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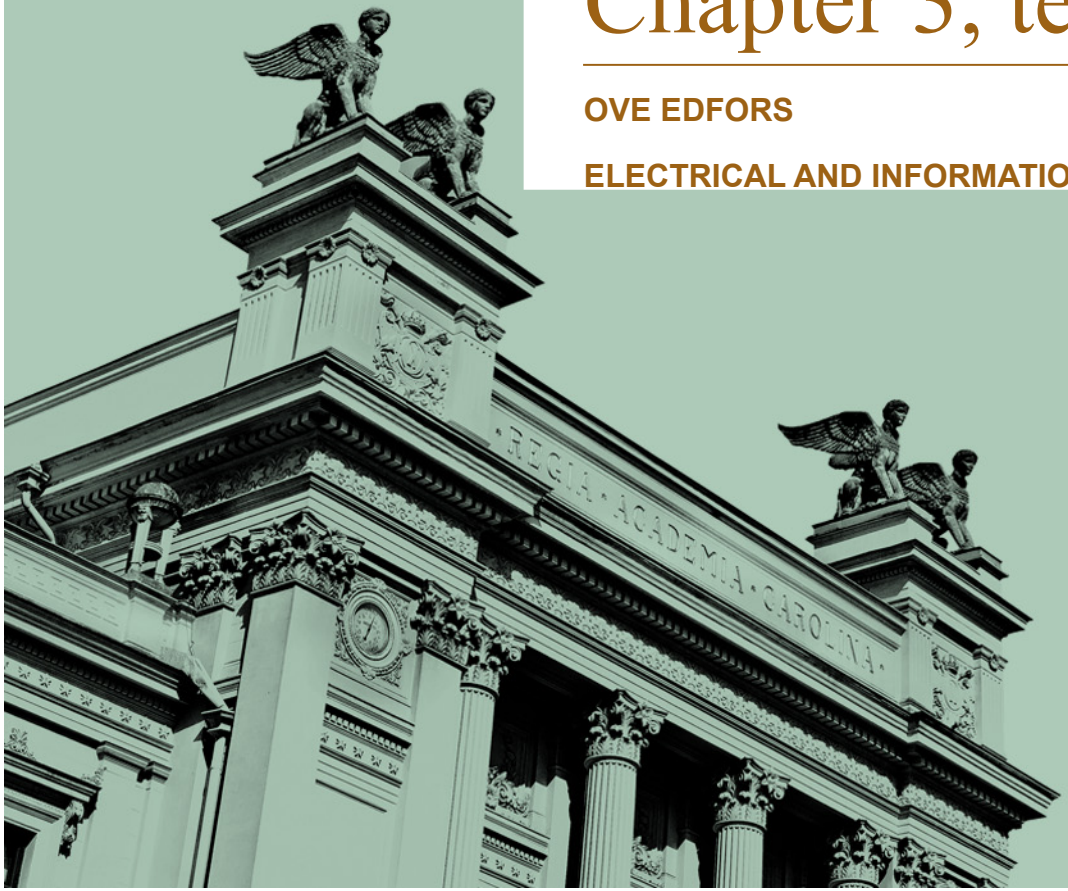
Information Transmission
Chapter 3, text and speech

OVE EDFORS

ELECTRICAL AND INFORMATION TECHNOLOGY



Learning outcomes

Understand

- some of the most important concepts regarding information and its representation (bits, bandwidth, SNR),
- how to perform decibel calculations,
- what text is and how it can be coded,
- signal frequency content/components and spectrum,
- voice generation and properties,
- audio quality measures, and
- basics of (digital) audio/music recording.

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Some concepts

- Bits
  - Small pieces of information
  - The information in a 2-valued variable
- Bandwidth
  - Fourier transform of a signal
  - (The number of bits/s from a source)
- Signal to noise ratio – SNR
  - Average signal power / average noise power

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Decibel - dB

- Convenient when comparing values with a really small difference or a really large one
- If A and B are power values

$$10 \log_{10}(A/B) \text{ dB}$$

- Or if A and B are amplitude values

$$10 \log_{10}(A/B)^2 = 20 \log_{10}(A/B) \text{ dB}$$

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What is text?

