6

Data Communication

Week 6 Digital Transmission (2)

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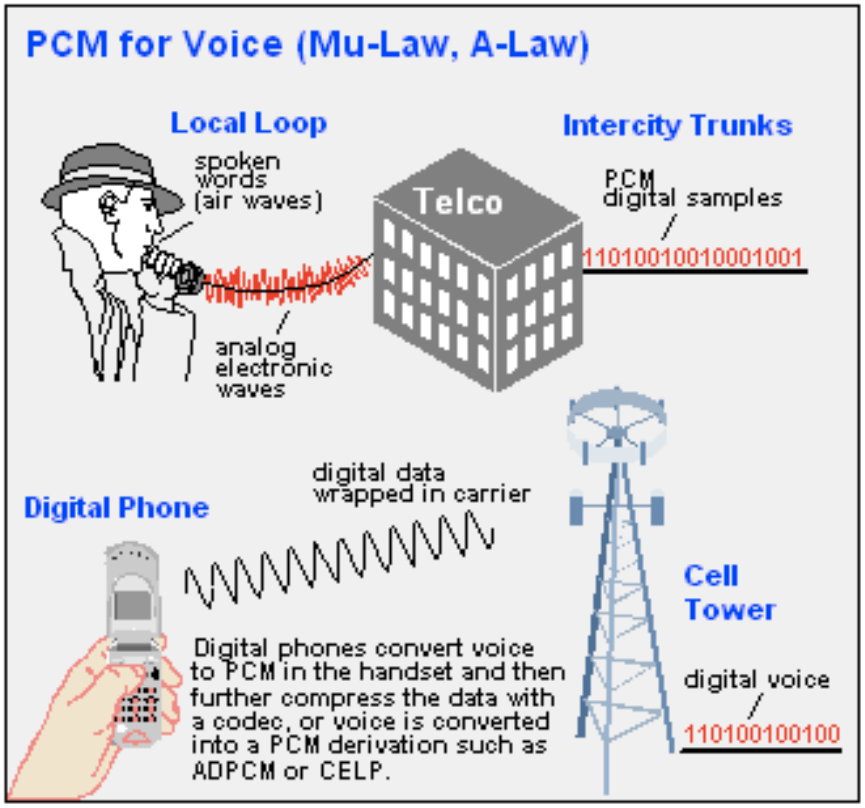
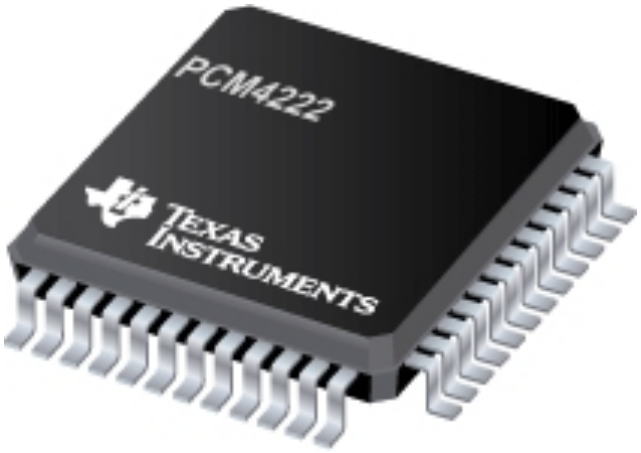
Digital Transmission

- 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 (PCM)**
  - **Delta Modulation (DM)**

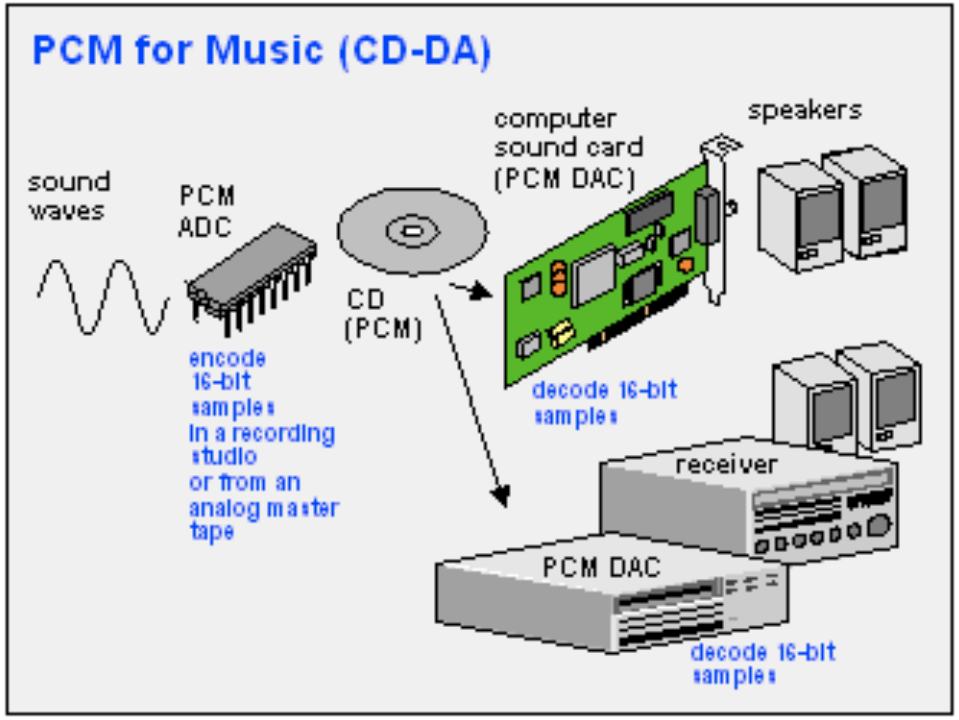
Pulse Code Modulation

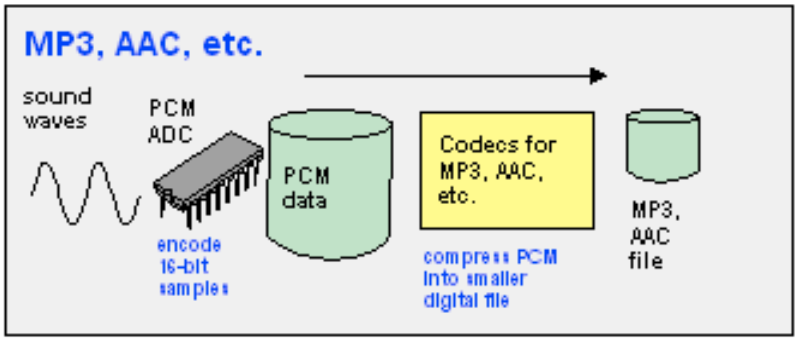
- The most common technique to change an analog signal to digital data (digization) is called Pulse Code Modulation (PCM). A PCM encoder has three process, sampling, quantization and encoding.



