

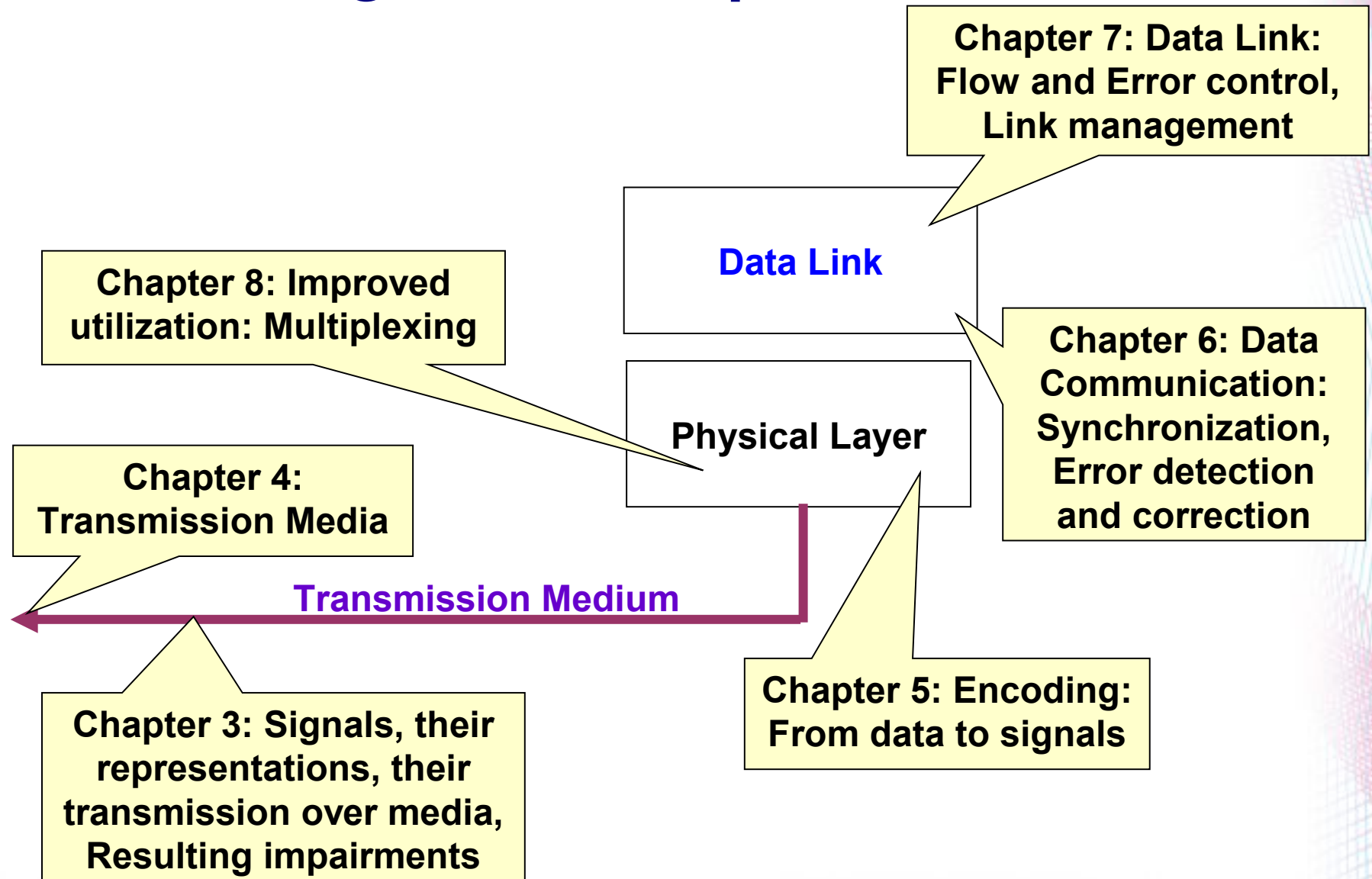
# CAN 1011: Data Communication

- Transmission Basics
- Analogue and Digital Data Transmission

# Contents

- Transmission terminologies
- Analogue & Digital Data
- Analogue & Digital Signals
- Analogue & Digital Transmission

# Remaining Six Chapters



# Terminology

Transmission system components:

- Transmitter
- Receiver
- Medium
  - Guided media
    - e.g. twisted pair, coaxial cable, optical fibre
  - Unguided media (radiated)
    - e.g. air, water, vacuum

