CSE-3215
Data Communication

Lecture-22, 23

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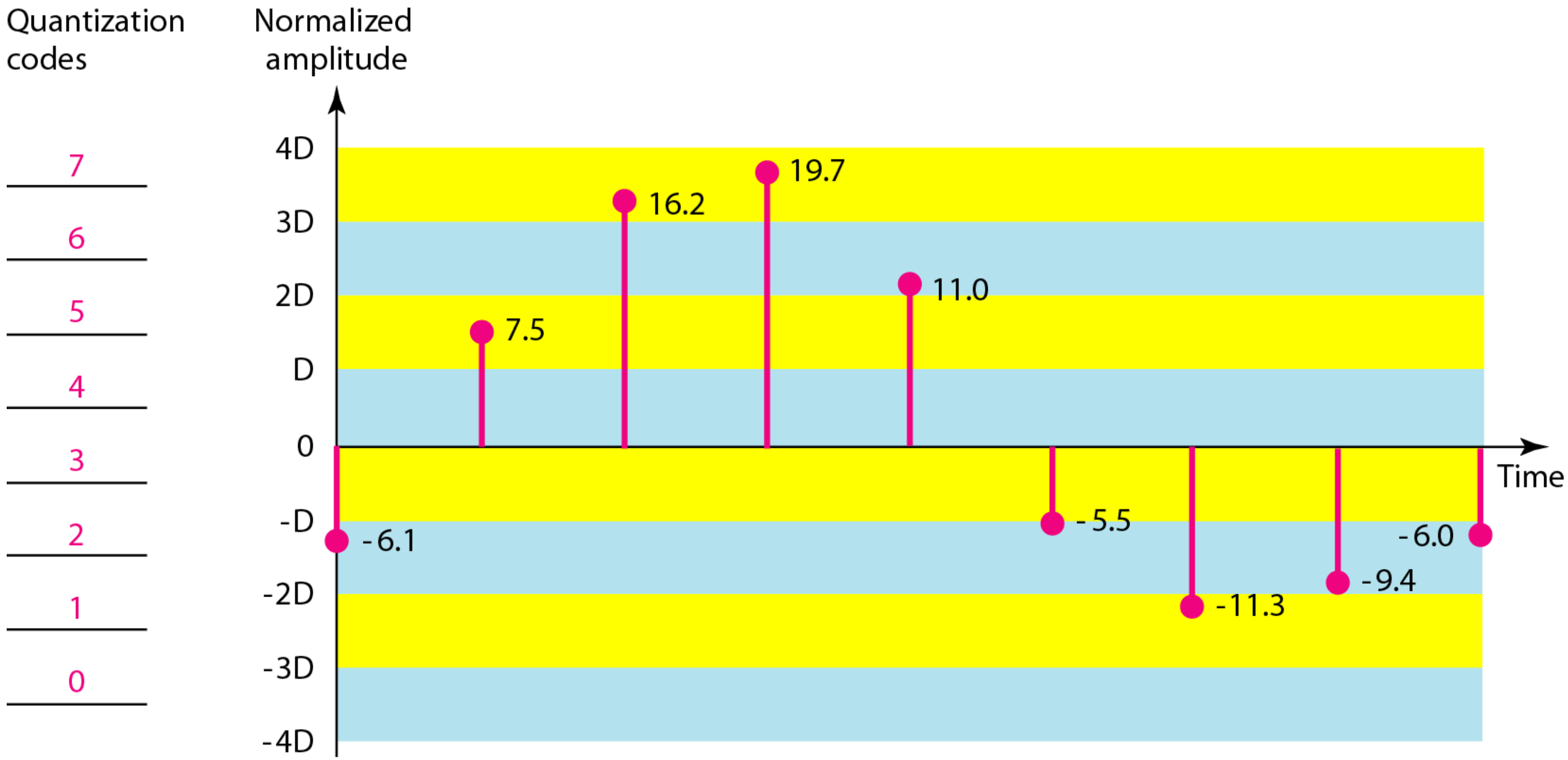
Quantization –

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 two limits.