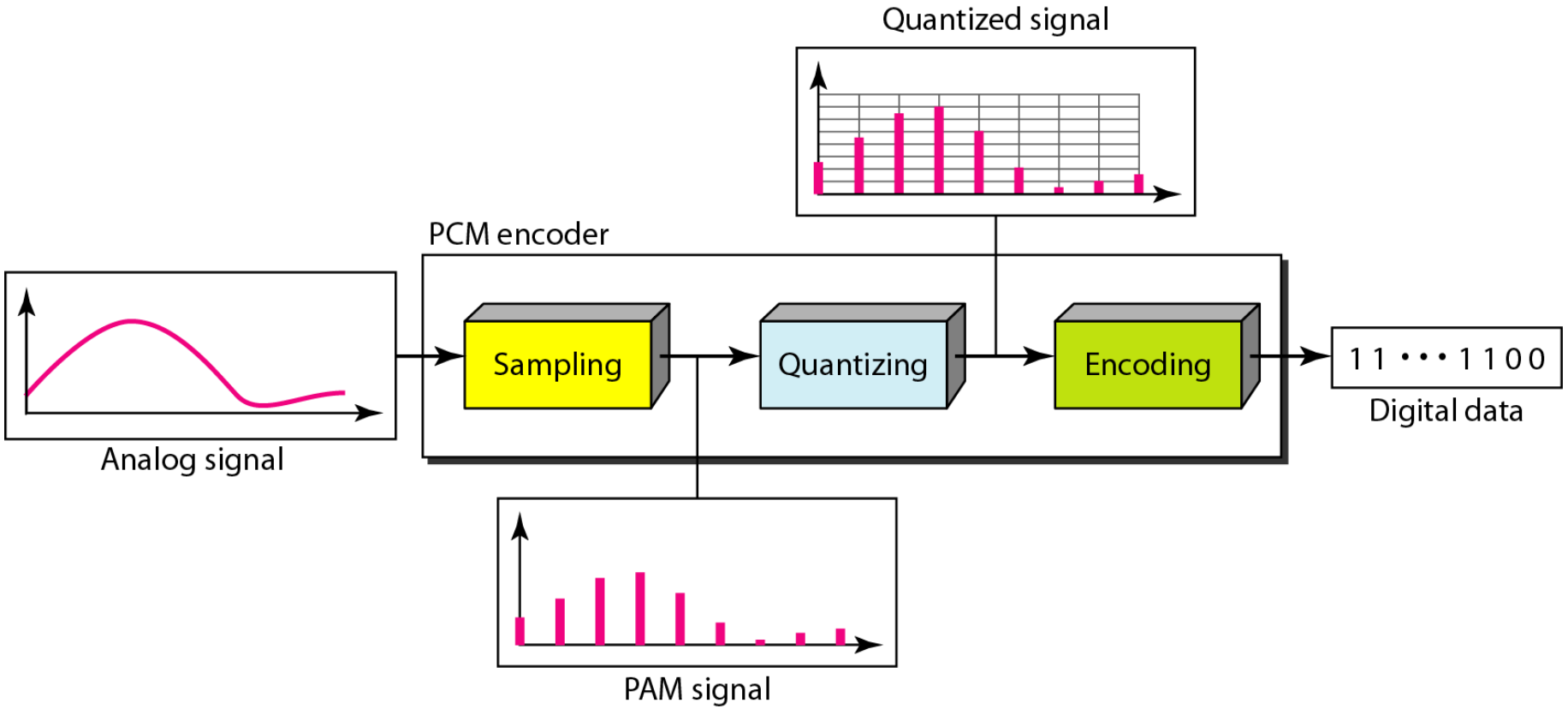


PCM Implementation



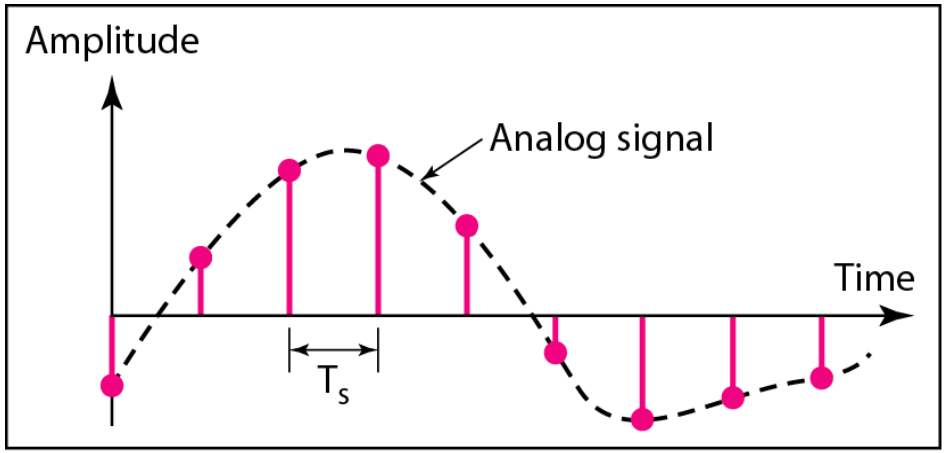


Component of PCM Encoder

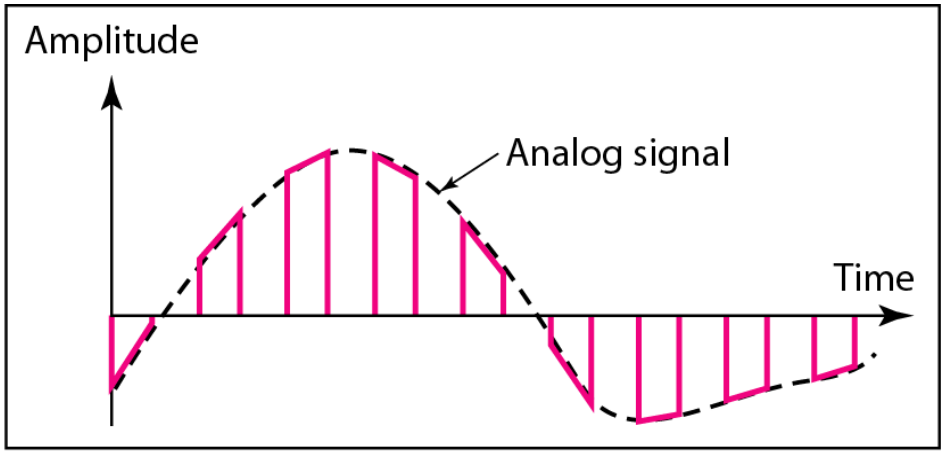


- 1. The analog signal is sampled.
  2. The sampled signal is quantized.
  3. The quantized values are encoded as streams of bits.

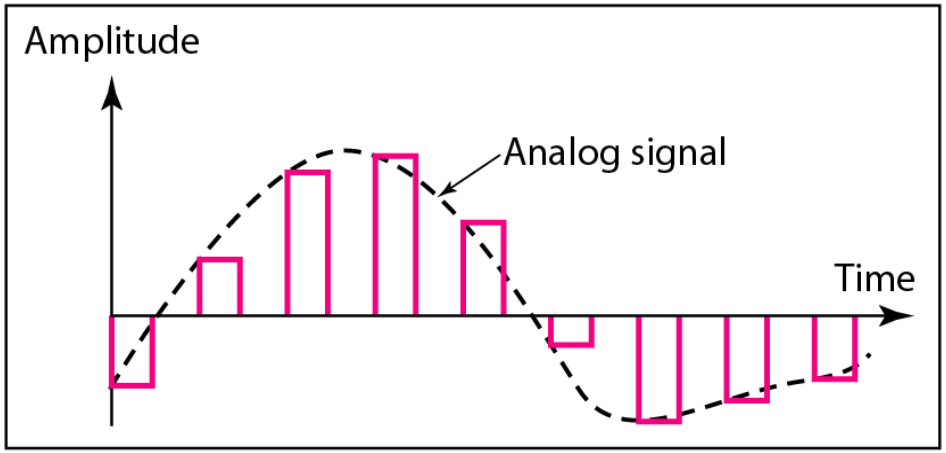
Three Different Sampling Methods for PCM