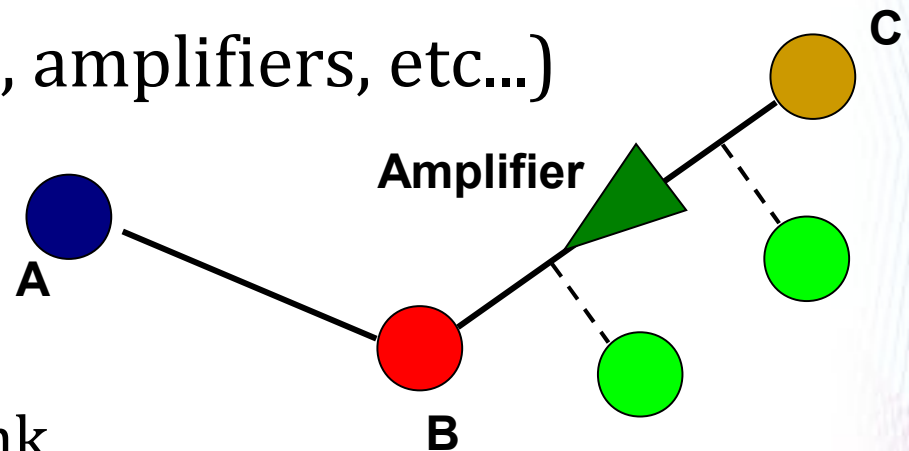
# Terminology

## Link Configurations:

- Direct link
  - No **intermediate** ‘communication’ devices (these exclude repeaters, amplifiers, etc...)

### Two types:

- Point-to-point (A-B)
  - Only 2 devices share link
- Multi-point (C-B)
  - More than two devices share the same link, e.g. **Ethernet** bus segment



# Analogue & Digital Data Transmission

- Data
  - Entities that convey meaning
- Signals
  - Electric or electromagnetic representations of **data**
- Transmission
  - Processing and propagation of **signals** that ultimately represent data

# Analogue & Digital Data in nature

- Analogue **Data**
  - **Continuous** values within some interval
  - **Examples**: audio, video
  - Typical bandwidths:
    - Human Voice: 100 Hz to 8 kHz
    - Speech over telephone: 300 Hz to 3400 Hz
    - Video: 0 to 4 MHz
- Digital **Data**
  - **Discrete** values (not necessarily binary)
  - **Examples**: integers, text characters, mixture: 2347, “text”, SDR054,...

