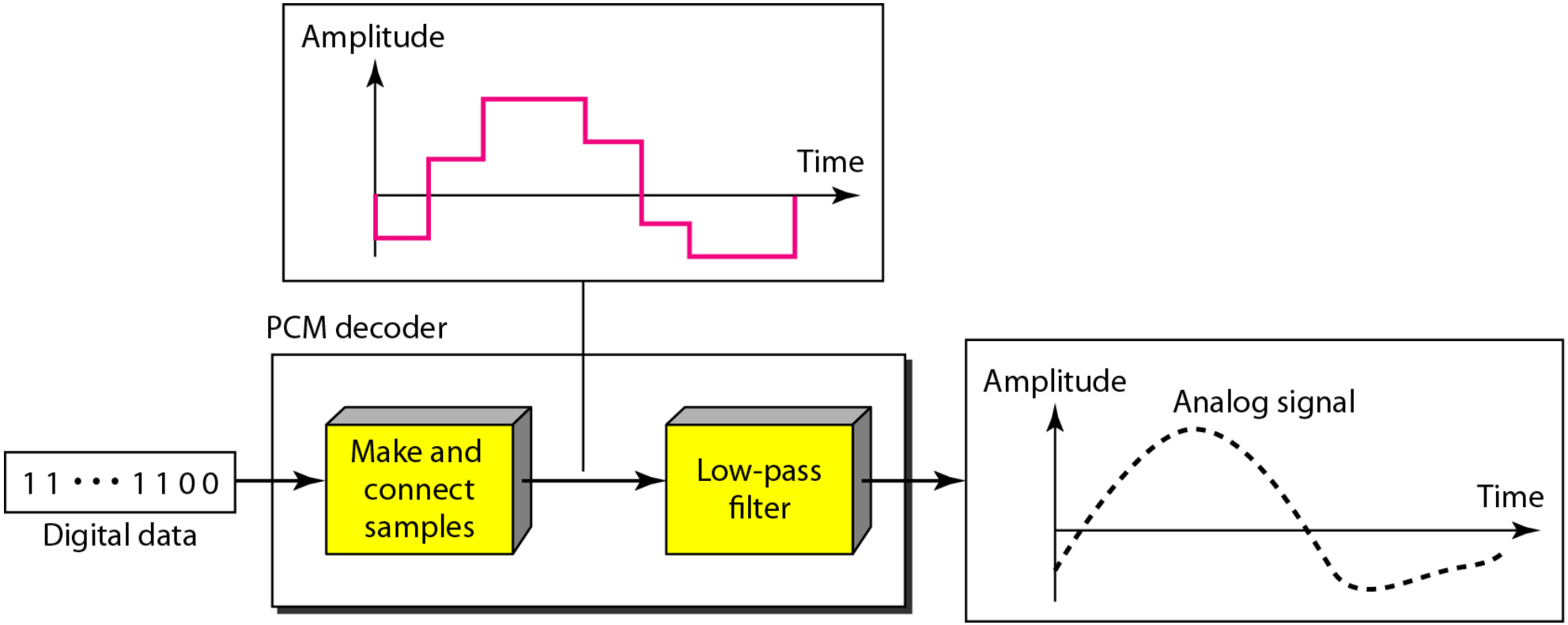


Normalized PAM values	-1.22	1.50	3.24	3.94	2.20	-1.10	-2.26	-1.88	-1.20
Normalized quantized values	-1.50	1.50	3.50	3.50	2.50	-1.50	-2.50	-1.50	-1.50
Normalized error	-0.38	0	+0.26	-0.44	+0.30	-0.40	-0.24	+0.38	-0.30
Quantization code	2	5	7	7	6	2	1	2	2
Encoded words	010	101	111	111	110	010	001	010	010

- We want to digitize the human voice. What is the bit rate, assuming 8 bits per sample?
- Solutions
  - The human voice normally contains frequencies from 0 to 4000 Hz. So the sampling rate and bit rate are calculated as follows:

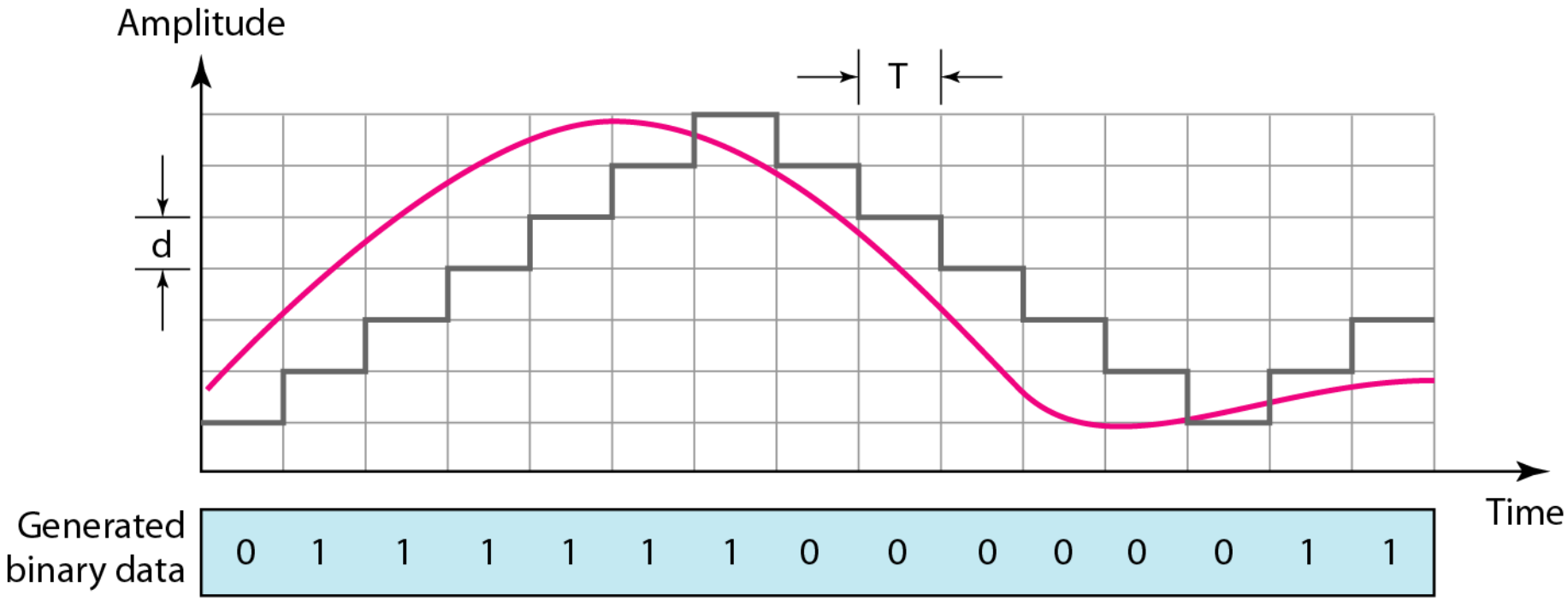
$$\text{Sampling rate} = 4000 \times 2 = 8000 \text{ samples/s}$$
$$\text{Bit rate} = 8000 \times 8 = 64{,}000 \text{ bps} = 64 \text{ kbps}$$

