DaTARIUS

Quality control and process management systems

CD – Formats, data, physical structure

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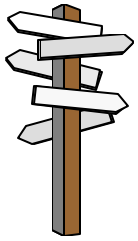
Research & Development

Contents



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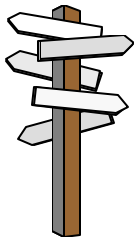
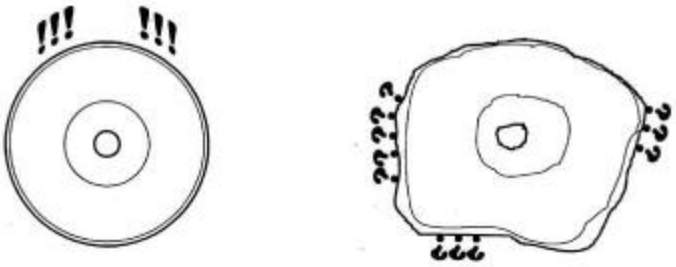


What means “Quality”?

CD ≠ CD



Why quality control?

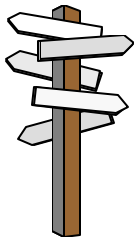
- Player requirements
  - Every CD within specs must be playable
  - Only major characteristics for the optical pickup are specified
- Disc requirements
  - Specs (REDBOOK, etc.)
- Process control
  - Better quality with faster cycle times
  - Localization of problems
- Cost efficiency
  - Reducing unnecessary replication
  - Less complaints - improved reputation

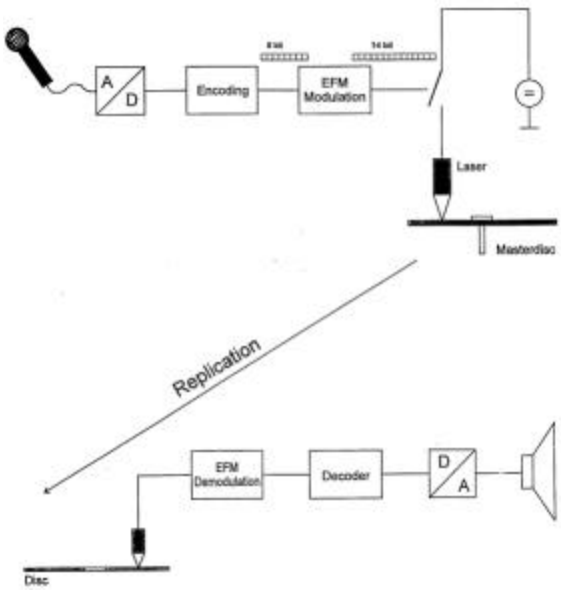
Standards

• REDBOOK	CD-Audio
• YELLOW BOOK	CD-ROM
• ORANGE BOOK	CD-R
• WHITE BOOK	CD-Bridge
• GREEN BOOK	CD-I
• DVD specification book	DVD

Interchangeability of media !