# Analogue and Digital Signals

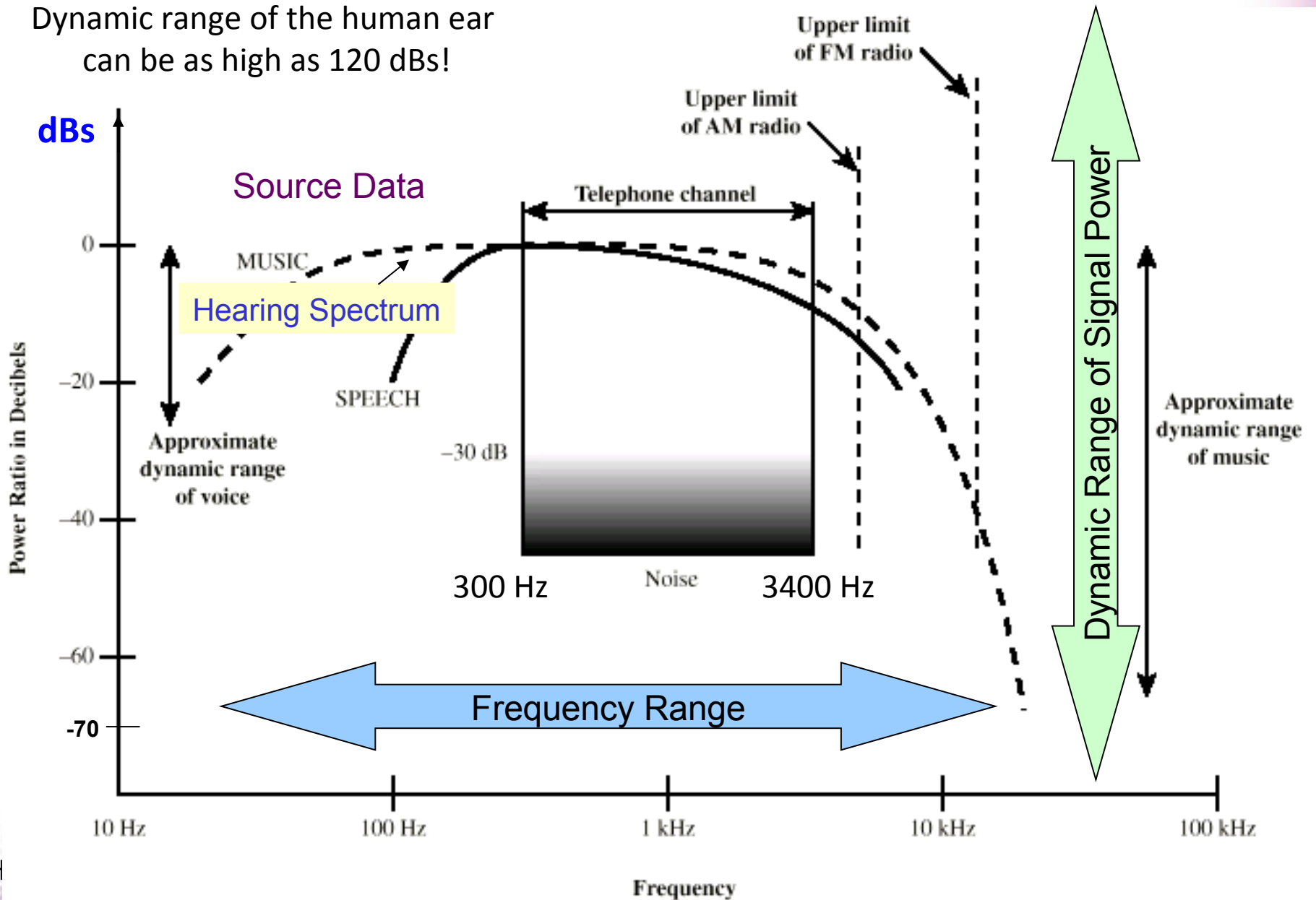
- Means by which data get represented for transmission over various media, e.g. wire, fibre optic, space, etc
  - Analog **signal**:
    - Continuously variable in time and amplitude
  - Digital **signal**:
    - Uses a few (two or more) DC levels

# Analogue data constructed as an analogue signals e.g. Speech Data

- Frequency range for human **hearing**: 20Hz - 20kHz
  - Almost fully utilized by **music**
  - Human **voice**: 100Hz - 7kHz
  - **Telephone voice channel**: Spectrum is further limited to 300 - 3400Hz (why?)
- **Mechanical** sound waves (data) are easily converted into **electromagnetic** signal for processing and transmission:
  - Mechanical waves (sound) of varying pitch and loudness (**data**) **is represented as** electromagnetic signals of different frequencies and amplitudes (**signal**)

# Example 1: The Acoustic

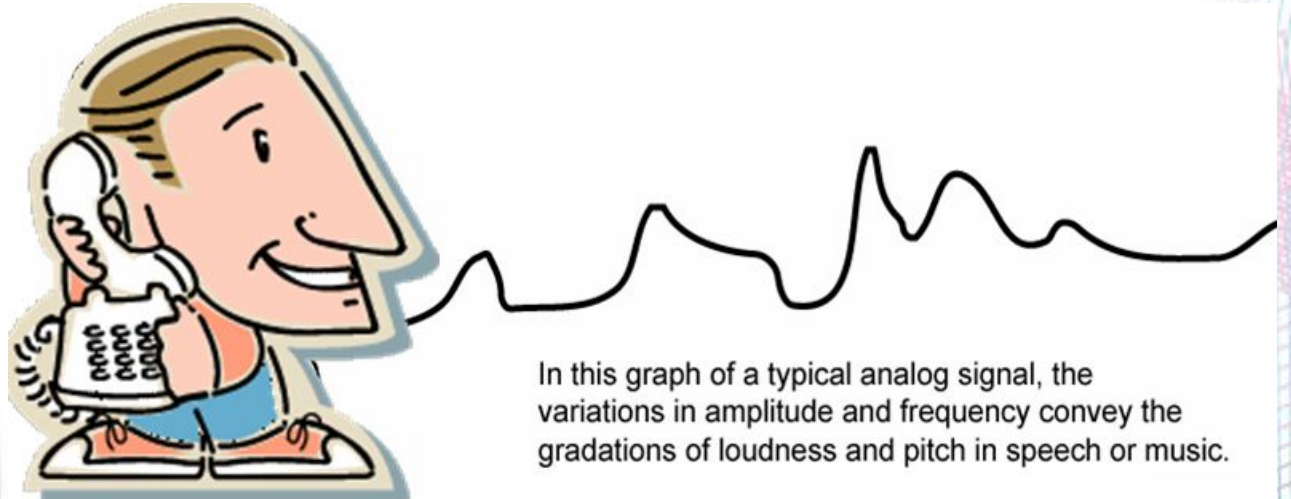
Dynamic range of the human ear can be as high as 120 dBs!