a. Ideal sampling



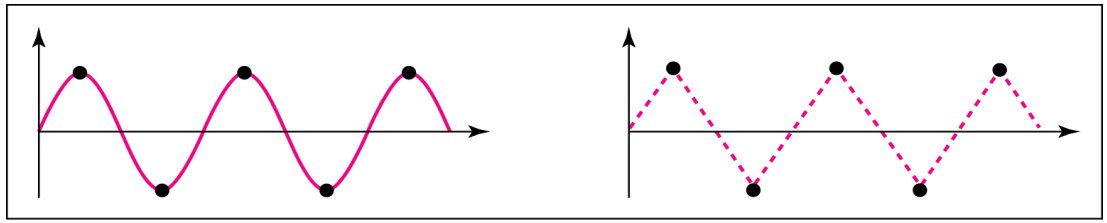
b. Natural sampling



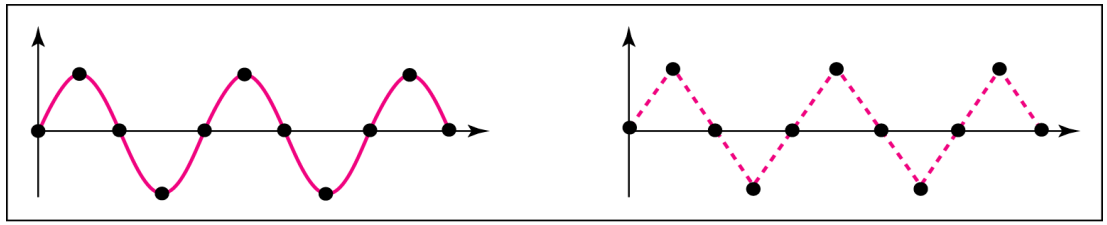
c. Flat-top sampling

Sampling

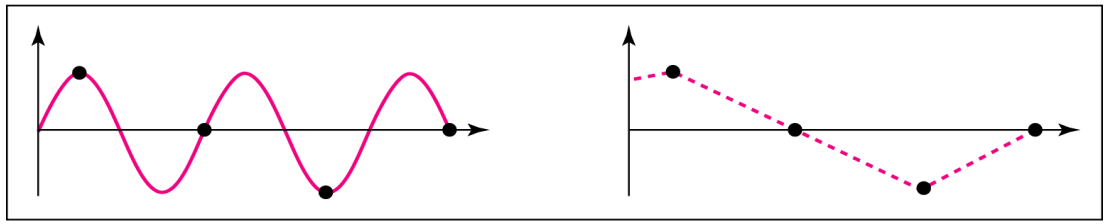
- According to the Nyquist theorem, the sampling rate must be at least 2 times the highest frequency contained in the signal.
- Figure below is recovery of a Sampled Sine Wave for Different Sampling Rate



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



b. Oversampling: $f_s = 4\,f$



c. Undersampling: $f_s = f$

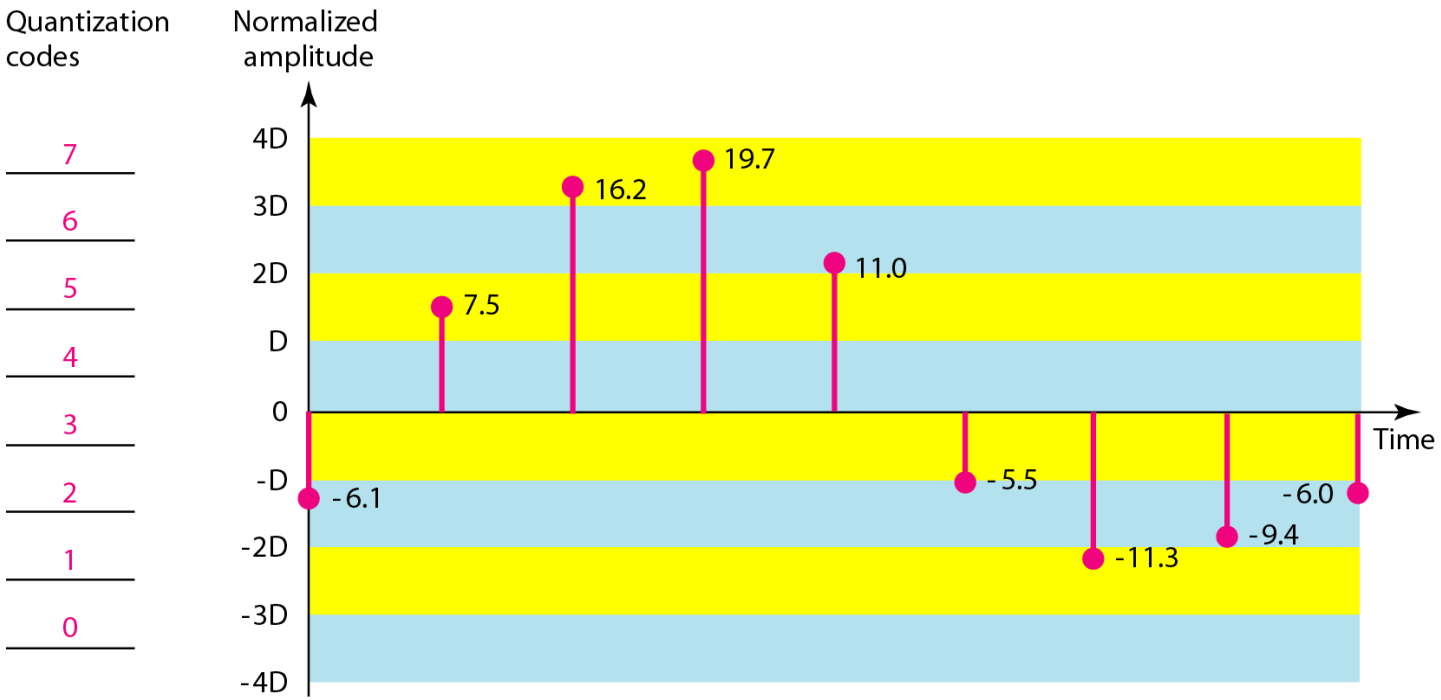
Quantization

- 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



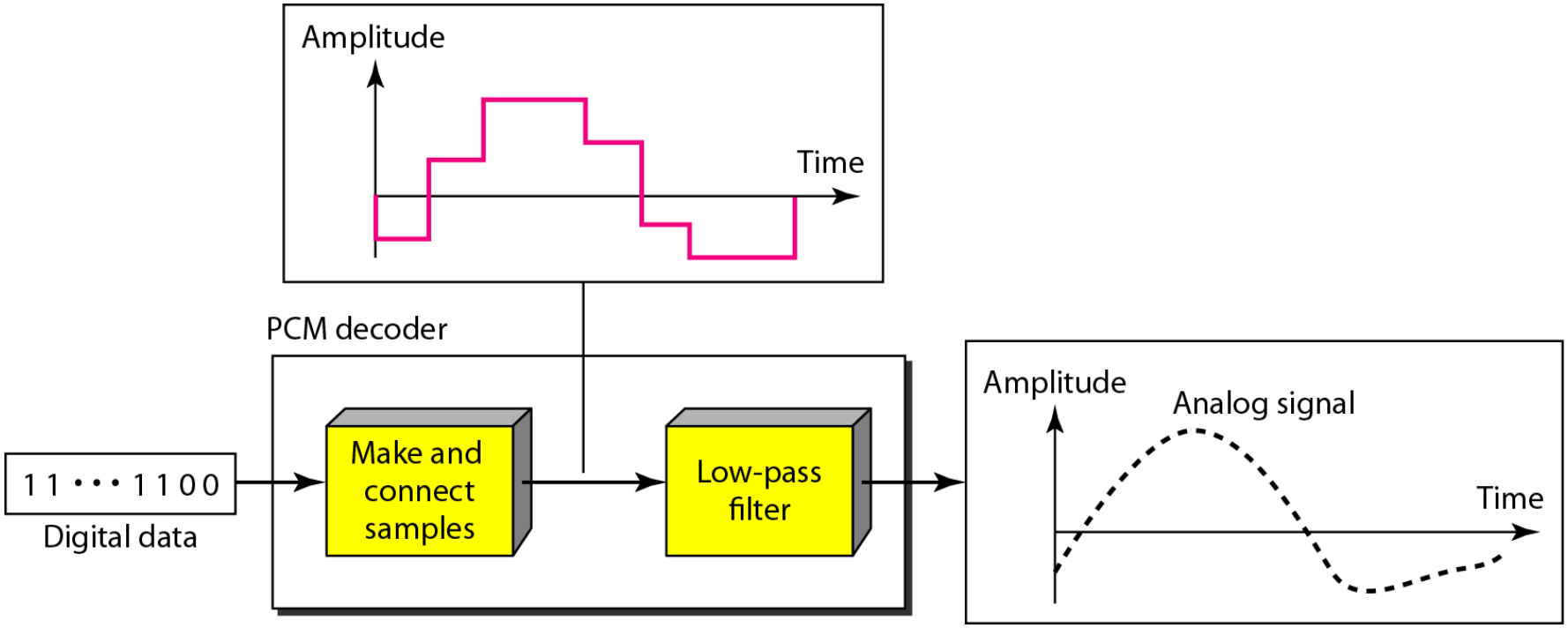
Normalized PAM values	-1.22	1.50	3.24	3.94	2.20	-1.10	-2.26	-1.88	-1.20
Normalized quantized values	-1.50	1.50	3.50	3.50	2.50	-1.50	-2.50	-1.50	-1.50
Normalized error	-0.38	0	+0.26	-0.44	+0.30	-0.40	-0.24	+0.38	-0.30
Quantization code	2	5	7	7	6	2	1	2	2
Encoded words	010	101	111	111	110	010	001	010	010

