Transmission and interconnection

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Chap 13: Audio interconnection

Chap 14: PC audio

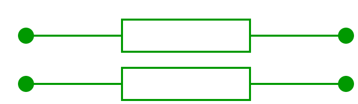
Chap 15: Telecomm and Internet Audio

When does the cable matter?

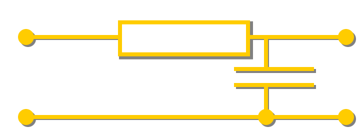
At low frequencies (= audio) in short cables only the *resistance* of the cable matters, and only for *power*.

The *reactance* of a cable becomes important only when the **wavelength of the signal in the cable <= the length of the cable**

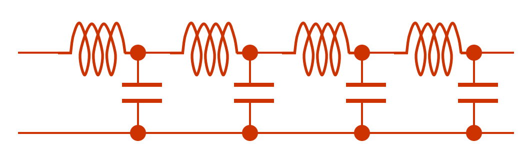
Low frequency $\lambda >> l$



Moderate frequency $\lambda \approx l$



High frequency $\lambda << l$



Transmission line $\lambda << l$

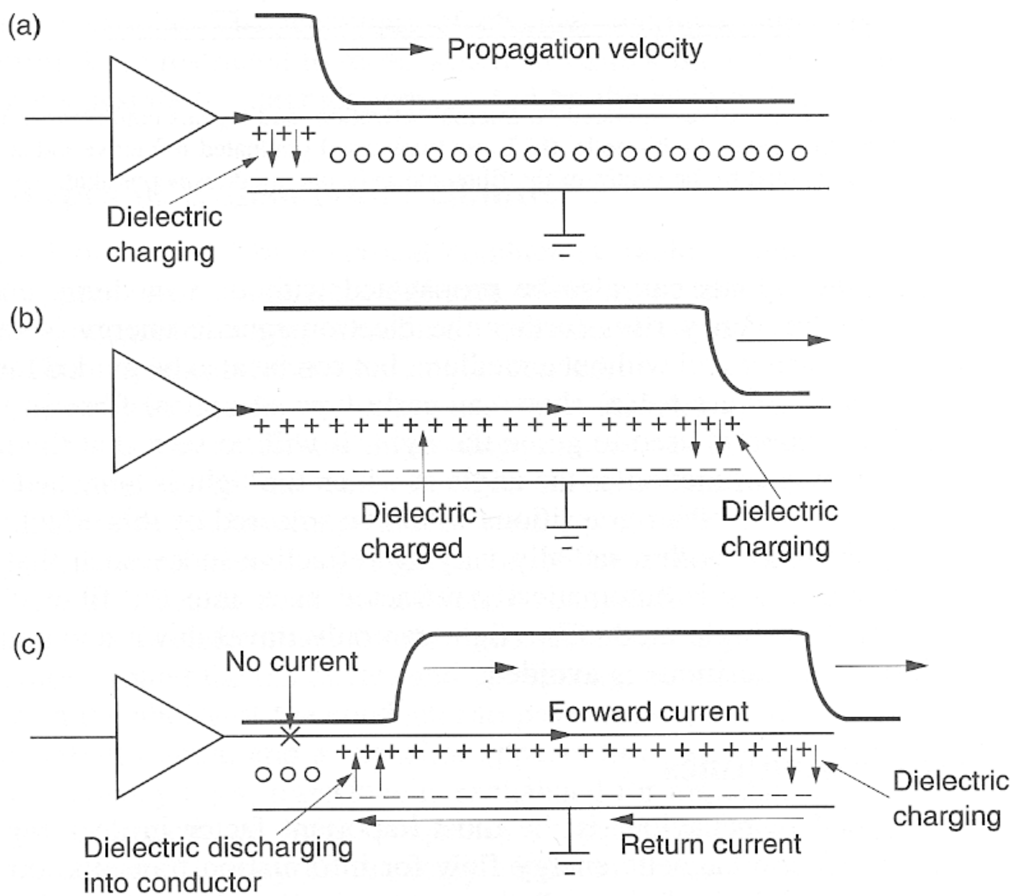
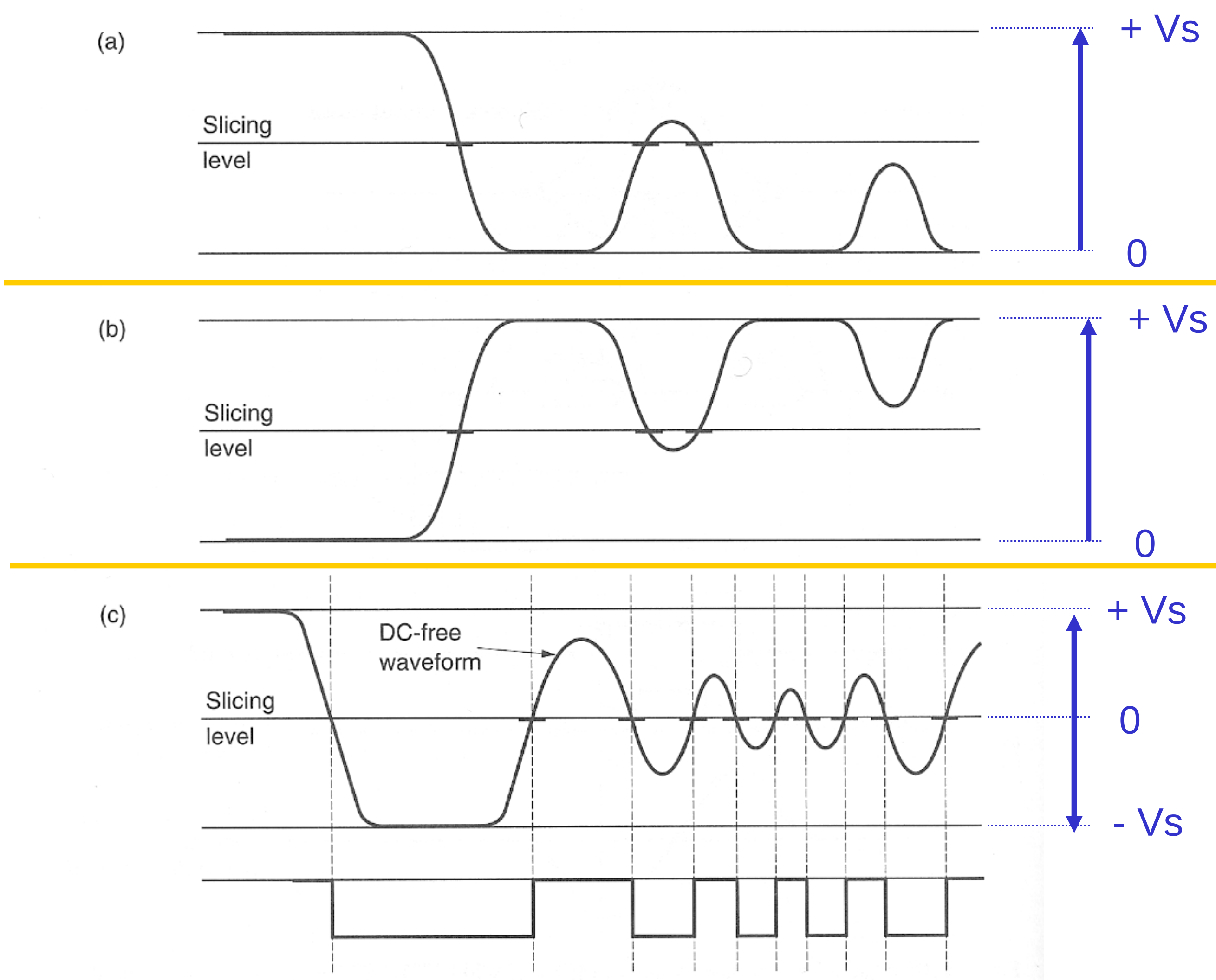


Figure 6.2 A transmission line conveys energy packets which appear with respect to the dielectric. In (a) the driver launches a pulse which charges the dielectric at the beginning of the line. As it propagates the dielectric is charged further along as in (b). When the drive ends the pulse, the charged dielectric discharges into the line. A current loop is formed where the current in the return loop flows in the opposite direction to the current in the 'hot' wire.

The cable is a low-pass filter

Sharp edges become soft

Zero is the best threshold...



and low-pass pulls toward the mean

...so the signal should have the mean value of zero! (*DC free*)

Loudspeaker cables

If you can hear differences of less than 1 dB, you might be able to hear a miniscule difference between a thin cable and a thick cable if they are longer than 3 m.