The following are the steps in Quantization:

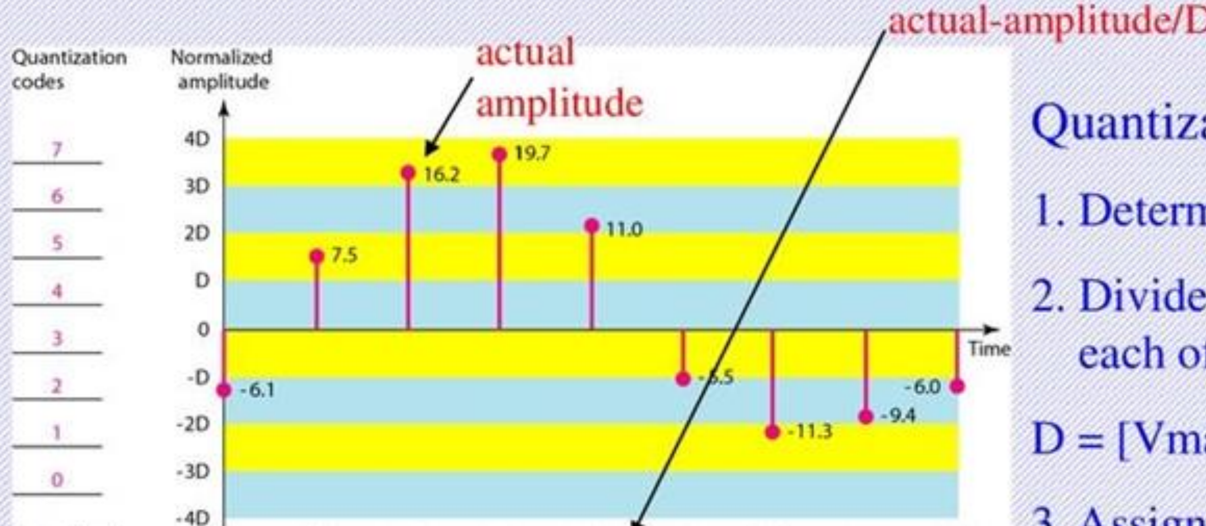
1. We assume that the signal has amplitudes between Vmax and Vmin
2. We divide it into L zones each of height d where,
   d= (Vmax- Vmin)/ L
3. The value at the top of each sample in the graph shows the actual amplitude.
4. The normalized pulse amplitude modulation(PAM) value is calculated using the formula amplitude/d.
5. After this we calculate the quantized value which the process selects from the middle of each zone.
6. The Quantized error is given by the difference between quantised value and normalised PAM value.
7. The Quantization code for each sample based on quantization levels at the left of the graph.



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

Figure 1 ***Quantization and encoding of a sampled signal***

Quantization and encoding of a sampled signal



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Norm. Actual

Error between actual and nornalized

Quant. value for code

Code that represents the voltage level

Quantization steps:

1. Determine V_{min} and V_{max}
2. Divide range into L zones, each of height D

D = [Vmax - Vmin]/L

3. Assign quantized values of 0 to L-1 to midpoint of each zone
4. Map the sample value to a quantized value

Assume sample amplitudes between -20V and +20V

Let L = 8 (levels) – therefore, D = [20 - -20]/8 = 5

Bit rate = sampling rate x # of bits per sample = f_s x n_b

Encoding –

The digitization of the analog signal is done by the encoder. After each sample is quantized and the number of bits per sample is decided, each sample can be changed to an n bit code. Encoding also minimizes the bandwidth used.

# # #

What is the SNR_{dB} in the example of Figure 1?

Solution

We can use the formula ($SNR_{dB} = 6.02\, n_b + 1.76$) to find the quantization. We have eight levels and 3 bits per sample, so

$$SNR_{dB} = 6.02(3) + 1.76 = 19.82\ dB$$

Increasing the number of levels increases the SNR.