Components of a PCM Encoder

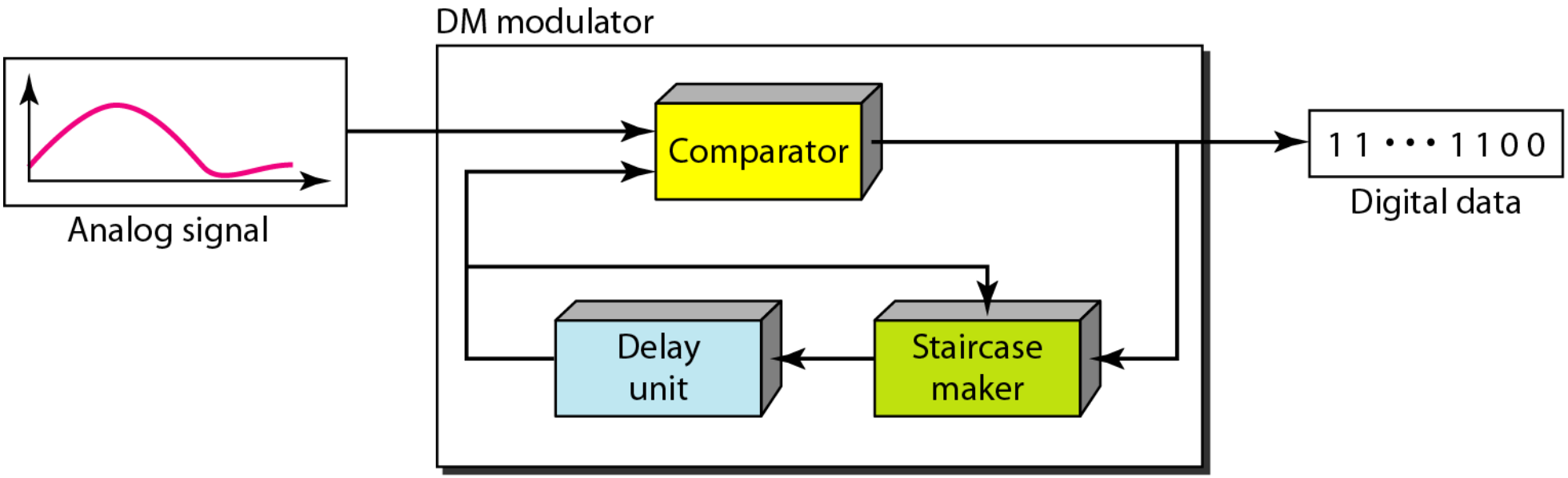


Delta Modulation

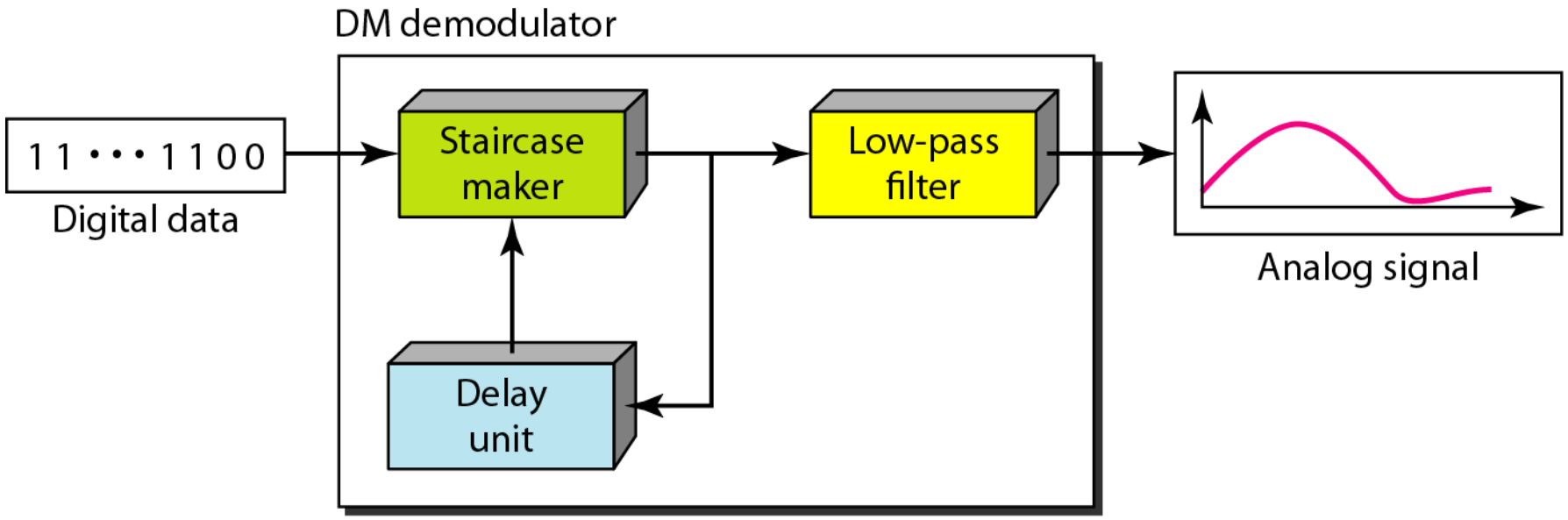
- PCM is a very complex technique. Other techniques have been developed to reduce the complexity of PCM. The simplest is delta modulation. PCM finds the value of the signal amplitude for each sample; DM finds the change from the previous sample. Figure below shows the process. Note that there are no code words here; bits are sent one after another.