If your amplifier is prone to oscillate, a cheap resistor termination at the end of the cable might make a tiny difference to the sound.

The cost for these items is on the order of 10 kr.

There is no technical reason to spend big money on speaker cables.

The *detent period* versus *jitter*

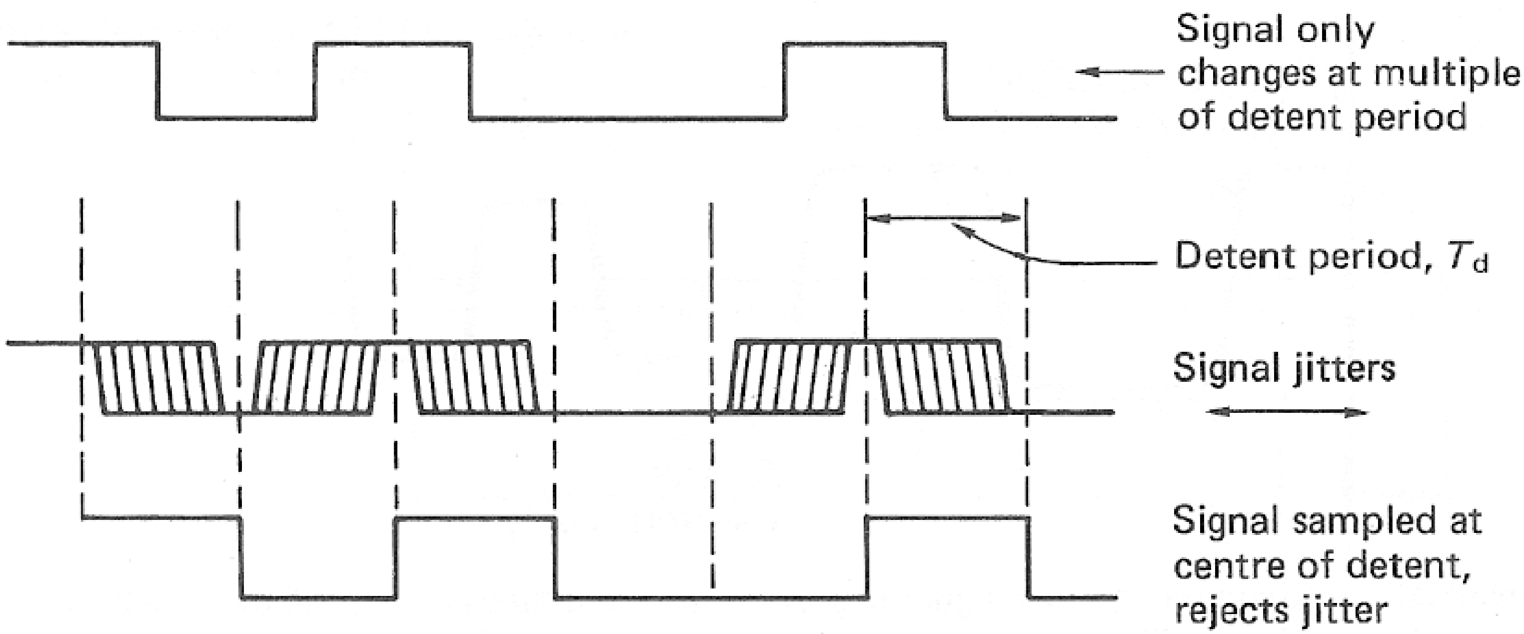
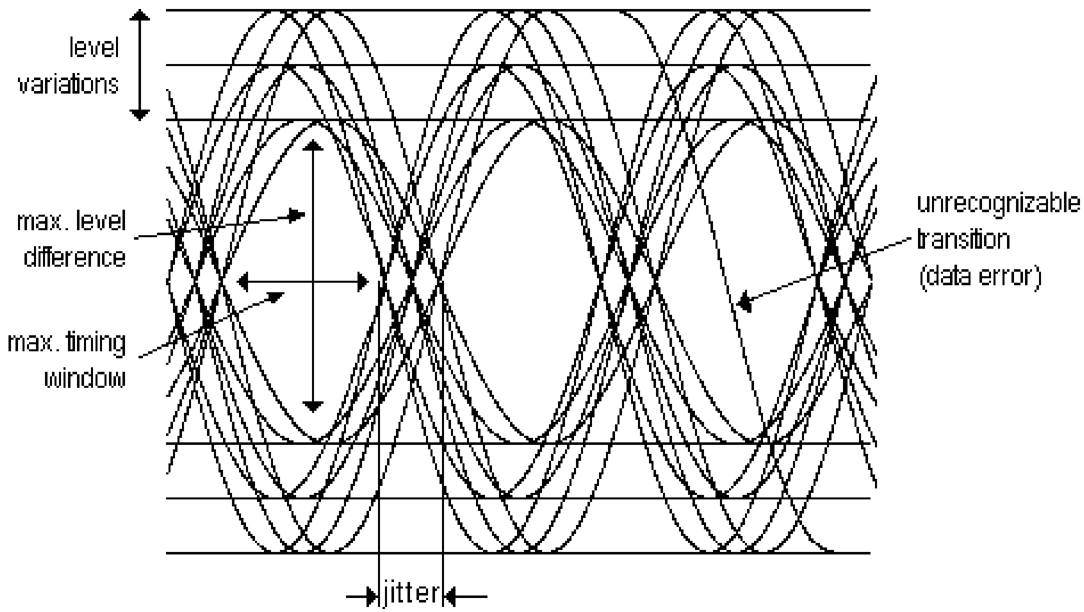
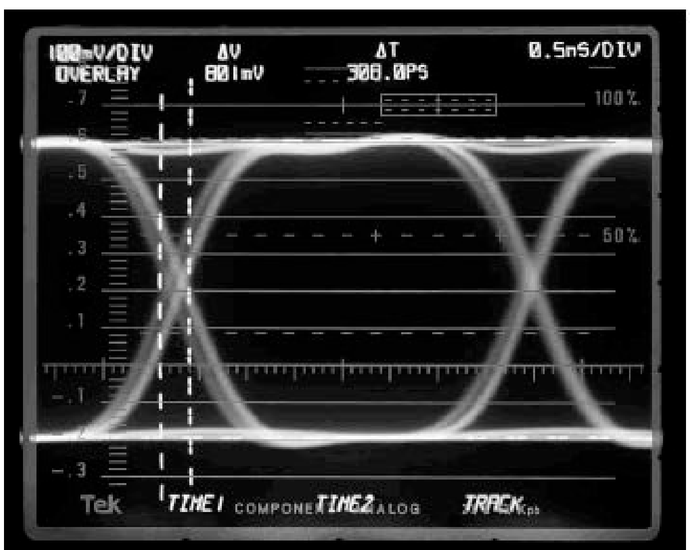
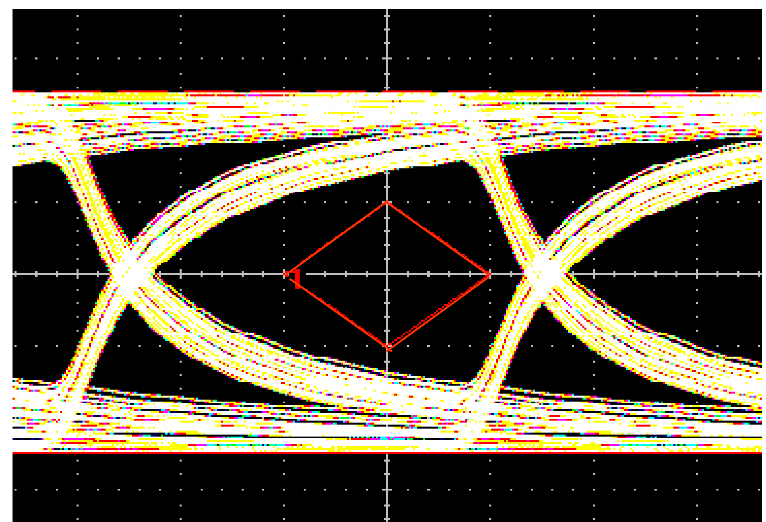