Example

- 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:

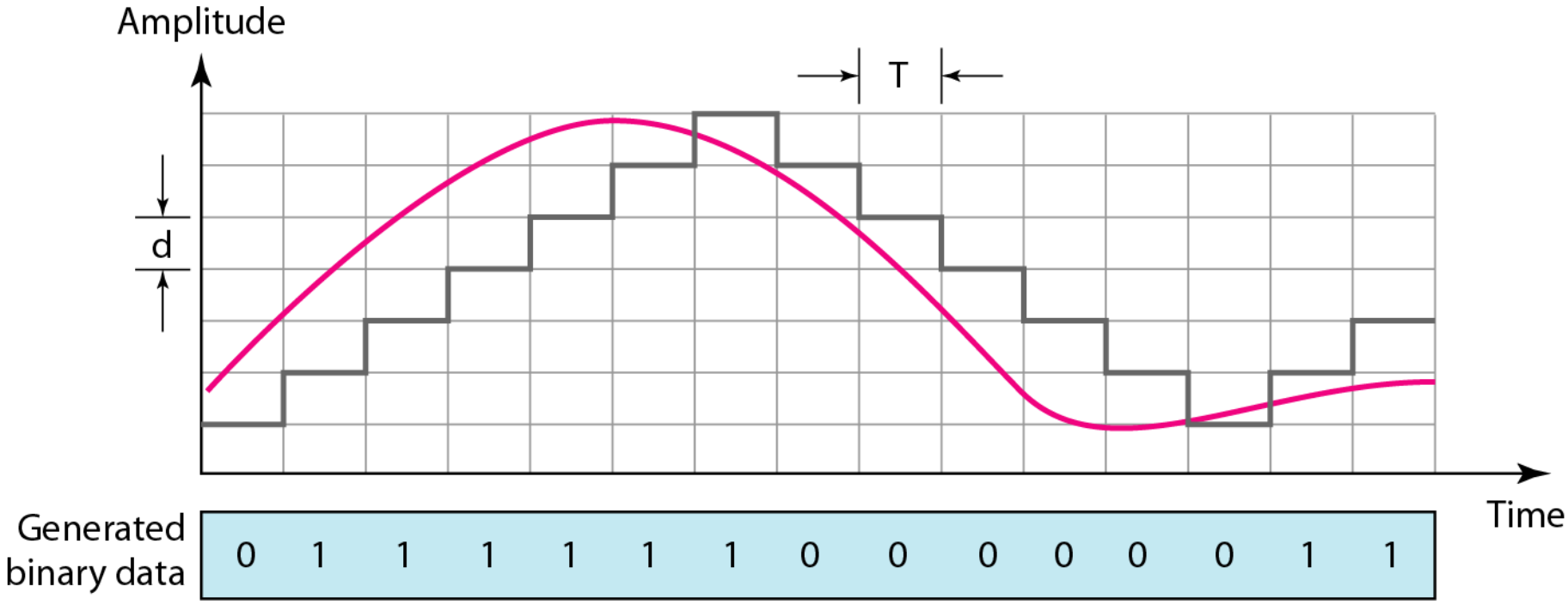
$$\text{Sampling rate} = 4000 \times 2 = 8000 \text{ samples/s}$$
$$\text{Bit rate} = 8000 \times 8 = 64{,}000 \text{ bps} = 64 \text{ kbps}$$