# Conventional Telephony

## Analogue data -> Analogue signal

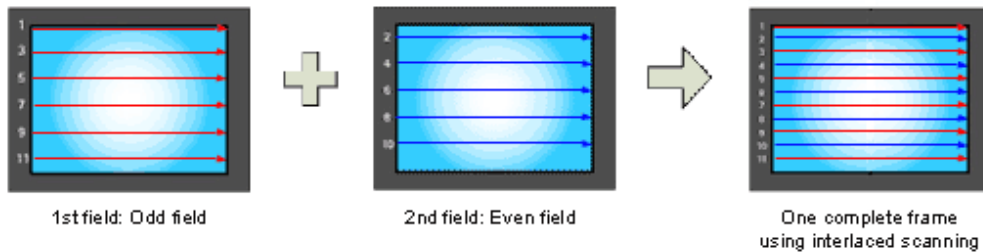
- Telephone mouthpiece converts mechanical voice analogue data into electromagnetic analogue electrical signal
- Signal is transmitted over telephone lines in an analogue or digital manner.
- At receiver, speaker re-converts received electrical signal to voice



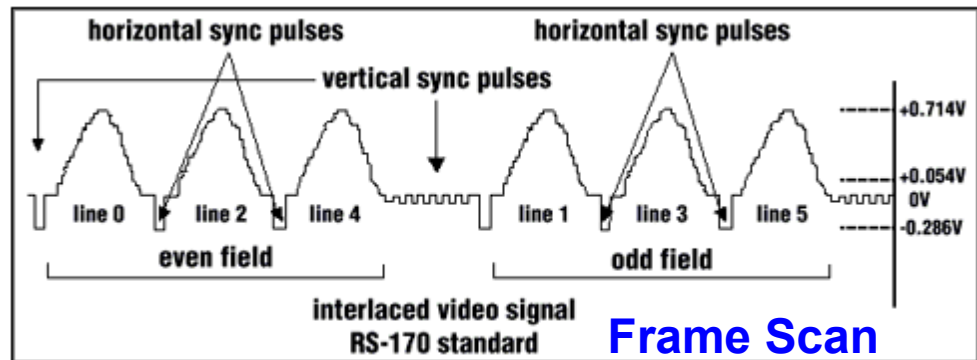
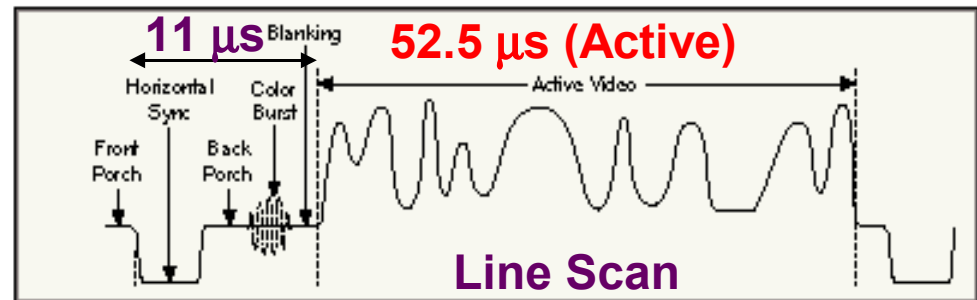
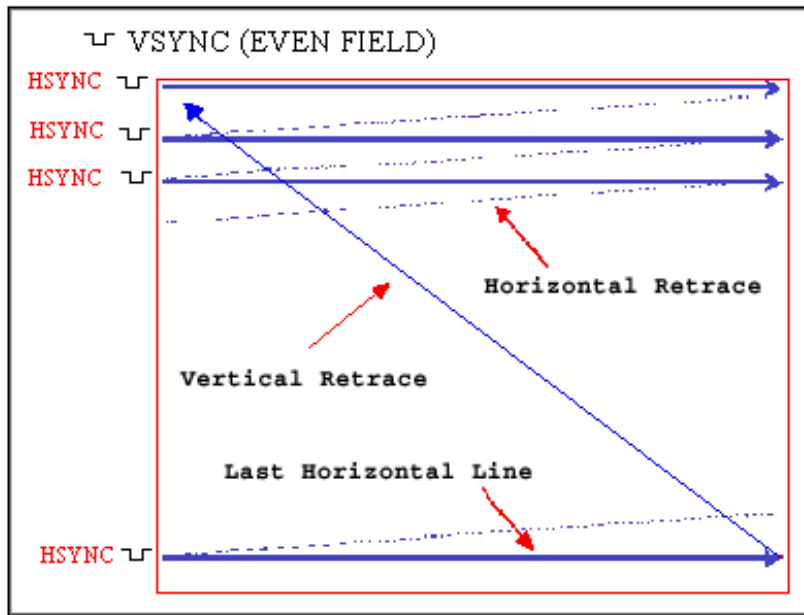
In this graph of a typical analog signal, the variations in amplitude and frequency convey the gradations of loudness and pitch in speech or music.