Def: A collection of letters (numbers, symbols, …) to form words (math figures, software, crypto-text, …)

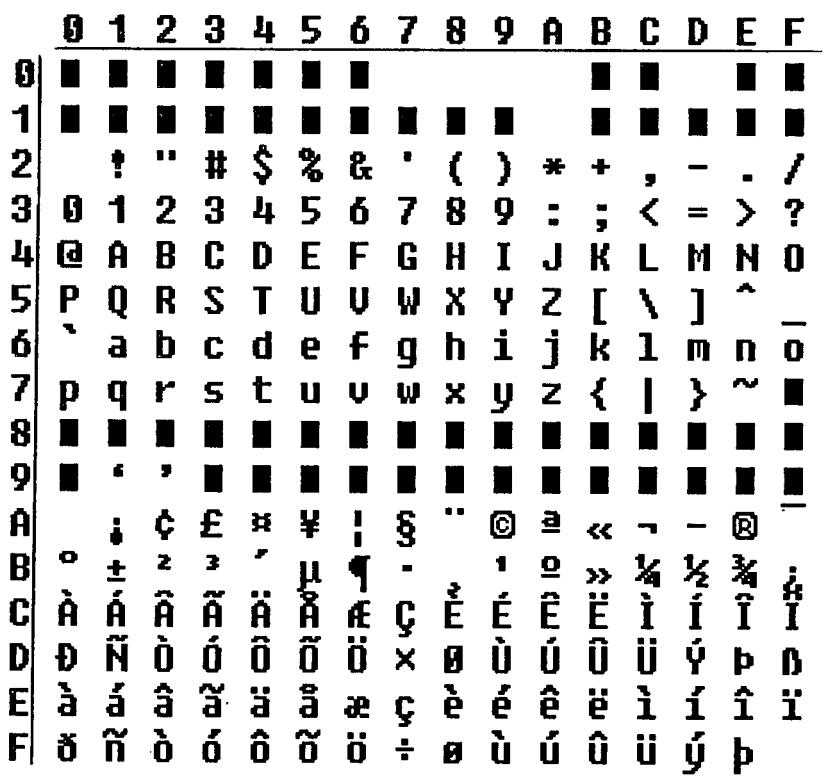
Symbols come from a set called the *alphabet*

Do we have any standard alphabets?

ASCII american standard for information interchange

Binary to Hexadecimal

0000	0
1000	1
0100	2
1100	3
0010	4
1010	5
0110	6
1110	7
0001	8
1001	9
0101	A
1101	B
0011	C
1011	D
0111	E
1111	F



Frequency and bandwidth

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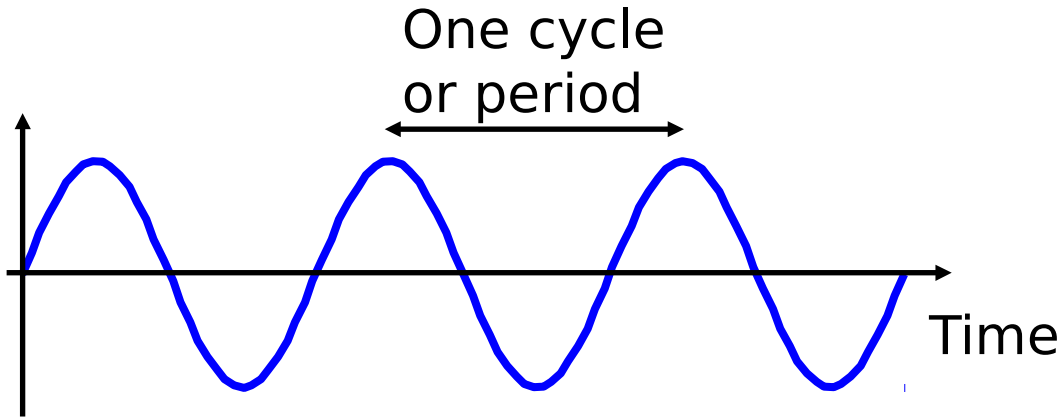
Frequency

Sinusoidal signals:



Frequency = Number of cycles per second [Herz]

Example: The AC power in your home has a frequency of 50 Hertz.
This also means that the cycle time is 20 ms.