Figure 6.19 A certain amount of jitter can be rejected by changing the signal at multiples of the basic detent period T_d.

"Eye patterns" - oscilloscope pictures







FM coding

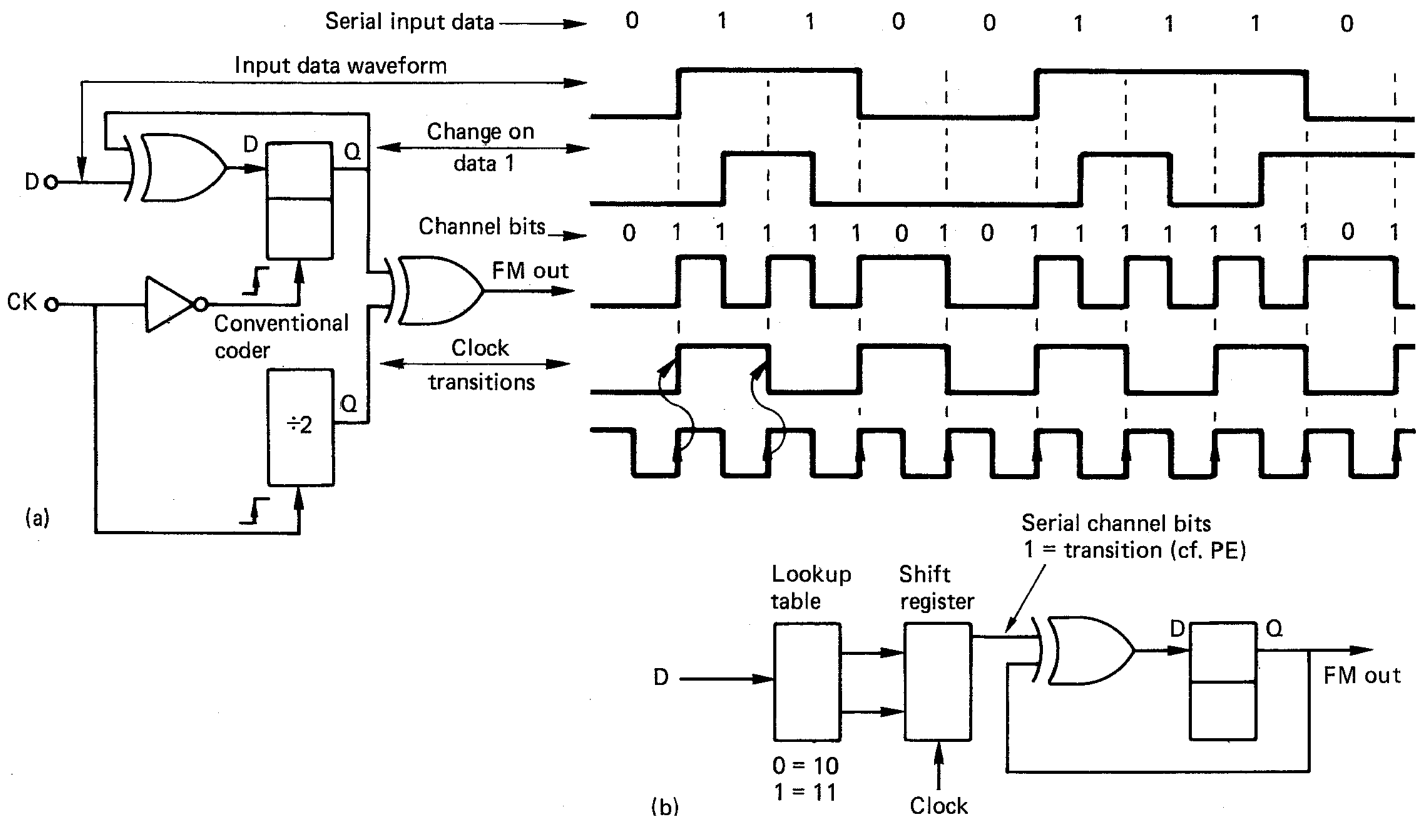


Figure 6.24 FM encoding. At (a) are the FM waveform and the channel bits which may be used to describe transitions in it. The FM coder is shown at (b).

Note that the lowest and highest pulse frequencies differ by a factor of 2

Density Ratio

a fundamental parameter of channel coding methods

$$\text{DR} = \frac{\text{number of bits transmitted}}{\text{number of transitions in the signal}}$$