Delta Modulation Components



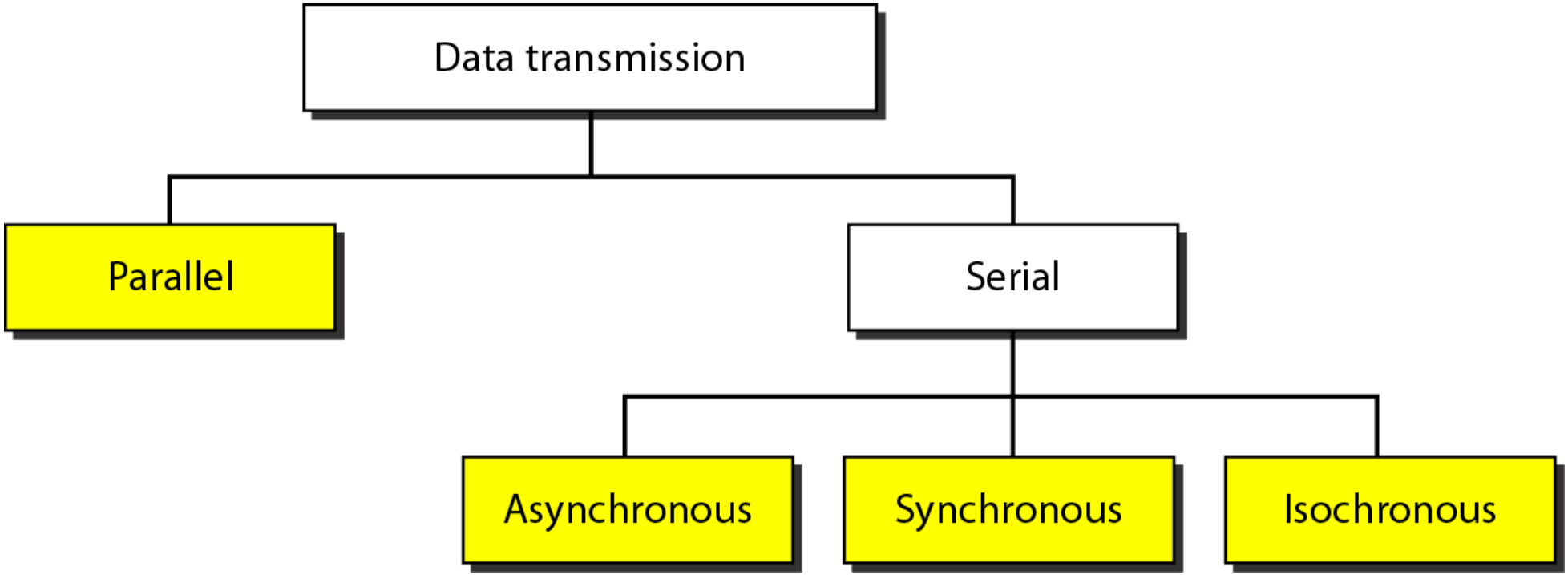
Delta Demodulation Components



Transmission Modes

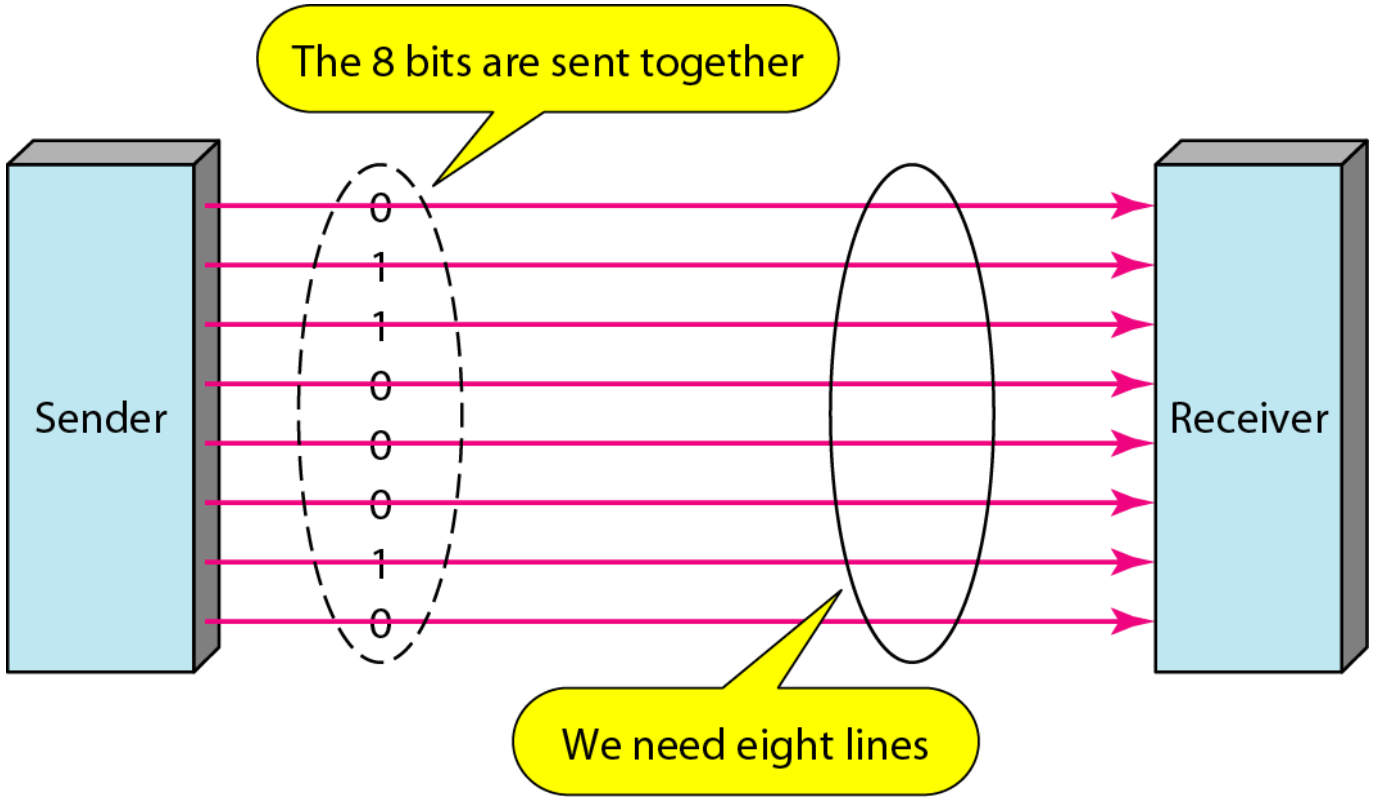
- The transmission of binary data across a link can be accomplished in either parallel or serial mode.
  - In parallel mode, multiple bits are sent with each clock tick.
  - In serial mode, 1 bit is sent with each clock tick.
- While there is only way to send parallel data, there are three subclasses of serial transmission: asynchronous, synchronous, and isochronous.