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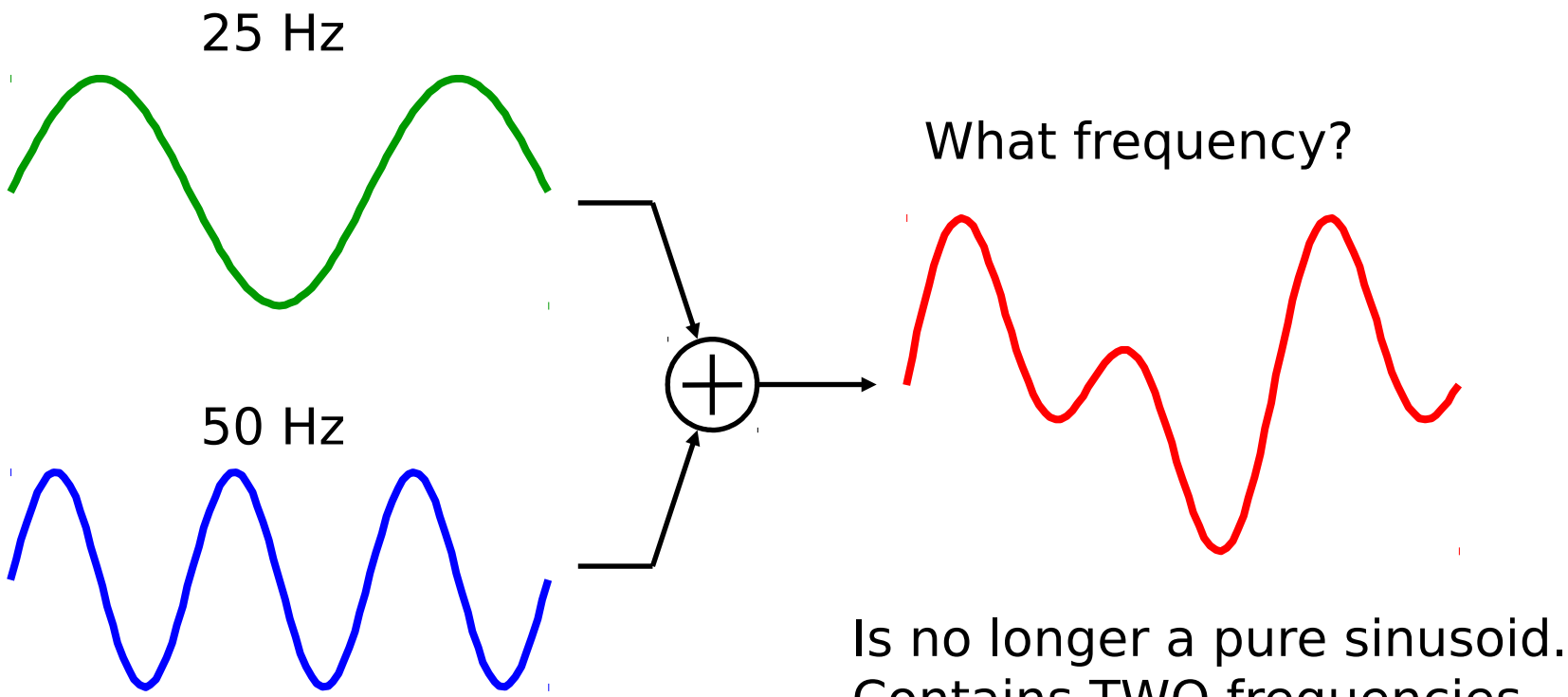
Adding sinusoids [1]



Is no longer a pure sinusoid.