Contents

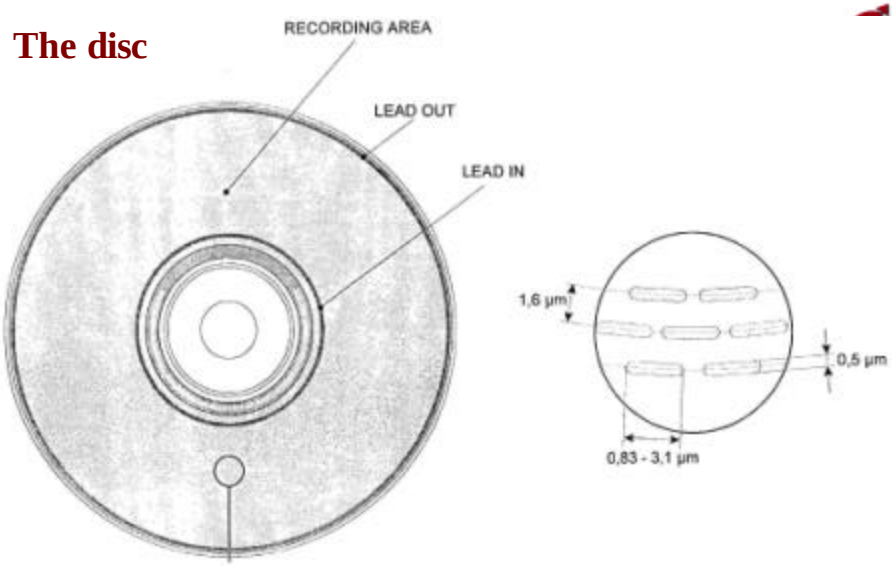




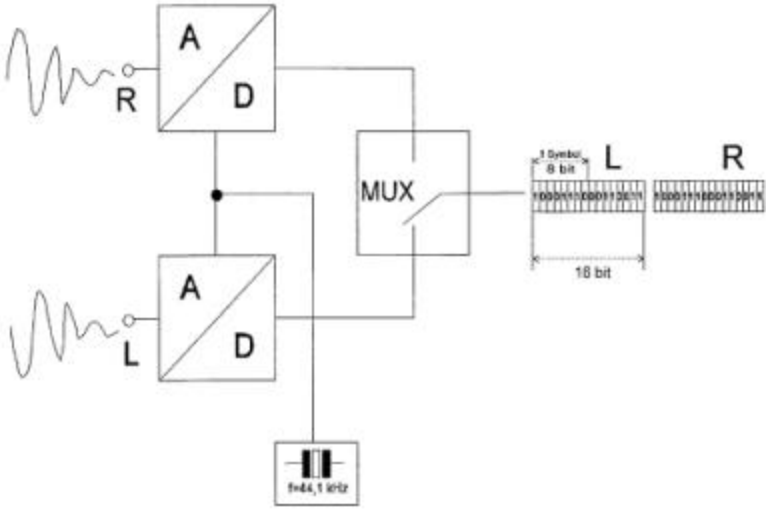
Signal flow diagram

DaTARIUS quality control and process management systems

The disc



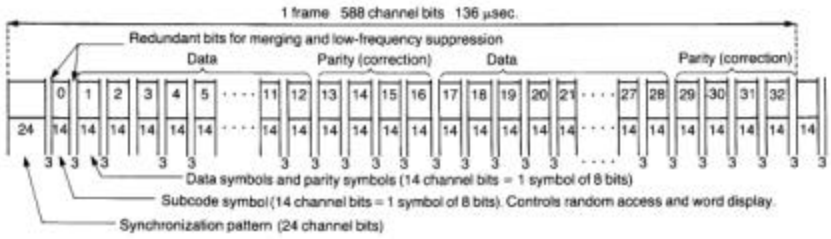
Analog to digital conversion



Channel coding

- Sampling rate is **44.1 kHz**
- Sufficient for the reproduction of max. **audio frequency** of approx. **20 kHz** (Nyquist criterion)
- The quantization of each channel is **16 Bits** per sample
- This results in a bit rate of 44100*16 = **1.41 Mbit/s**
- The audio bits are grouped into so-called **Frames**
- Error correction bits are added in accordance with the **CIRC** (Cross Interleave Reed Solomon Code)
- For control and display information additional data are added to the frames
- The whole bitstream is modulated according to the rules of **EFM modulation**