Transmission Modes



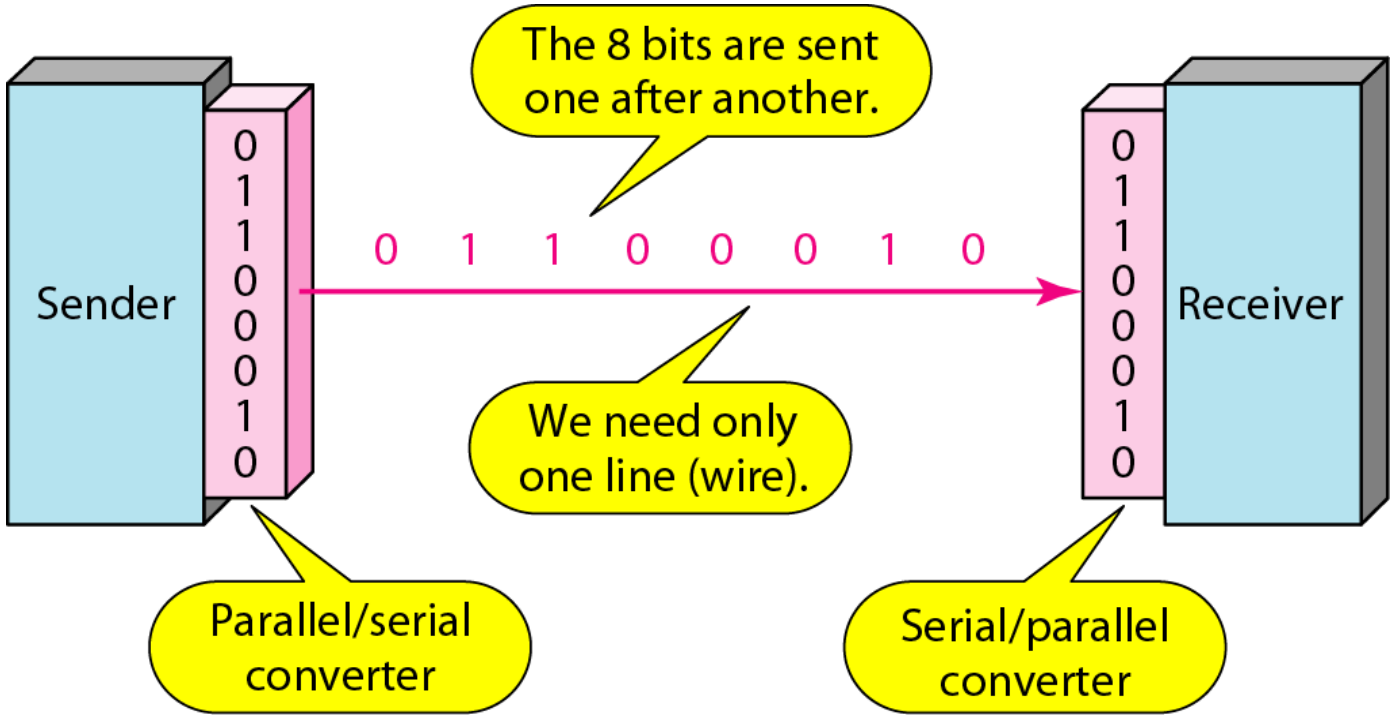
Parallel Transmission

- In computer science, parallel communication is a method of conveying multiple binary digits (bits) simultaneously