Contains TWO frequencies.

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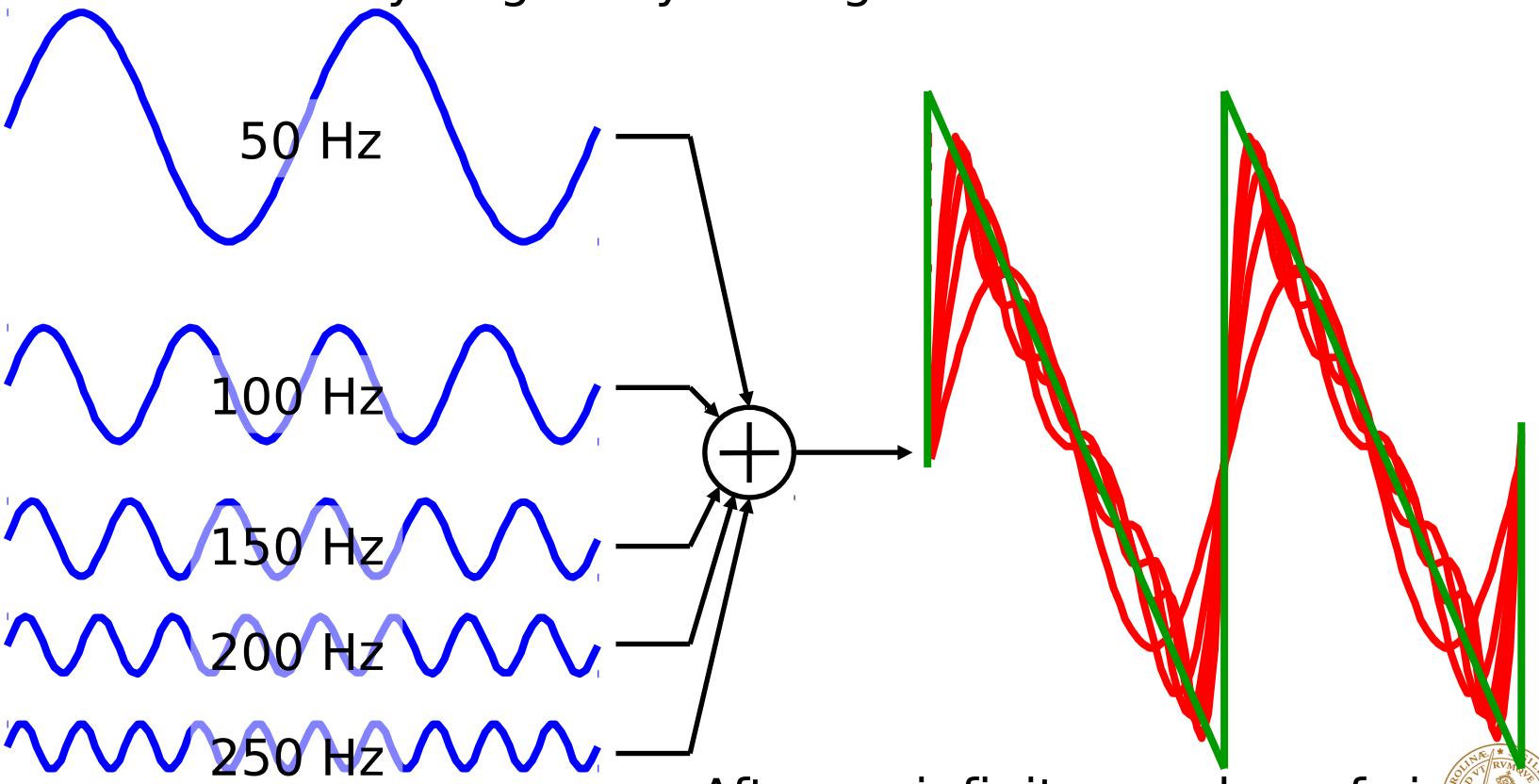
Adding sinusoids [2]