Components of a PCM Encoder

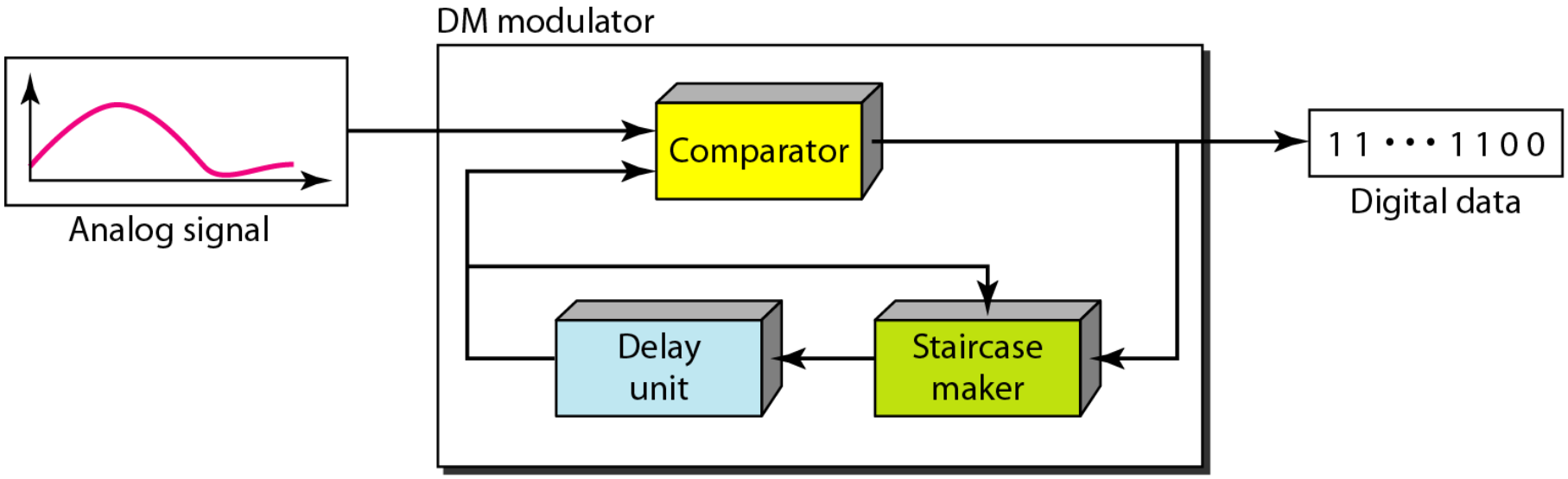


Delta Modulation

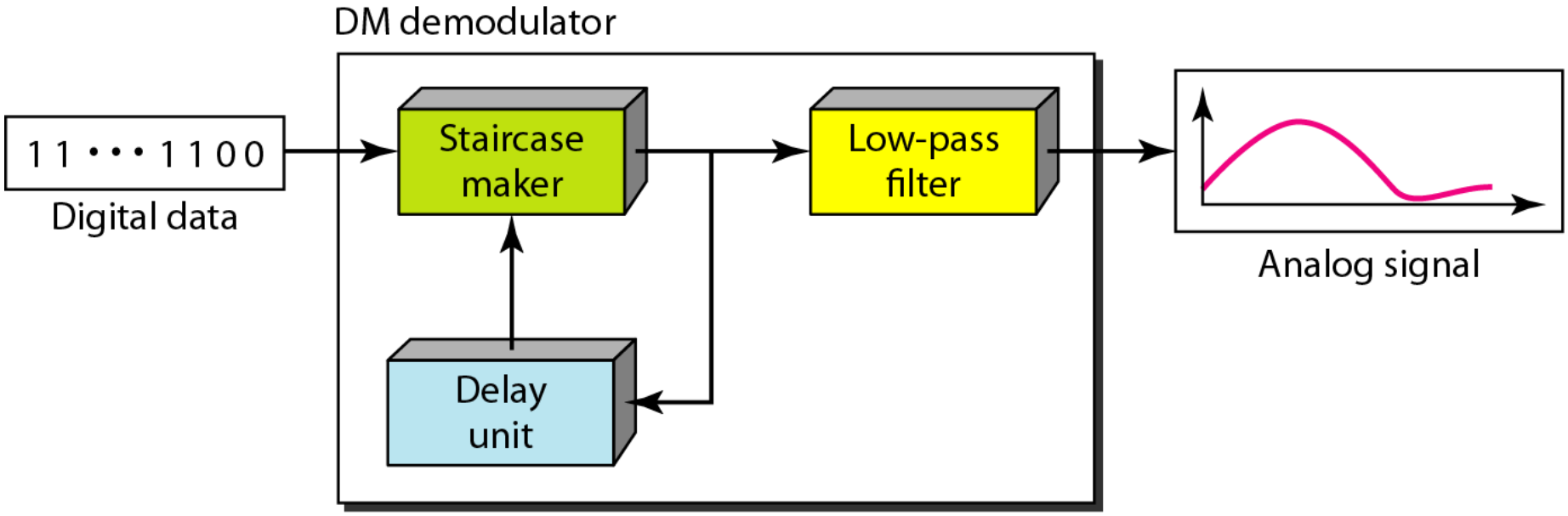
- PCM is a very complex technique. Other techniques have been developed to reduce the complexity of PCM. The simplest is delta modulation. PCM finds the value of the signal amplitude for each sample; DM finds the change from the previous sample. Figure below shows the process. Note that there are no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



Delta Modulation Components



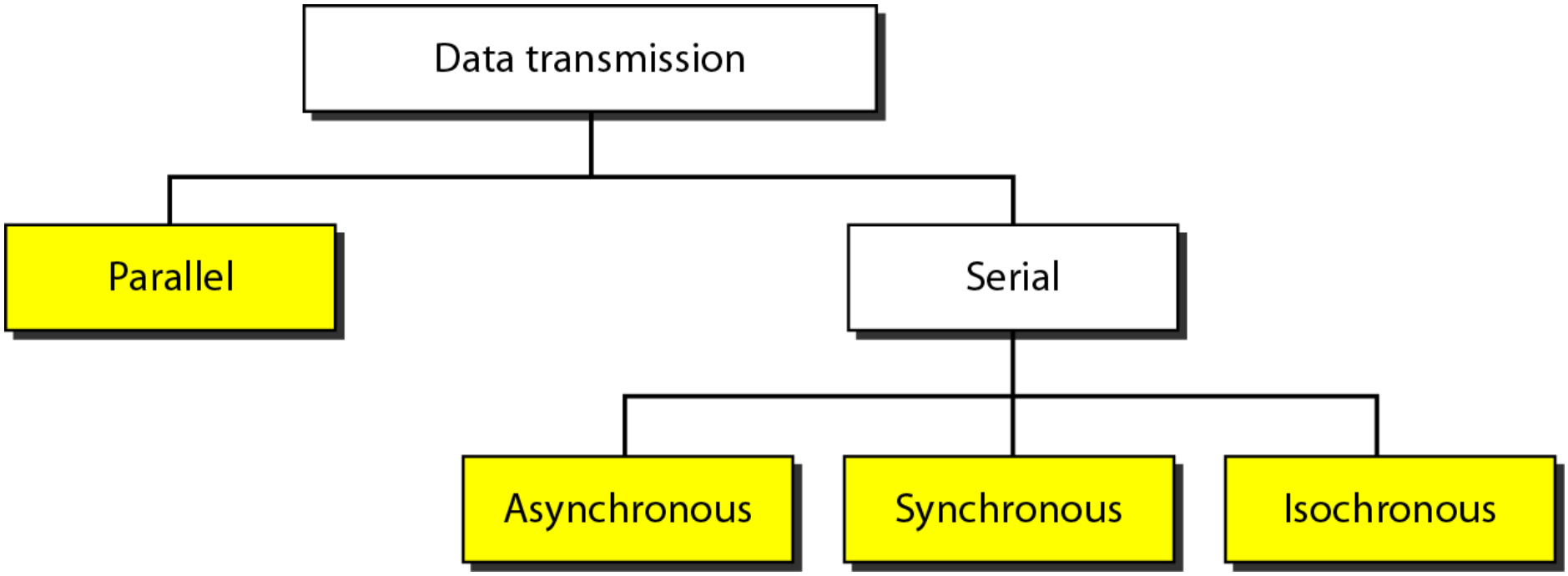
Delta Demodulation Components



Transmission Modes

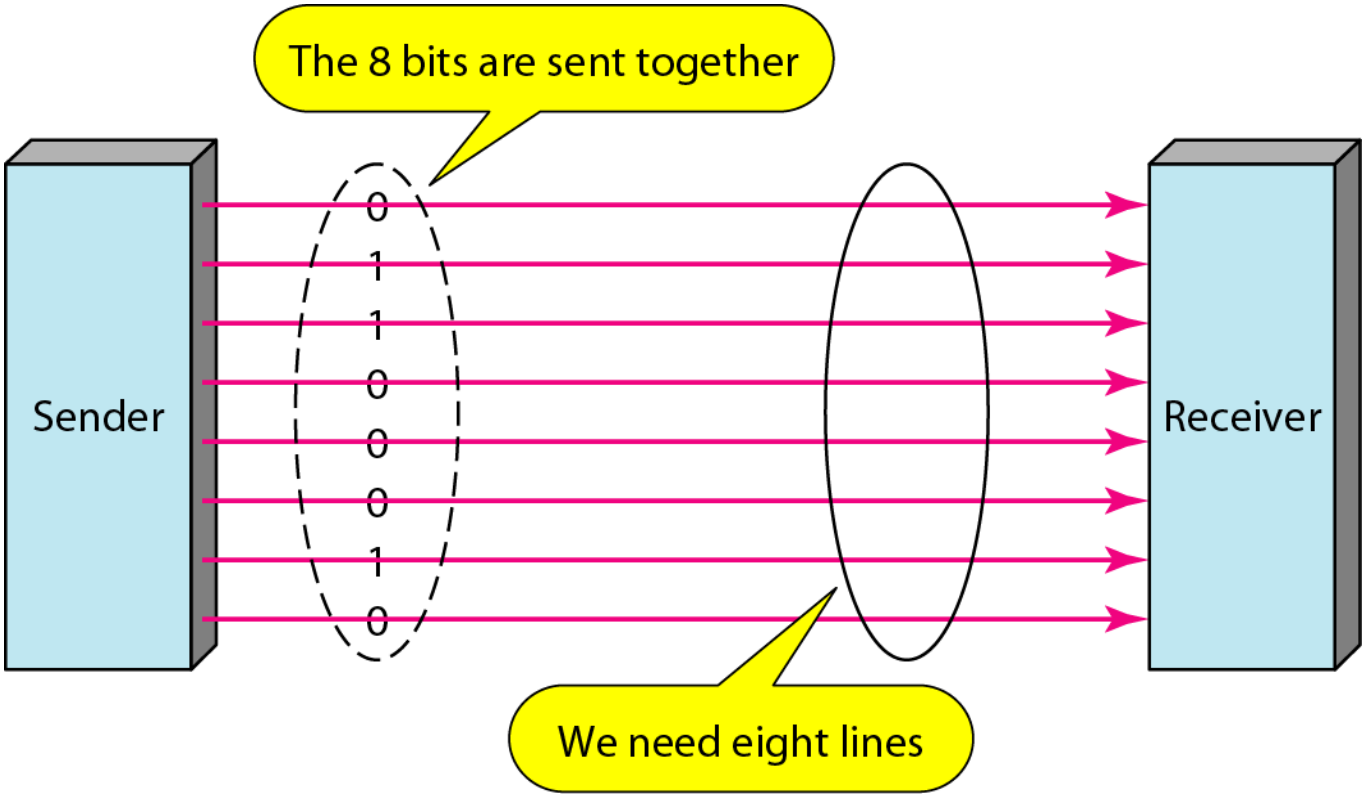
- The transmission of binary data across a link can be accomplished in either parallel or serial mode.
  - In parallel mode, multiple bits are sent with each clock tick.
  - In serial mode, 1 bit is sent with each clock tick.
- While there is only way to send parallel data, there are three subclasses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