# Example 2. Video Data

- Electrical signal proportional to the brightness of image spot on a raster-scanned phosphor screen



Interlaced Scan:  
Odd lines field +  
Even lines field = Frame

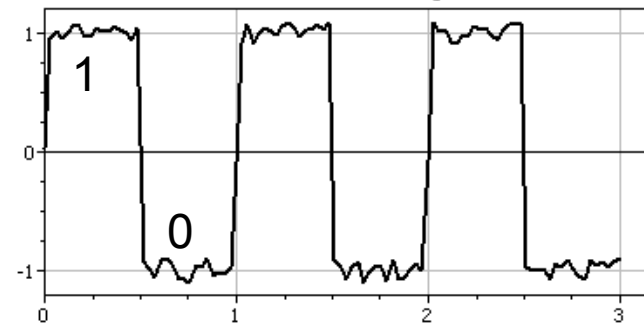


# Digital data represented as digital (baseband) signals

## Advantages:

- Cheaper and easier to generate: No extra processing needed
- Less susceptible to noise (*“Threshold effect”*)

Threshold



## Disadvantages:

- When noise is above threshold → **Total data reversal** (Bit error) ( $1 \rightarrow 0, 0 \rightarrow 1$ )
- Greater attenuation
  - Line capacitances make pulses rounded and smaller in amplitude, leading to loss of information
  - More so at higher data rates and longer distances
  - So, use at **low data rates** over **short distances**

# Attenuation of Digital Signals (later)

Increasing Data Rate



Voltage at transmitting end



Voltage at receiving end



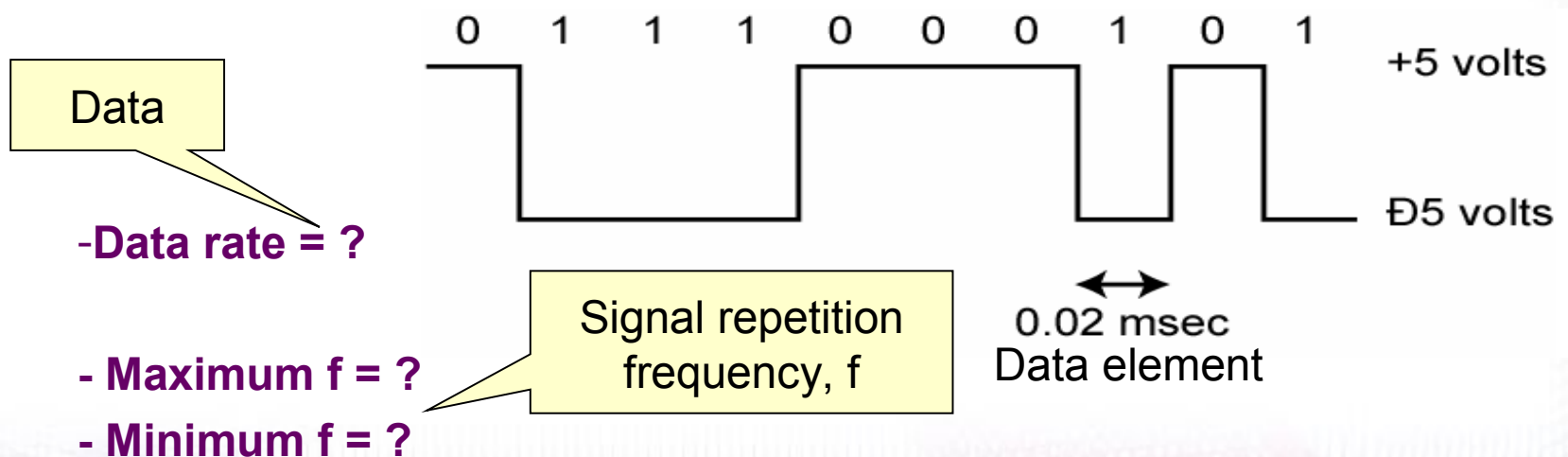
Pulse shaping  
Due to line capacitances:  
Worse over longer distances