Can we build ”any” signal by adding sinusoids? Yes!



After an infinite number of sinusoids we get a sawtooth signal!

Spectrum

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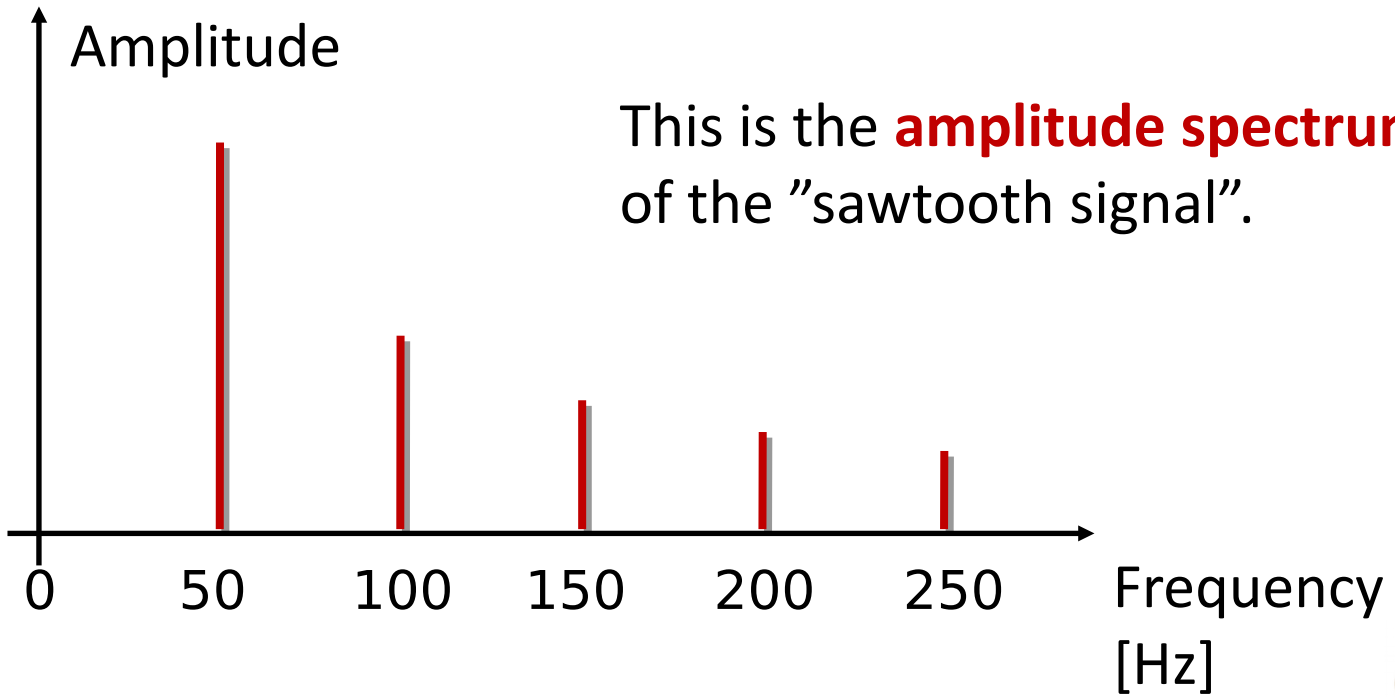
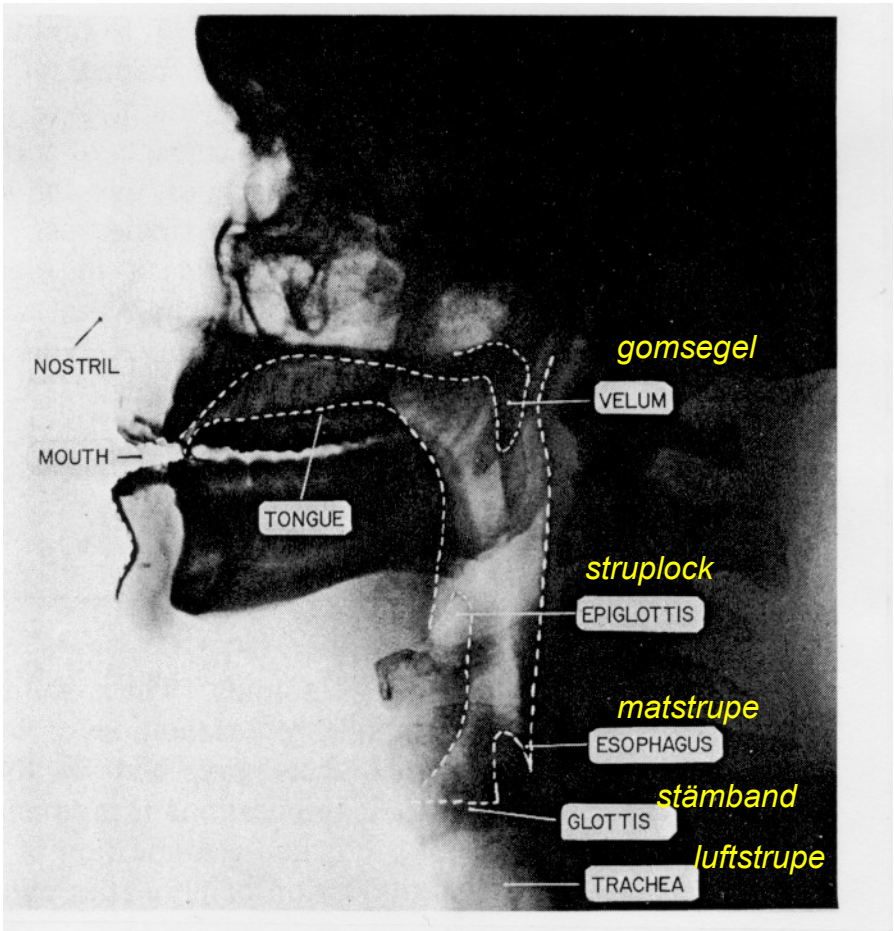
Spectrum [1]