Transmission Modes



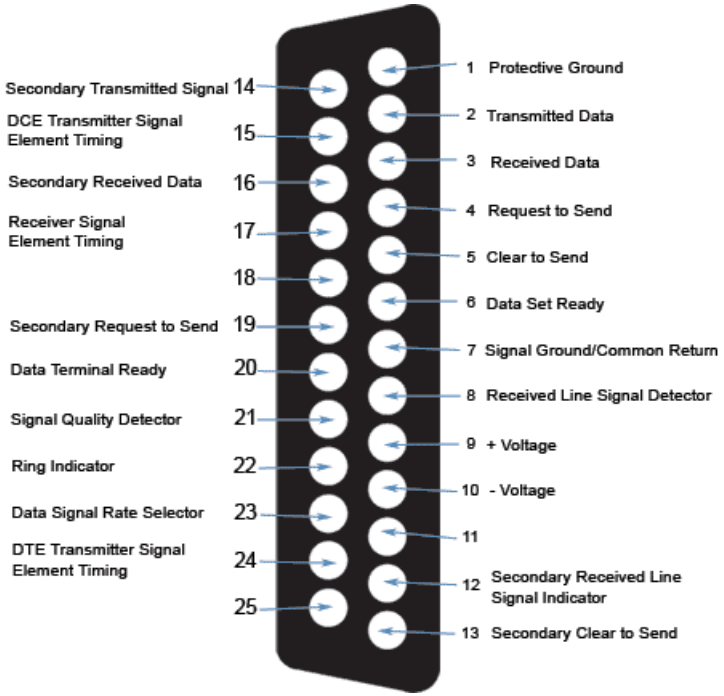
Parallel Transmission

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



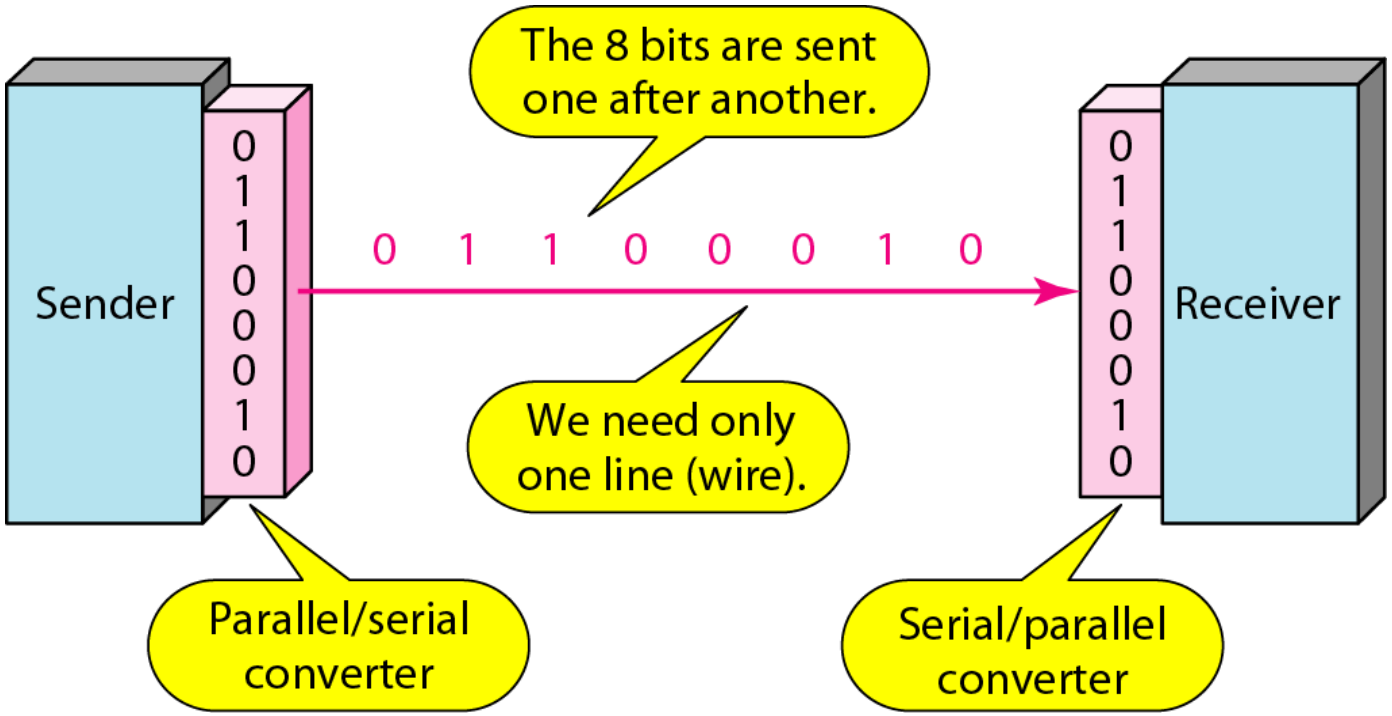
DB-25

- The parallel port is found on the back of IBM compatible computers and is a 25-pin (type DB-25) computer interface commonly used to connect printers to the computer