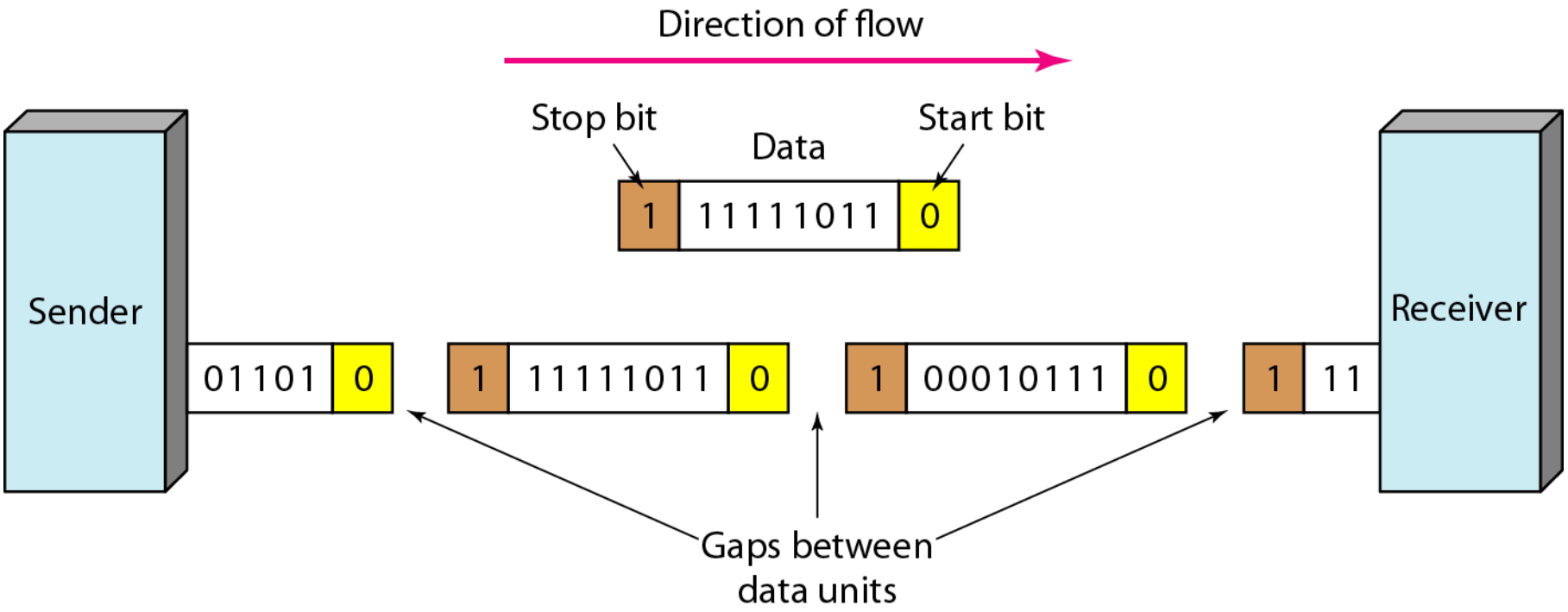


Serial Transmission

- In telecommunication and computer science, serial communication is the process of sending data one bit at a time, sequentially, over a communication channel or computer bus

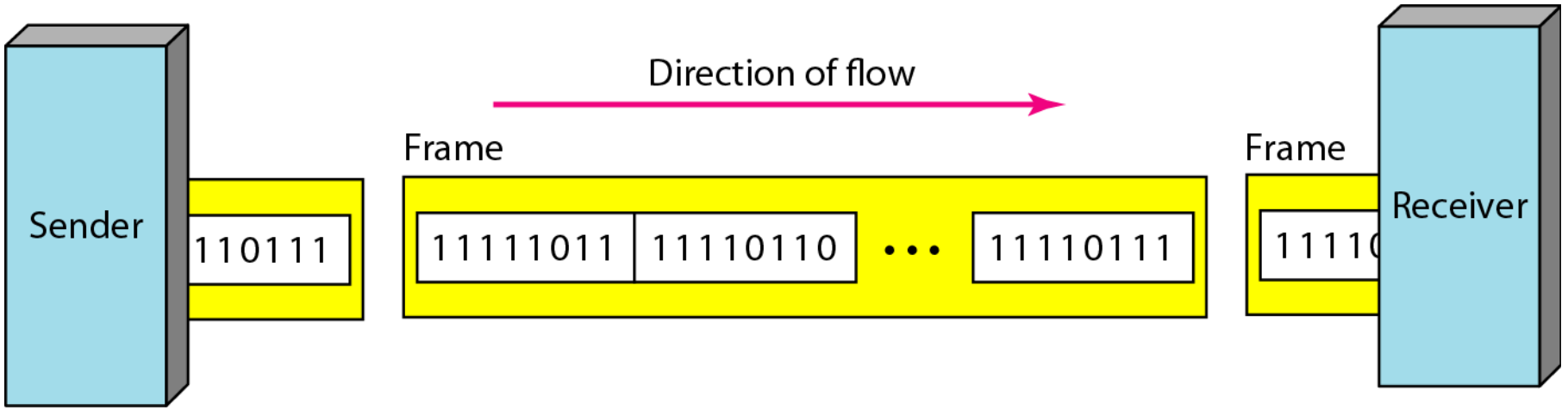


Asynchronous Transmission



- Asynchronous serial communication is a form of serial communication in which the communicating endpoints' interfaces are not continuously synchronized by a common clock signal. Instead of a common synchronization signal, the data stream contains synchronization information in form of start and stop signals, before and after each unit of transmission, respectively. The start signal prepares the receiver for arrival of data and the stop signal resets its state to enable triggering of a new sequence.
- A common kind of start-stop transmission is ASCII over RS-232, for example for use in teletypewriter operation.

Synchronous Transmission



- Synchronous communication requires that the clocks in the transmitting and receiving devices are synchronized – running at the same rate – so the receiver can sample the signal at the same time intervals used by the transmitter. No start or stop bits are required. For this reason "synchronous communication permits more information to be passed over a circuit per unit time"[2] than asynchronous serial communication. Over time the transmitting and receiving clocks will tend to drift apart, requiring resynchronization.