If we can build any signal by adding sinusoids ... can we view the frequency content of a signal in some way?



The vocal tract



- Vocal cord produces the tone, the rest is forming the sound
- Voiced sounds/unvoiced sounds
- 5-10 sounds/s in speech

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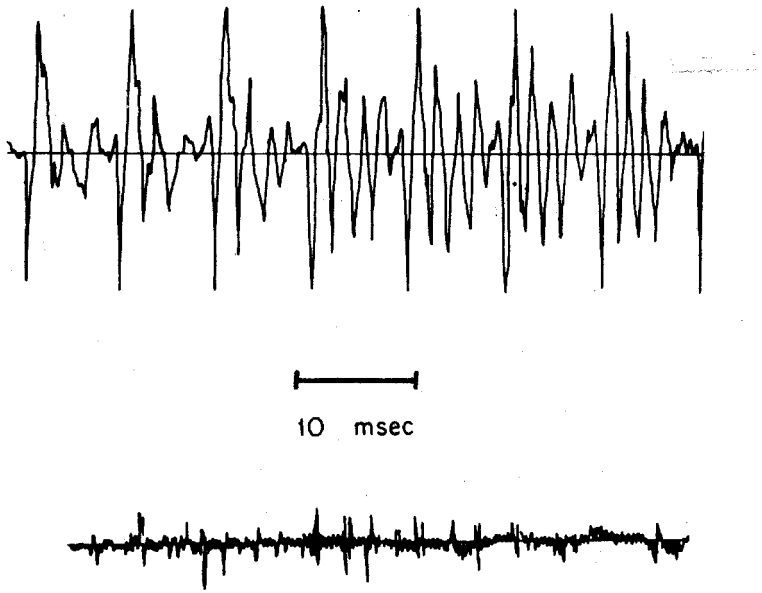
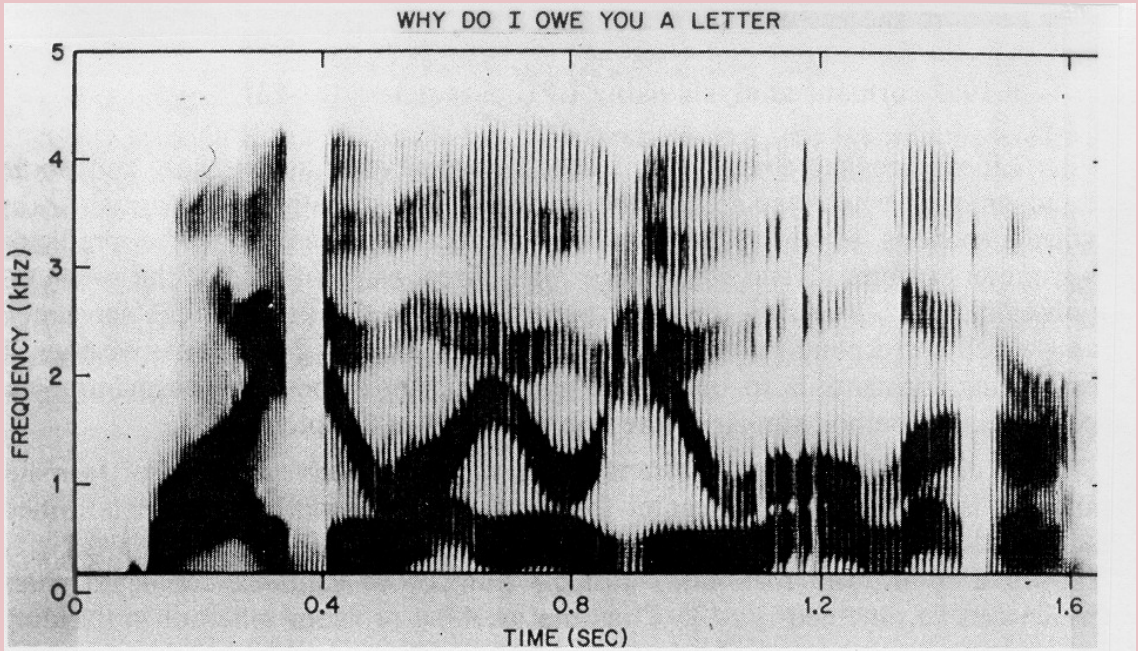
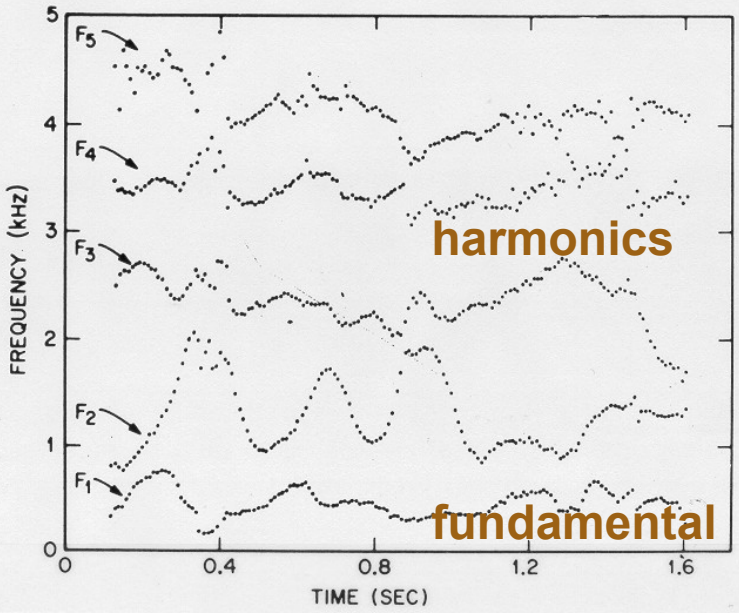
Voiced/unvoiced sounds







Main energy in 100-800 Hz (speaker recognition)

800 Hz-4 kHz (intelligibility range)

Less than 1% above 4 kHz

Demo:
Audio analyzer

Standard phone line

- 40 dB signal to noise ratio (SNR) desired
- 4 kHz bandwidth
- Uses uncompressed PCM, as opposed to cell phones where there is speech coding