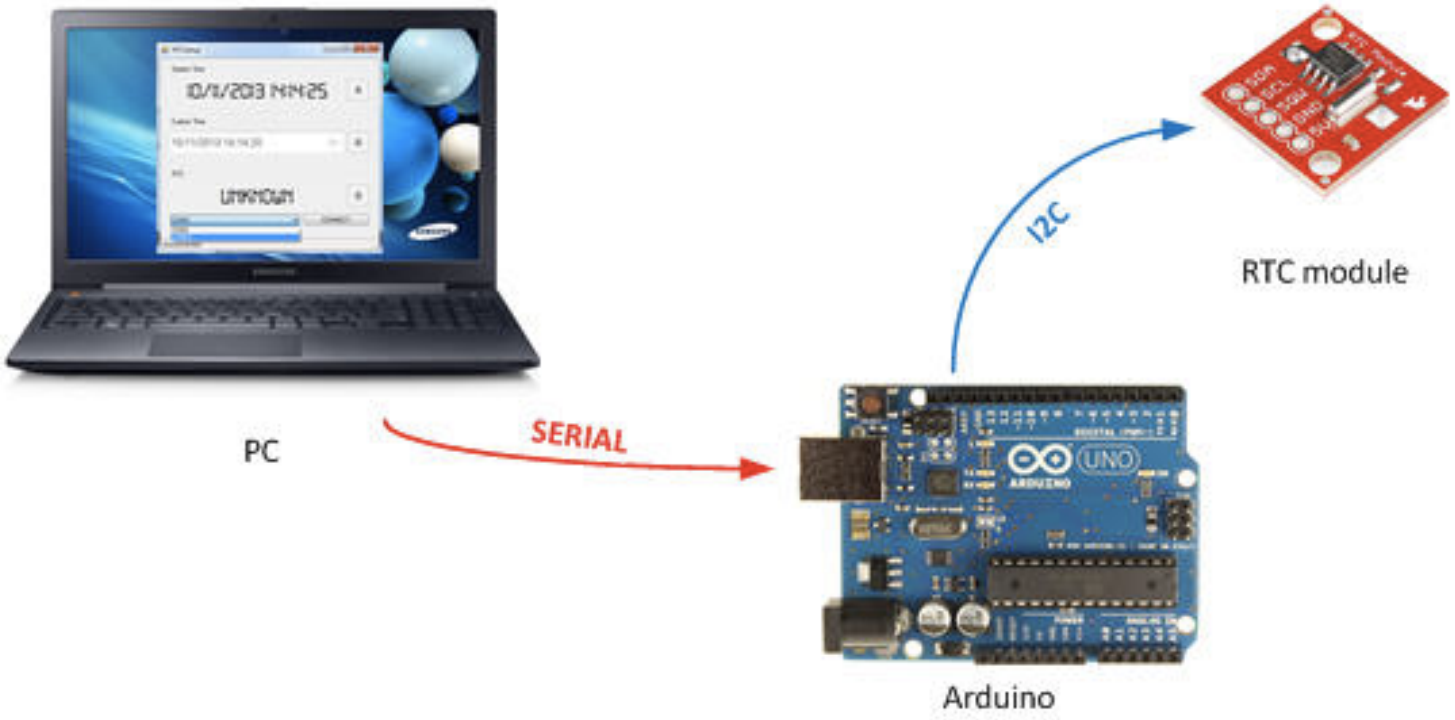


Serial Transmission

- 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

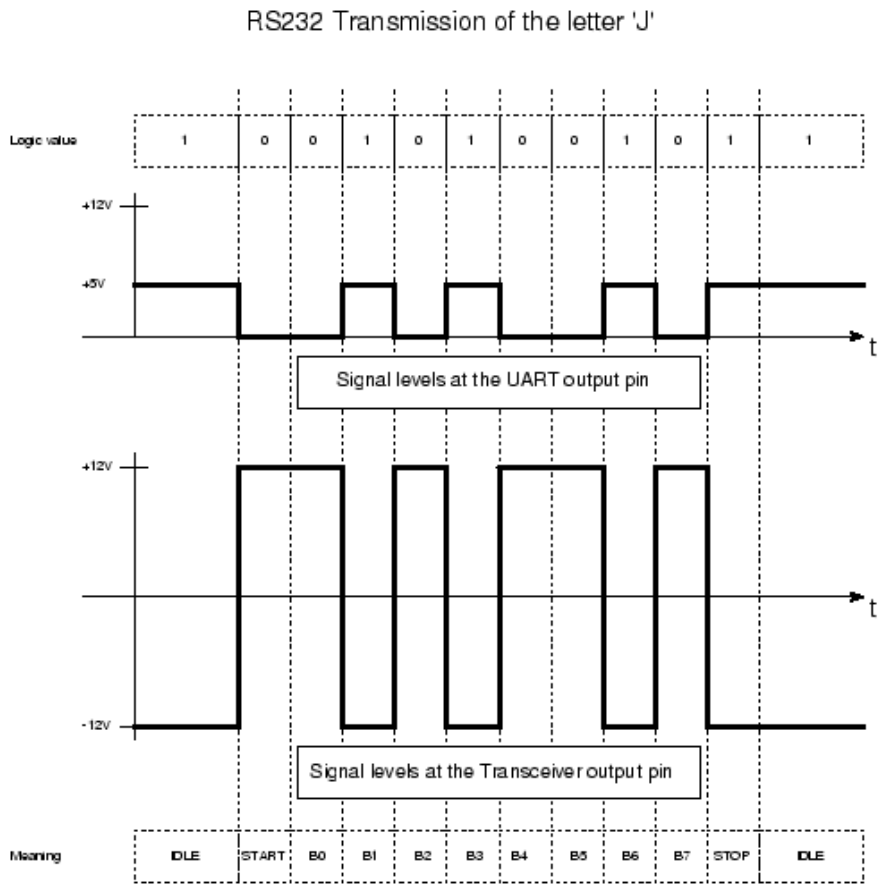


Example



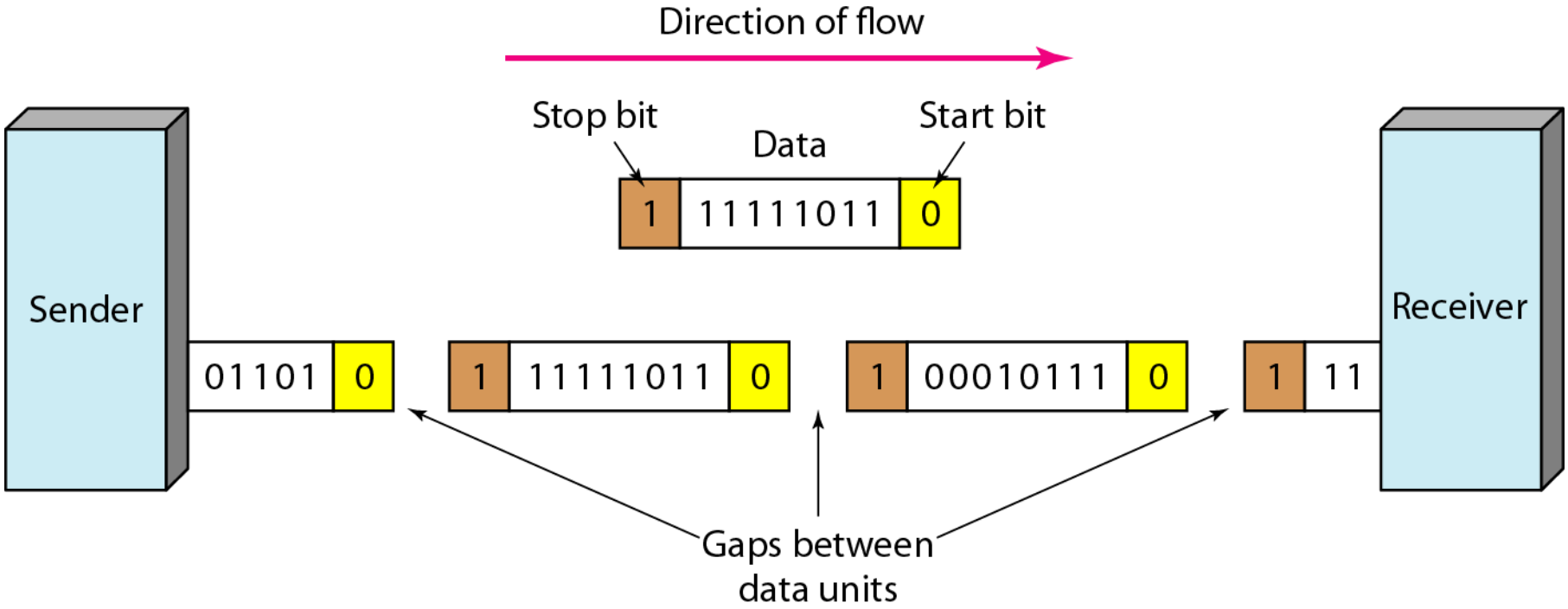
RS232

- RS-232 is a standard for serial communication transmission of data



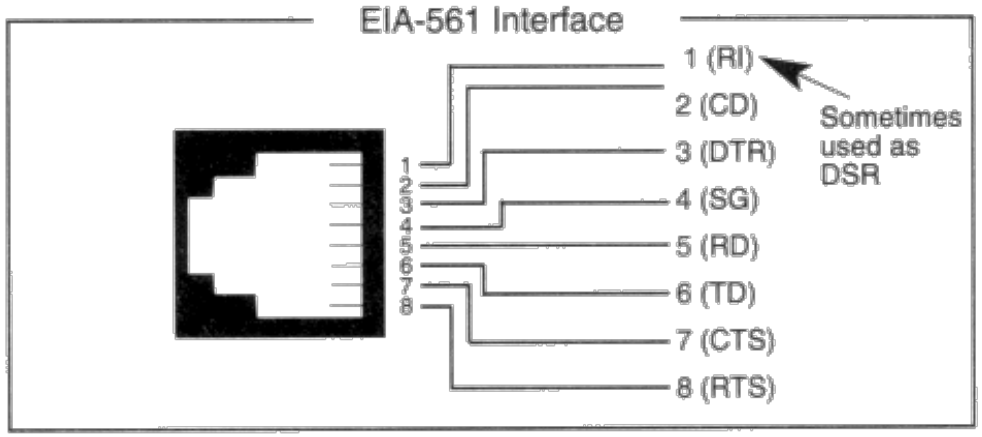
Asynchronous Transmission

- 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.