Effect of line capacitances

Worse at higher data rates  
(narrower pulses)  
→ Weaker received signal

# Digital Binary (Base band) Signal

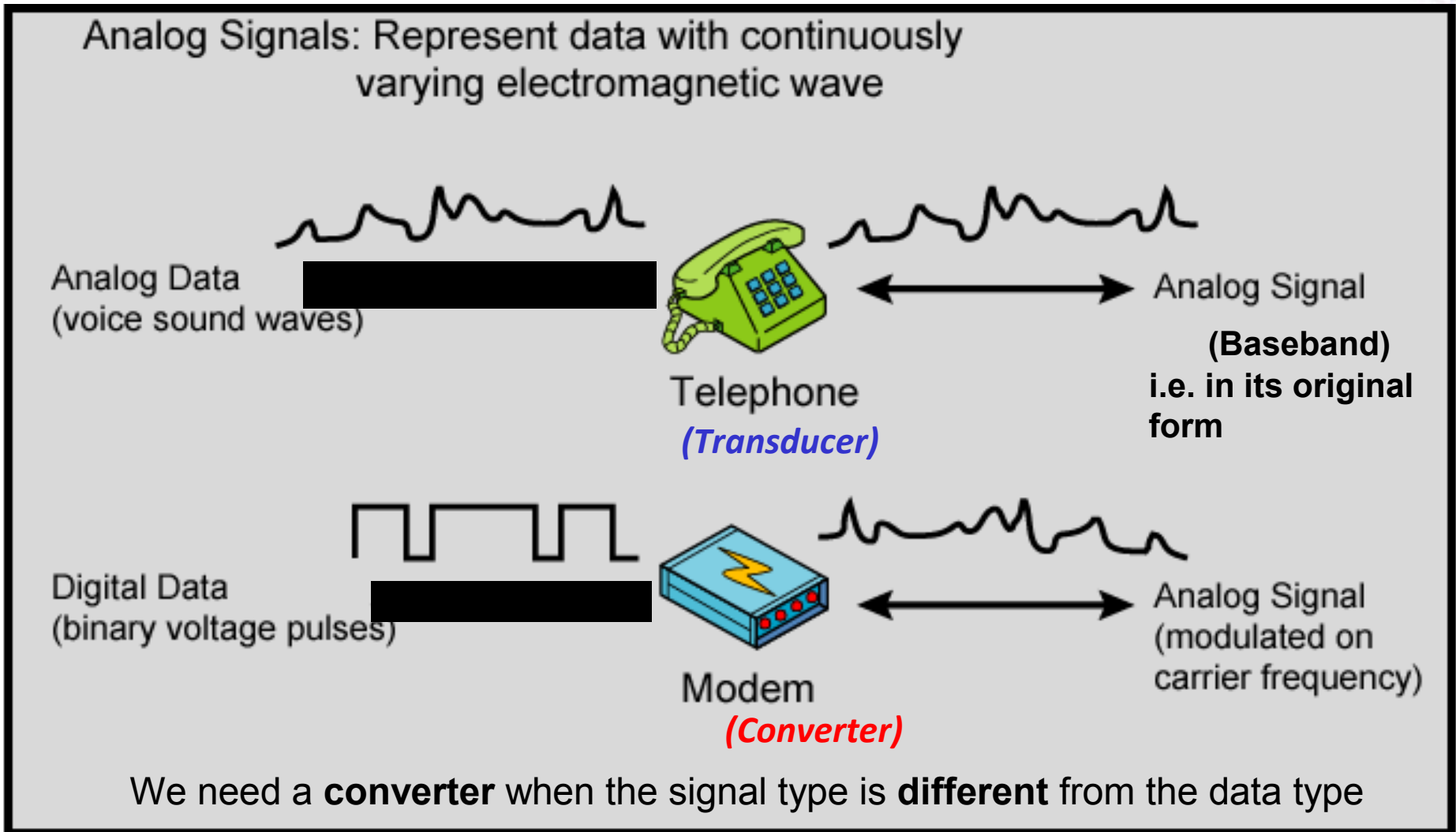
- Example: Between keyboard and computer
- Two bipolar DC levels (+ and - : Why?)
- Bandwidth required depends on the signal frequency, which depends on:
  - The data rate (bps) and
  - The actual data sequence transmitted