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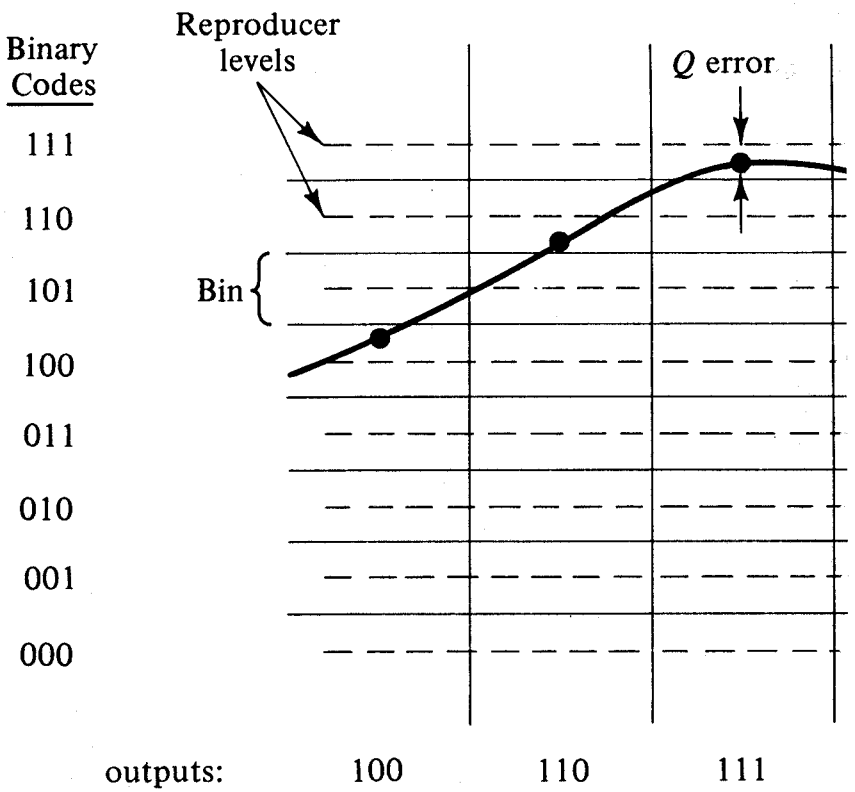
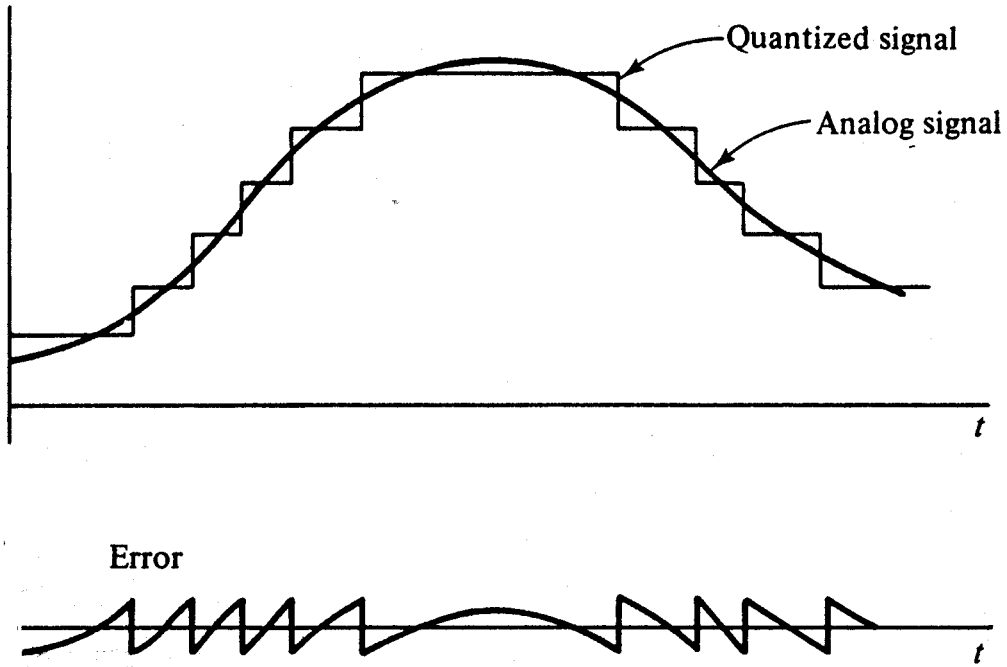
3 bit PCM



- 2^3 regions (bins)
- A deviation means an error – noise
- SNR= $6b$-C_0 dB

- If C_0 =7.3,,,,, how many bits do you need?

Reconstruction error



Music

- Highly dynamic 30-50 dB power variations
- Funtamental tone+overtones, 20-20 000 Hz
  - Sensitive in the range 100-4000 Hz
  - No direction below 100 Hz