# # #

A telephone subscriber line must have an SNR_{dB} above 40. What is the minimum number of bits per sample?

Solution

We can calculate the number of bits as

$$\boxed{\mathrm{SNR}_{\mathrm{dB}} = 6.02n_b + 1.76 = 40 \longrightarrow n = 6.35}$$

Telephone companies usually assign 7 or 8 bits per sample.

We want to digitize the human voice. What is the bit rate, assuming 8 bits per sample?

Solution

The human voice normally contains frequencies from 0 to 4000 Hz. So the sampling rate and bit rate are calculated as follows:

Sampling rate = 4000 × 2 = 8000 samples/s
Bit rate = 8000 × 8 = 64,000 bps = 64 kbps

[**Formula:** Bit rate = Sampling rate (F_s) x No. of bits per sample (n_b)]

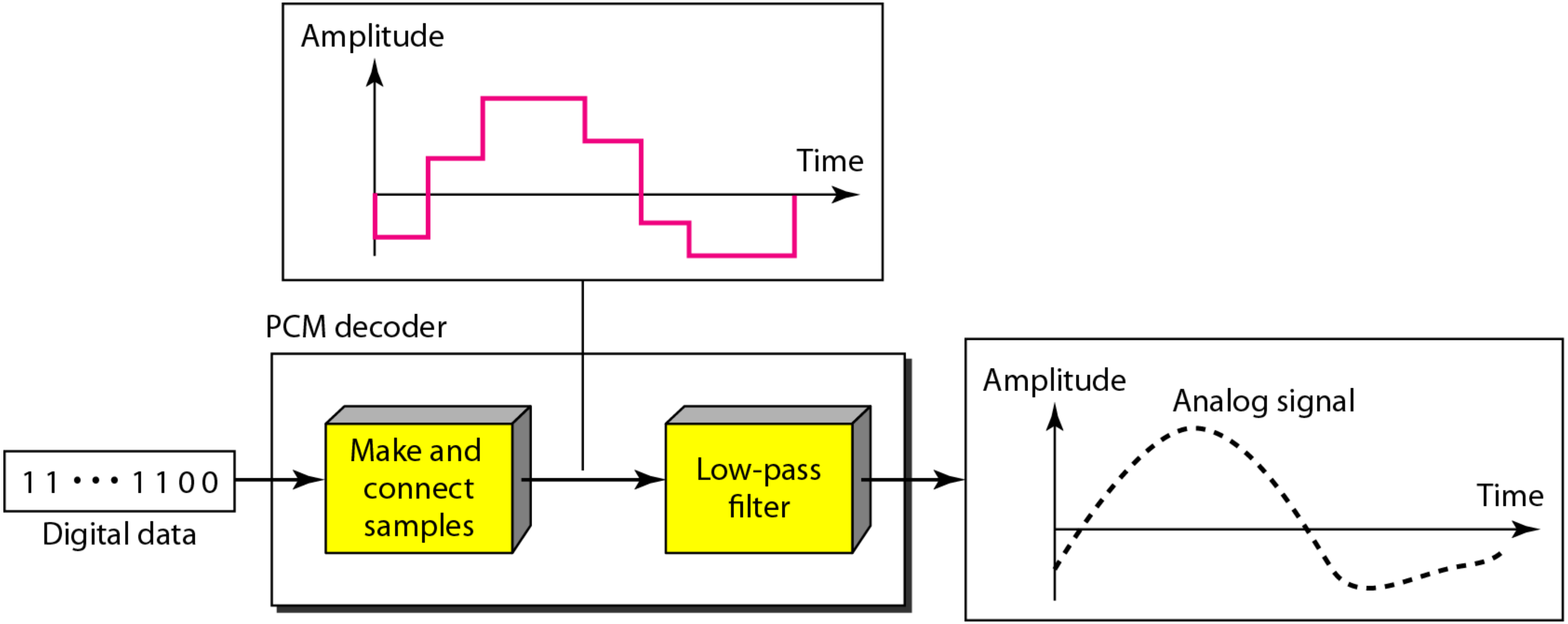

Figure 2 ***Components of a PCM decoder***

Delta Modulation

Since PCM is a very complex technique, other techniques have been developed to reduce the complexity of PCM. The simplest is delta Modulation. Delta Modulation finds the change from the previous value.