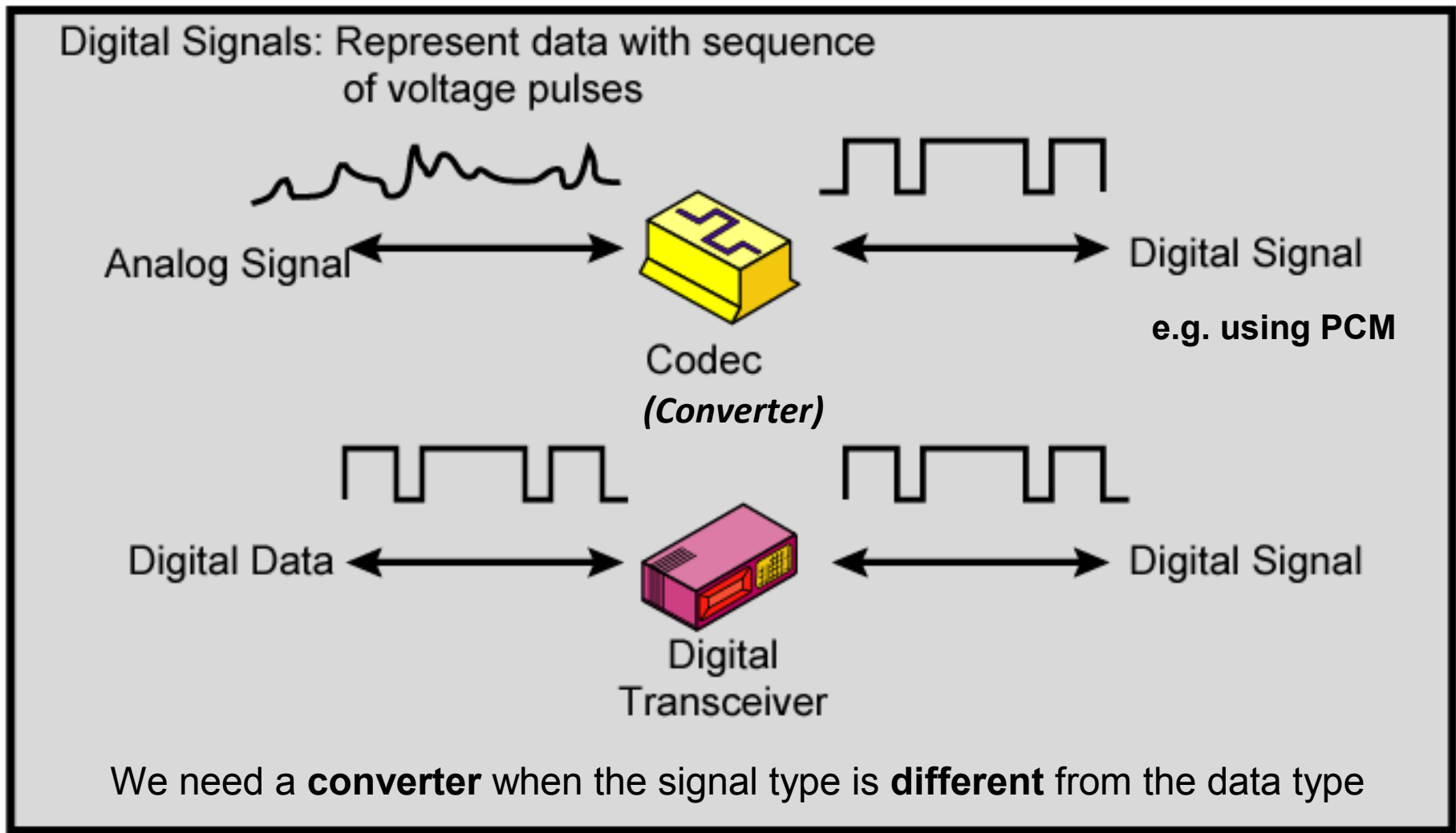
# Data and Signal combinations

- We have seen above: (data and signal of same type)
  - Simple- one only needs a **transducer** or **transceiver**
    - Analogue signals carrying analogue data: Telephony, Video
    - Digital signals carrying digital data: Keyboard to PC
- But we may also have: (data and signal of different types)
  - More complex- Need a **converter**
    - Analogue signal representing digital data: e.g. digital data over telephone wires (use a modem)
    - Digital signal representing analogue data: CD Audio, PCM (pulse code modulation) (use a codec)
- So, all the four data-signal combinations are possible!

# Analogue Signals can carry either Analogue Data or Digital Data



# Digital Signals can carry either Analogue Data or Digital Data



# Four Data/Signal Combinations

		Signal	
		Analogue	Digital
Data	Analogue	<p><i>Two ways:</i></p> <p><i>Signal has same spectrum as data (baseband): e.g. Telephone to Exchange.</i></p> <p><i>Signal has different spectrum (through modulation): e.g. AM Radio.</i></p>	<p><i>Use a converter like a codec, e.g. for PCM (pulse code modulation)</i></p>
	Digital	<p><i>Use a converter like a modem e.g. V.90 standard</i></p>	<p><i>Simple unipolar signal e.g. NRZ-L or special encoding: e.g. Manchester</i></p>

# Analogue Transmission of Analogue/Digital Signals

- Treats the signal as “analogue” regardless of what it represents i.e. not interested in the data content of signal.
- Following **attenuation** over distance, signal level is boosted using **amplifiers** or **boosters**.
- **Unfortunately, this also amplifies in-band noise.**
- With cascaded amplifiers (i.e. one after the other at locations along the link), effect on **noise** and **distortion** are **cumulative**, i.e. they get amplified again and again.
- **Effect of noise and distortion on analogue systems may be tolerated**, e.g. with telephony you can still manage to get the message! (Humans are good at filling-in the gaps!)
- But digital systems are more sensitive to the effects of excessive noise and distortion → unacceptable error rates!!!
- **So... Do not transmit a digital signal the analogue way!**