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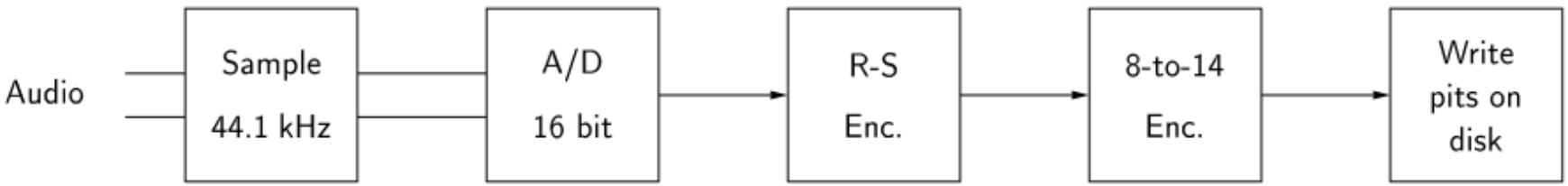
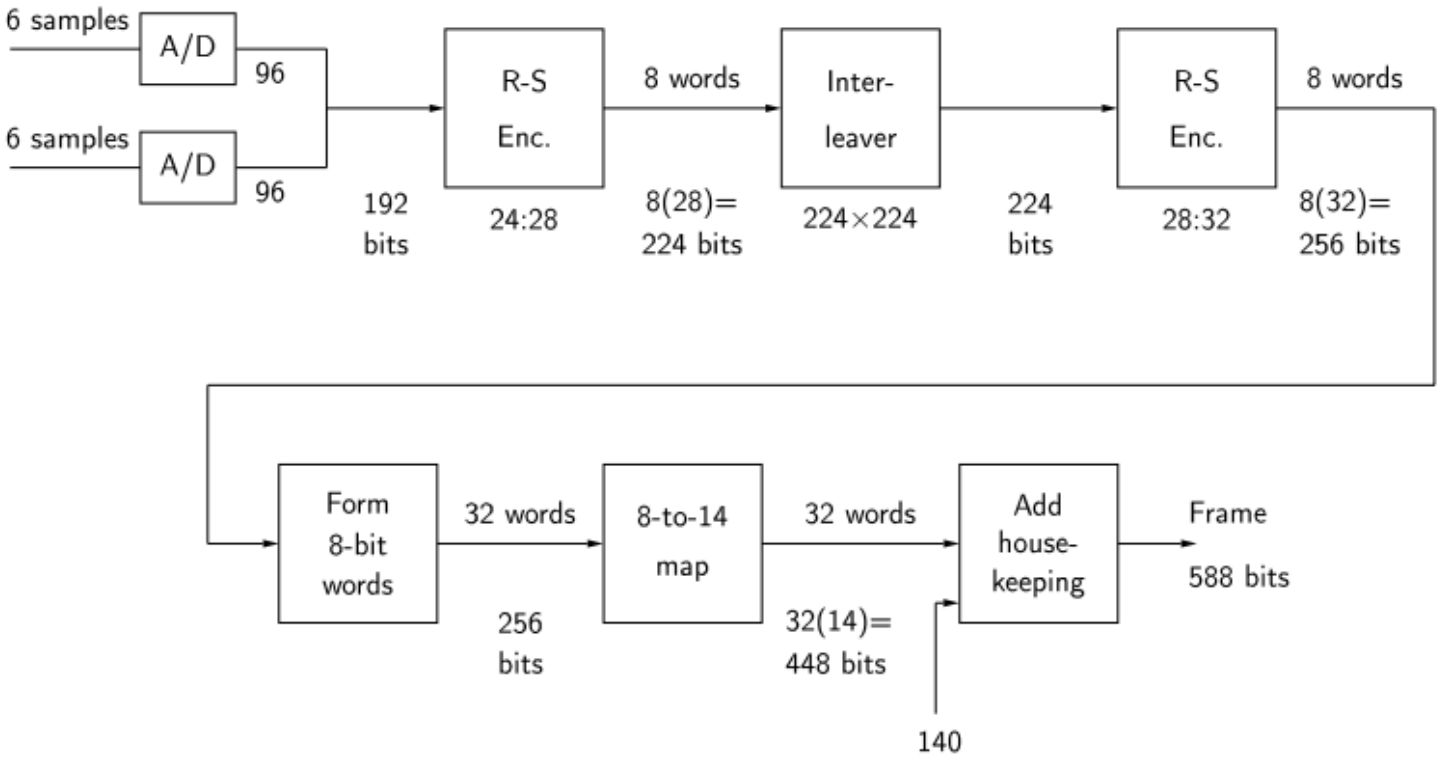
Music recording on a CD



2 channels*44.1 k samples/s*16 bits/sample result in a bit stream of 1.4 Mbit/s

How many bits are there?



SUMMARY

- Signal quality – dB measure
  - Power ratio in dB: $10 \log_{10}(A/B)$ dB
  - Amplitude ratio in dB: $20 \log_{10}(A/B)$ dB
- Text:
  - Sequence letters (symbols from an alphabet) forming words
  - Several coding standards, e.g. ASCII
- Sinusoidal signals
  - Have frequency (period time) and amplitude
  - Can be added to form signals of other shapes
  - Amount of each sinusoidal used (amplitude) called the spektrum
- Voice
  - Voice signals/speech created by vocal cords producing the tone

    … and rest of the voice aparatus forming the spectrum
  - Voiced and univoiced sounds
  - Most information contained below 4 kHz
  - 40 dB SNR PCM coding: 8 kHz sampling x 8 bit/sample = 64 kbit/sek
- Music
  - Different instruments playing the same tone differ in their over-tones
  - Frequency span: from 20 Hz to 20 kHz
  - CD quality PCM (stereo): 44.1 kHz sampling x 2 channels x 16 bit/sample = 1.4 Mbit/sek
  - Error correcting codes used to protect against errors when reading from CD

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