Modulator – The modulator is used at the sender site to create a stream of bits from an analog signal. The process records a small positive change called delta. If the delta is positive, the process records a 1 else the process records a 0. The modulator builds a second signal that resembles a staircase. The input signal is then compared with this gradually made staircase signal.

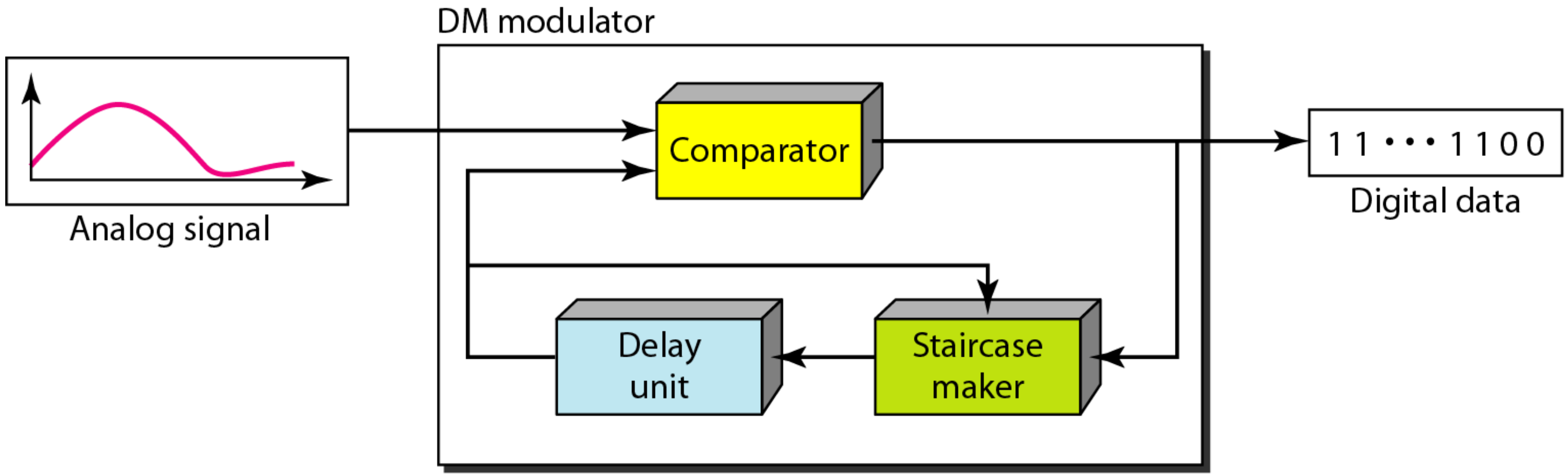

Figure 3 ***Delta modulation components***

We have the following rules for output:

1. If the input analog signal is higher than the last value of the staircase signal, increase delta by 1, and the bit in the digital data is 1.
2. If the input analog signal is lower than the last value of the staircase signal, decrease delta by 1, and the bit in the digital data is 0.

- Note that we need a delay unit to hold the staircase function for a period between two comparisons.