# Digital Transmission of Analogue/Digital Signals

- Concerned with the **data content** of the signal.
- It assumes that the signal carries the digital data.
- Uses a **repeater (NOT amplifier)**, which:
  - Receives the signal.
  - **Extracts** the data bit stream from it.
  - Retransmits a new **fresh (clean), strong** signal representing the extracted bit stream.
- This way:
  - We overcome the effect of **attenuation**.
  - **Noise and distortion are NOT cumulative.**

# 4 Signal/Transmission Combinations

		Transmission mode	
		Analogue	Digital
		<ul style="list-style-type: none"> <li>- Uses amplifiers</li> <li>- Not concerned with what data the signal represents</li> <li>- Noise and distortion are cumulative</li> <li>- Associated with FDM</li> </ul>	<ul style="list-style-type: none"> <li>- Uses repeaters</li> <li>- Assumes signal represents digital data, extract this data and presents it as a new outbound signal</li> <li>- This way, noise and distortion are not cumulative</li> <li>- Associated with TDM</li> </ul>
Signal	Analogue	OK if the analogue signal represents analogue data	Makes sense only if the analogue signal represents digital data! What data is the repeater going to extract?
	Digital	Avoid	OK

# Advantages of Digital Transmission

- Use of digital technology
  - Lower cost, smaller size, and high speed VLSI technology (now!!!)
- Higher data integrity (reliability) as noise effects are not cumulative
  - Cover longer distances, at higher data rate, at low error rates, over lower quality lines, etc.
- Easier to implement 'muxing' for improved utilization of link capacity
  - High bandwidth links are now economical (Fibre, Satellite...)
  - To utilize them efficiently we need to do a lot of multiplexing
  - This is done more efficiently using digital TDM rather than analogue FDM (later)
- Other related functions are also done digitally:
  - Compression to reduce bandwidth requirement
  - Encryption for data security and confidentiality
- Easier to integrate different data types
  - Convert analogue data to digital signals...and use one system to handle all voice, video, and data, e.g. one network for all types of traffic