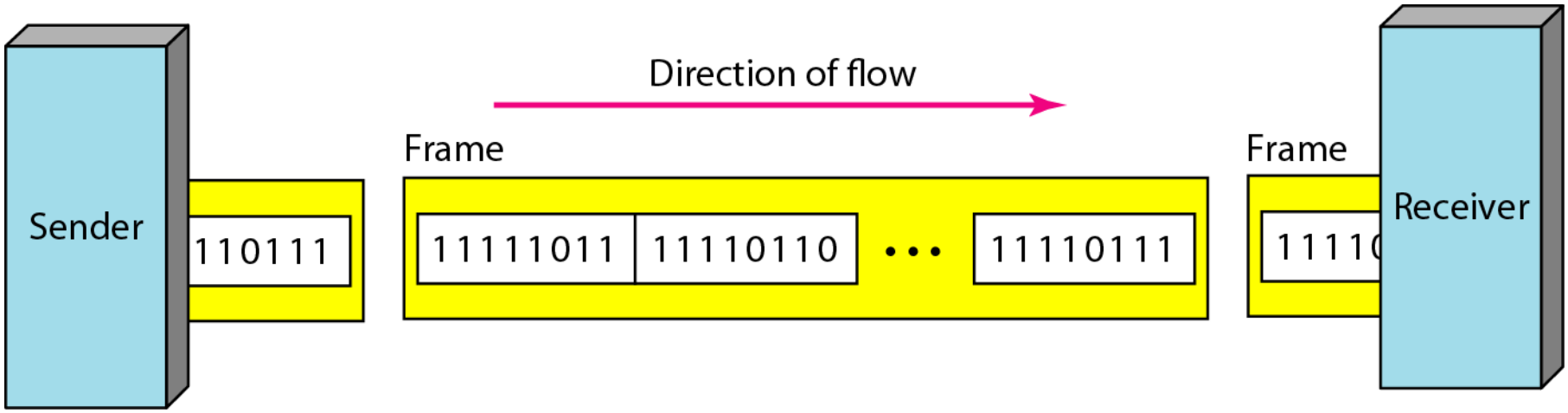
- A common kind of start-stop transmission is ASCII over RS-232, for example for use in teletypewriter operation.

EIA-561 defines RS-232 on a modular connector. (For nonsynchronous applications only, since it does not provide for the synchronous clocking signals.)



Synchronous Transmission

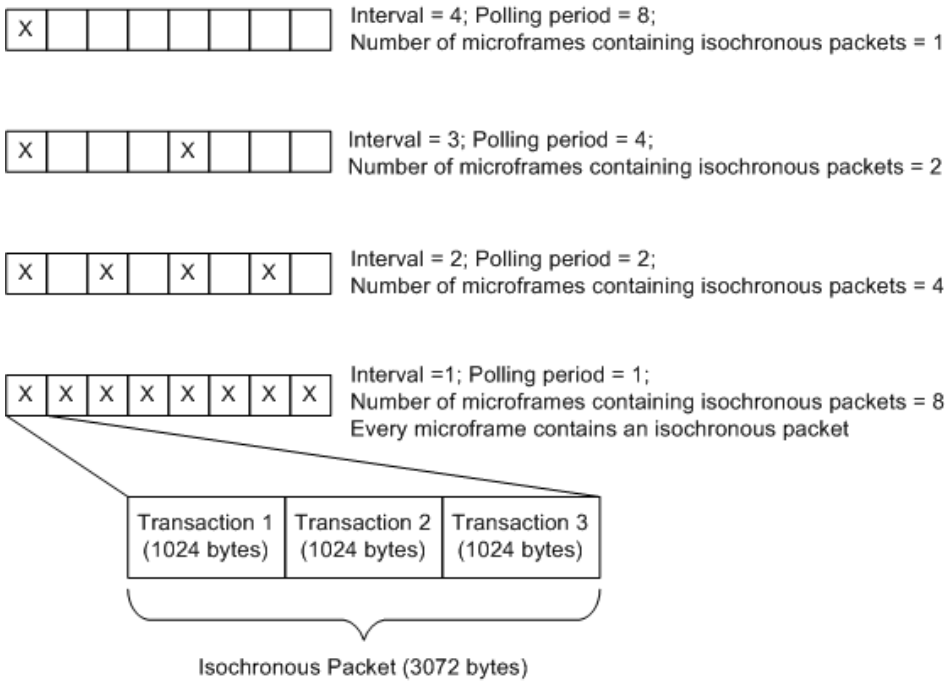
- Synchronous communication requires that the clocks in the transmitting and receiving devices are synchronized – running at the same rate – so the receiver can sample the signal at the same time intervals used by the transmitter. No start or stop bits are required. For this reason "synchronous communication 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.



Isochronous

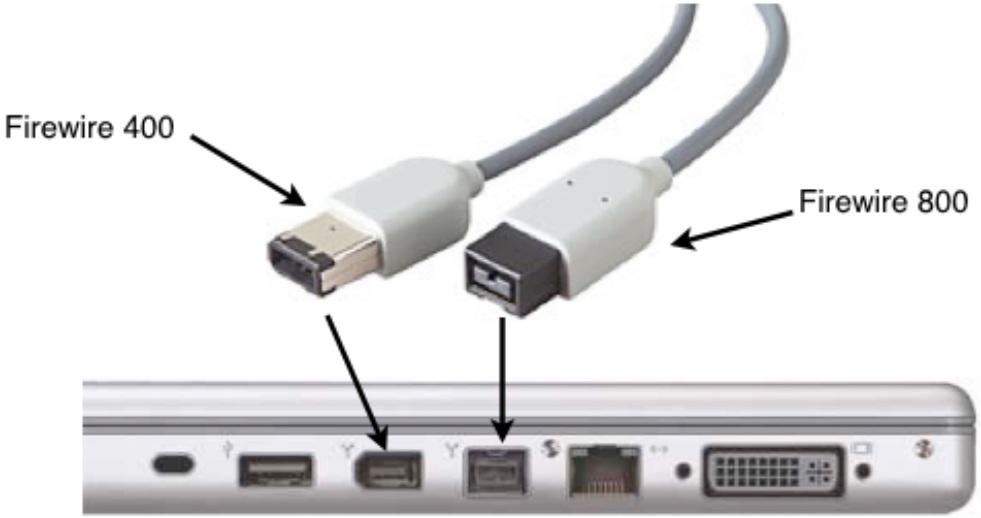
- In real-time audio and video, in which uneven delays between frames are not acceptable, synchronous transmission fails.
- For example, TV images are broadcast at the rate of 30 images per second; they must be viewed at the same rate. If each image is sent by using one or more grames, there should be no delays between frames. For this type of application, synchronization bwtween characters is not enough; the entire stream of bits must be syncronized. The isochronous transmission guarantees that the data arrive at a fixed rate.
- In the Universal Serial Bus used in computers, isochronous is one of the four data flow types for USB devices (the others being Control, Interrupt and Bulk). It is commonly used for streaming data types such as video or audio sources. Similarly, the IEEE 1394 interface standard, commonly called Firewire, includes support for isochronous streams of audio and video at known constant rates.

Universal Serial Bus (USB)



Firewire - IEEE 1394

- IEEE 1394 is an interface standard for a serial bus for high-speed communications and isochronous real-time data transfer. It was developed in the late 1980s and early 1990s by Apple, which called it FireWire. The 1394 interface is also known by the brand i.LINK (Sony), and Lynx (Texas Instruments).



High Definition Multimedia Interface (HDMI)

- The High Definition Multimedia Interface (HDMI) and DisplayPort are both modern serial interfaces for carrying digital video from one product to another over cables. They replace long-running analog interfaces like VGA, S-video, and RGB. With most video and audio in data-intensive high-definition (HD) format, any interface must have a high data rate. HDMI and DisplayPort are both high-speed digital interfaces, but they differ in several important aspects (see the table). HDMI is used mainly for consumer electronics equipment, while DisplayPort is primarily for computer and peripheral video connections.