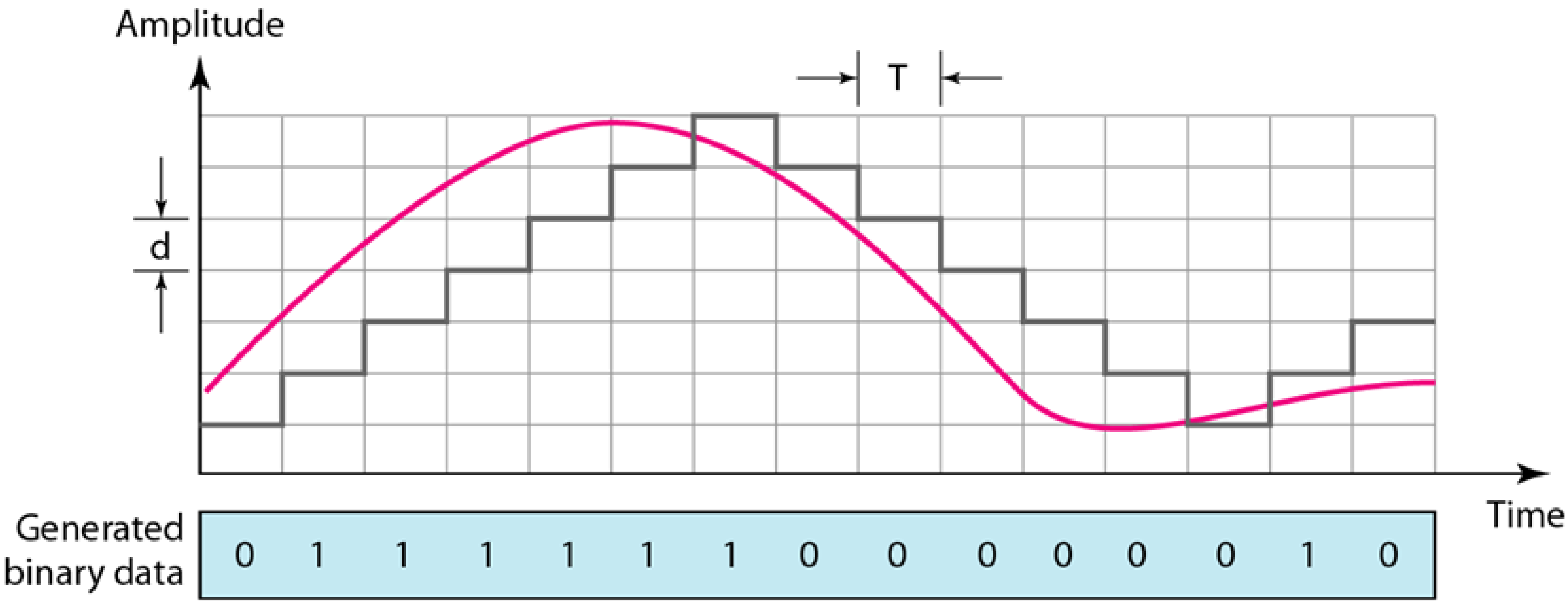

Figure 4 ***The process of delta modulation***

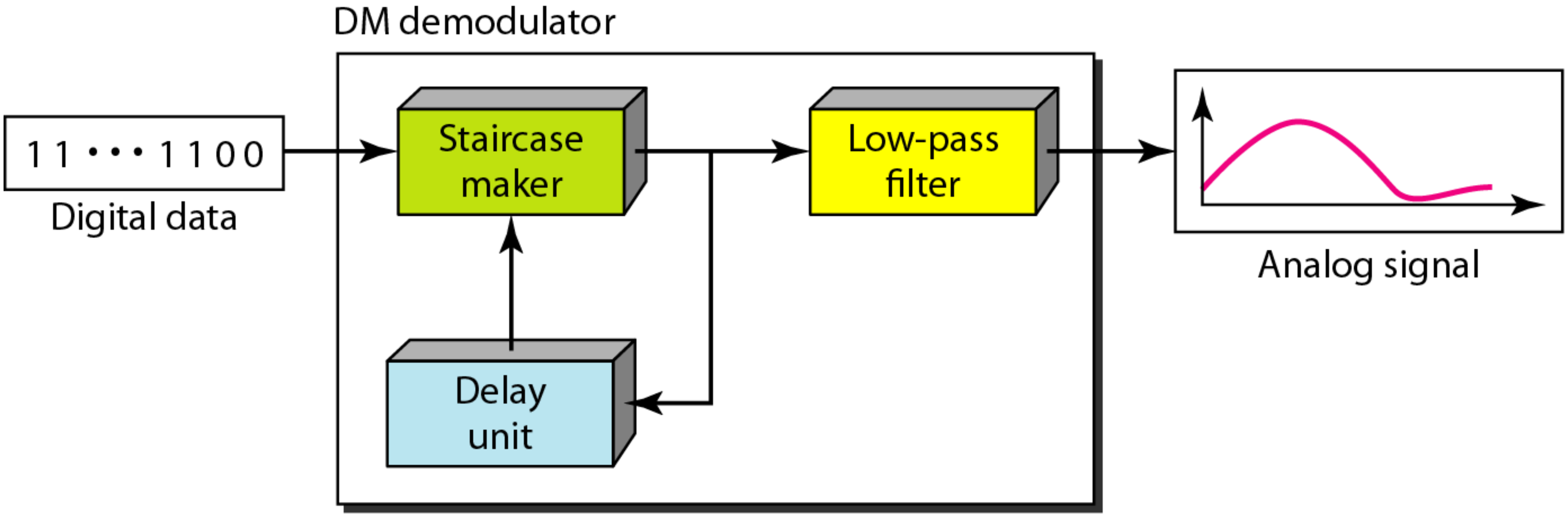

Figure 5 ***Delta demodulation components***

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 pulse. In serial mode, 1 bit is sent with each clock pulse. While there is only one way to send parallel data, there are three subclasses of serial transmission: asynchronous, synchronous, and isochronous.

Topics to be discussed in this section:

Parallel Transmission
Serial Transmission

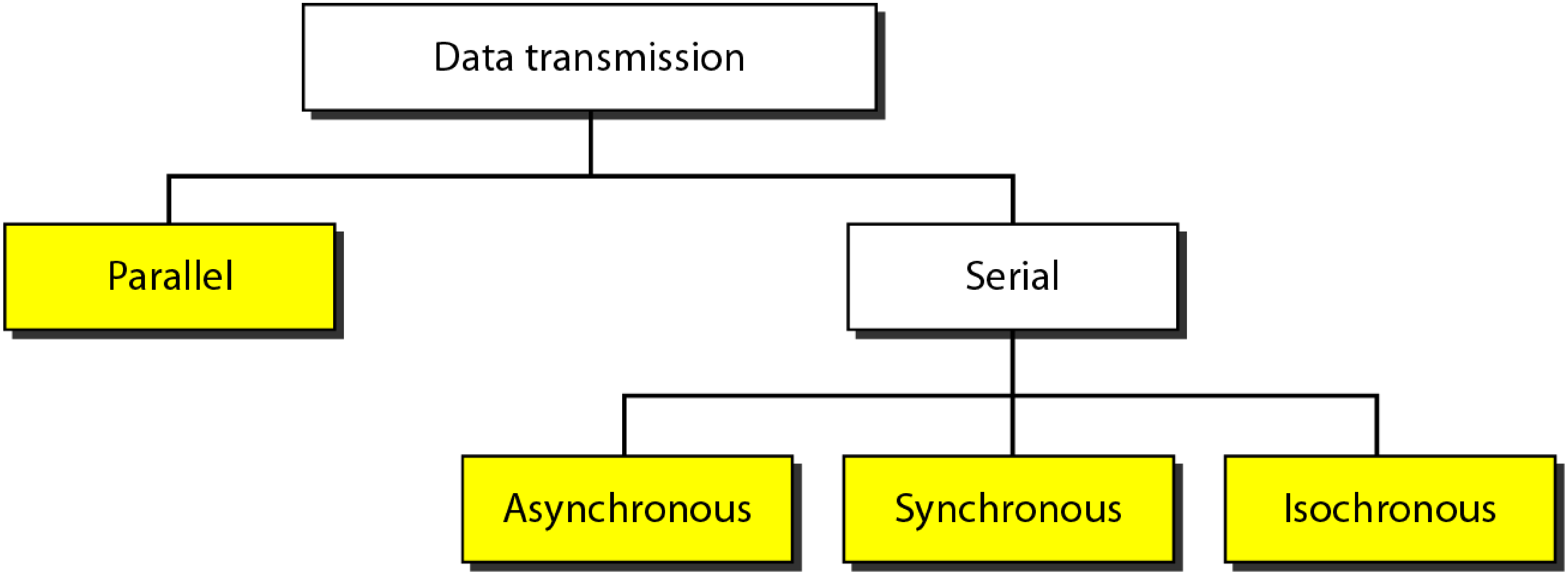

Figure 6 ***Data transmission modes***

Parallel Transmission

In Parallel Transmission, multiple bits flow together simultaneously from one device to another