or

$$\text{DR} = \frac{\text{the data rate}}{2 \times \text{channel bandwidth}}$$

The spectrum of a channel code should be constrained

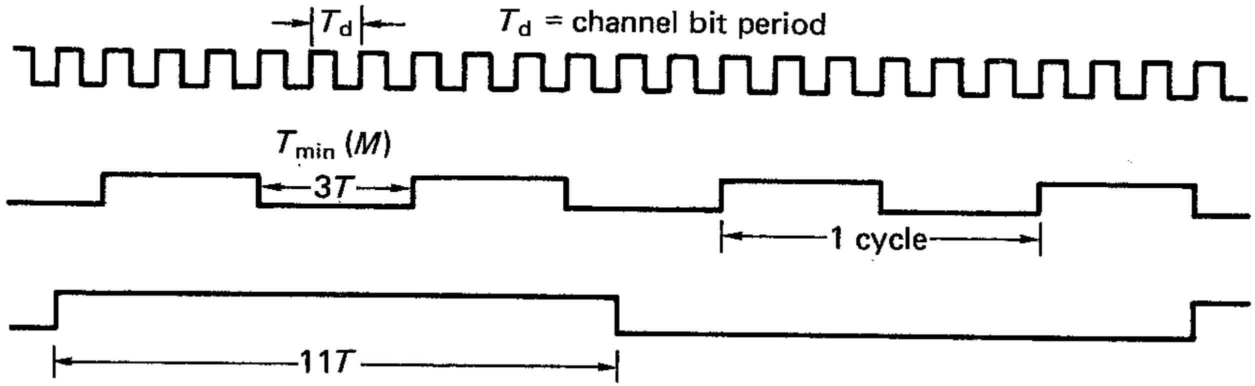


Figure 6.26 A channel code can control its spectrum by placing limits on T_{min} (M) and T_{max} which define upper and lower frequencies. The ratio of T_{max}/T_{min} determines the asymmetry of waveform and predicts DC content and peak shift. Example shown is EFM.

This can be done with *group codes*

2^m bit patterns are chosen from a table with 2^n values, $n > m$ such that transitions (”ones”) always occur within a minimum and a maximum time interval.

The AES/EBU interface

Audio Engineering Society / European Broadcasting Union

First version 1985; current version AES-3-1992

Physical aspects

- only point-to-point, sender to receiver
- balanced connection
- XLR connectors
- 2…7 volt peak-to-peak
- Ordinary microphone cable can be used
- Special cables can increase the range
- 110 ohm impedance in transmitter, cable and receiver.

AES/EBU (continued)

Physical variants

Consumer format S/P-DIF

- unbalanced connection
- RCA connectors
- 0,5 volt peak-to-peak

TosLink (optical S/P-DIF)

Long range

- Unbalanced
- 75 ohm coaxial cable
- BNC connectors
- 1 V signal
- can be transmitted through an analog video distribution network

MADI – Multichannel Audio Digital Interface

- Protocol similar to AES/EBU, but 56 channels per frame, not 2
- Constant bit rate 125 Mbit/s
- Unused channels are filled with non-data
- More efficient channel coding
- 75 ohm coaxial cable
- Separate sync connection (an ordinary AES/EBU)
- 32-48 kHz $\pm$12,5%

Dolby E - for surround distribution
(not mentioned by Watkinson)

- A compression scheme
- Allows transmission of up to 8.1 surround over **stereo** digital audio links such as AES/EBU
- Synchronized with TV video frames - one frame of delay
- Metadata protocol
- Used only in distribution, not to end users
- Similar in concept to DTS (!)

Synchronisation

- *synchronous* (e.g., AES/EBU, or dedicated Ethernet)
  data packets run in time with the audio

- *asynchronous* (e.g., ordinary Ethernet)
  data packets are sent at any convenient times
  – timing is unpredictable

- *isochrononous*
  controlled asynchronicity
  – the overall throughput is guaranteed

In FireWire and USB for audio the latter two are combined

Audio over computer networks

Technically, less than ideal:

- data protocol overhead
- network congestion can jeopardise real-time operation
- network switching may introduce delays

In practice: dedicated nets, same hardware

Fast, cost effective, and very flexible

Commercial audio network implementations

- EtherSound by DigiGram (www.ethersound.com)
- synchronous, 64 channels × 48 kHz × 24 bits @ 100 Mbit/s
- broadcast and unicast modes
- uses standard Ethernet hardware
  plus master/slave encoders/decoders
- Ordinary CAT5 cable in lengths up to 100 m

- CobraNet by Cirrus Logic (www.cobranet.info)
- Cheaper than EtherSound
- Allows concurrent TCP/IP on the same network

- mLAN by Yamaha
- based on IEEE-1394, a.k.a. FireWire (Apple)
- for the music studio environment
- dozens of audio and hundreds of MIDI channels