device. Parallel Transmission is faster than serial transmission to transmit the bits. Parallel transmission is used for short distance.

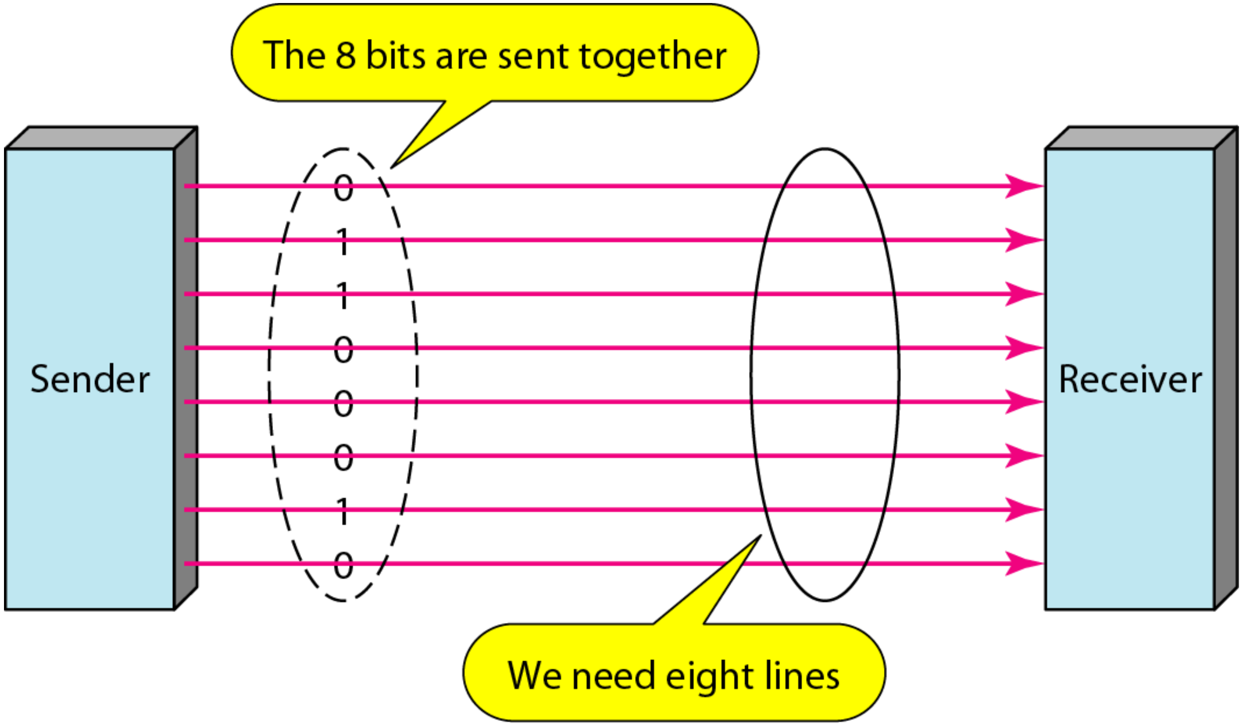

Figure 7 ***Parallel transmission***

That's all for today

Thank You