Summary of frame format after EFM modulation



EFM - Eight to Fourteen Modulation

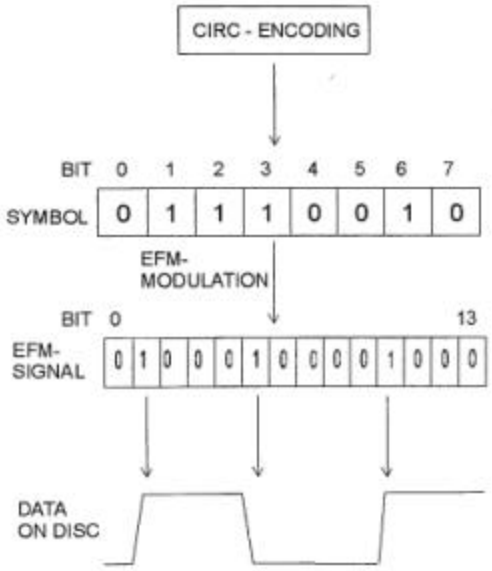
- Every 8 bit pattern (byte) is converted to 14 bit symbol by means of a look up table
- A “one” indicates the beginning of a land or a pit on the disc
- A “zero” indicates the continuation of a land or a pit
- 8 bits offer 256 different code patterns
- 14 bits offer 16384 different code patterns

EFM - Eight to Fourteen Modulation

Original data	After EFM encoding
0 1 0 1 1 1 0 0	0 1 0 1 1 1 0 0 1 1 0 0 1 1
0 1 0 1 1 0 0 1	0 1 0 1 1 1 0 0 1 0 0 0 0 0
0 1 0 1 1 0 1 0	0 1 0 1 1 1 0 0 1 0 0 0 1 1
0 1 0 1 1 0 1 1	0 1 0 1 1 1 0 0 1 0 0 0 1 0

Lock-up table

Data encoding

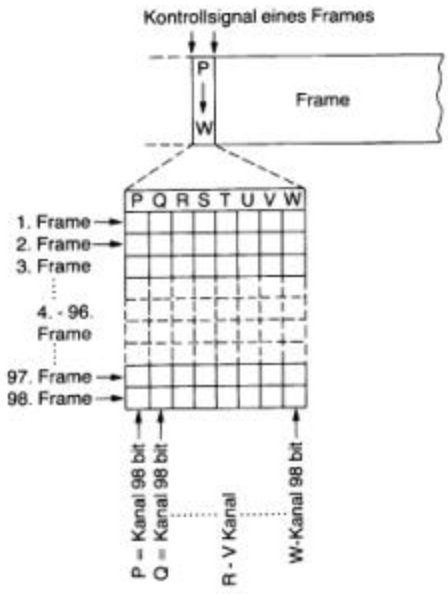


- Due to system margins (e.g. limited spot diameter) the pits and lands must not be too short
- The distance between the individual “ones” should be at least 3 bits (minimum run length condition)
- In order to retrieve the clock content of the datastream the pit or land must not be too long
- As a consequence the distance between the “ones” should not exceed 11 bits (maximum run length condition)
- To guarantee the minimum and maximum run length condition additional bits are added ? **Merging Bits**
- Blocks of 14 bits are linked by 3 merging bits

Sub-Code

- As we have seen, the frame is a basic information unit in the CD encoding system. It is the smallest recognizable information unit for a CD player
- Every frame contains 8 bits of sub-code data
- The sub-code data of **98 frames** are collected to form a complete **sub-code data block**
- **75** such complete sub-code data blocks appear every second
- These blocks are split into the channel **P, Q, R, S, T, U, V, W**
- In the digital audio systems only the channels P and Q are used

Sub-Code data block



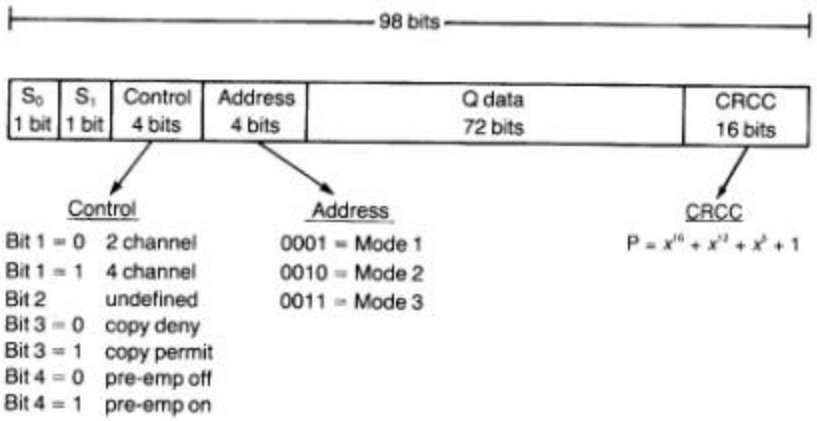
The P channel:

- Channel P contains the so-called P flag. It is used for track separation and to control the pick-up of a very simple player design.
- During the lead-in area this flag remains zero. If the P flag changes to a high level, the begin of the first track is indicated. It remains high for at least two seconds.
- After the flag changes to the low level the data is valid.
- In the lead-out area the P flag toggles with a frequency of 2 Hz.

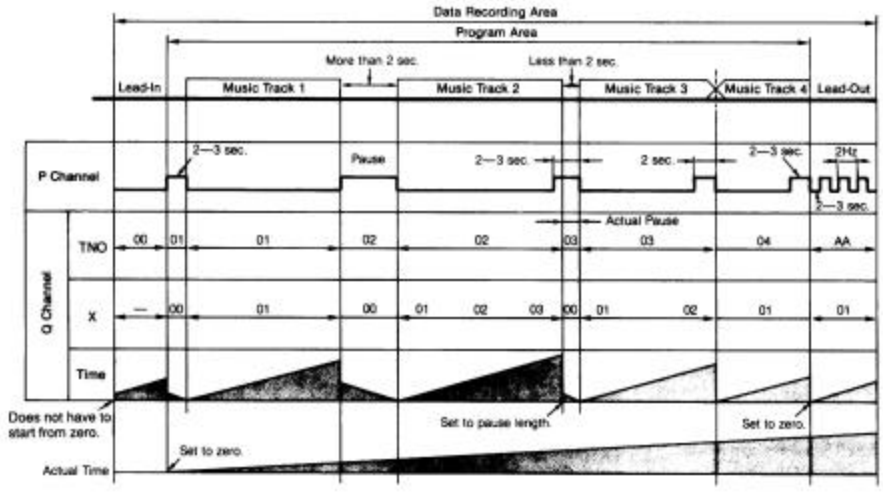
The Q channel:

- The channel Q contains four basic kinds of information:
  control, address, Q data and an error correction code.
- Control information (handling of player functions):
  - Number of audio channels (two or four)
  - Emphasis on or off
- Address information:
  Here the three modes for the Q data bits are indicated
  - Mode 1: Number and start times of tracks
  - Mode 2: Catalog number
  - Mode 3: International Standard Recording Code (ISRC)

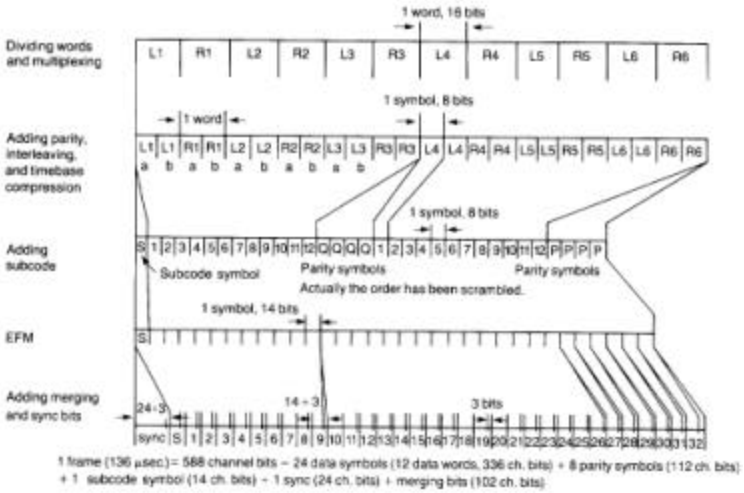
The Q channel format



P/Q channels



Frame format



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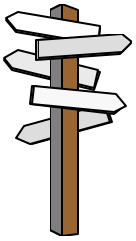
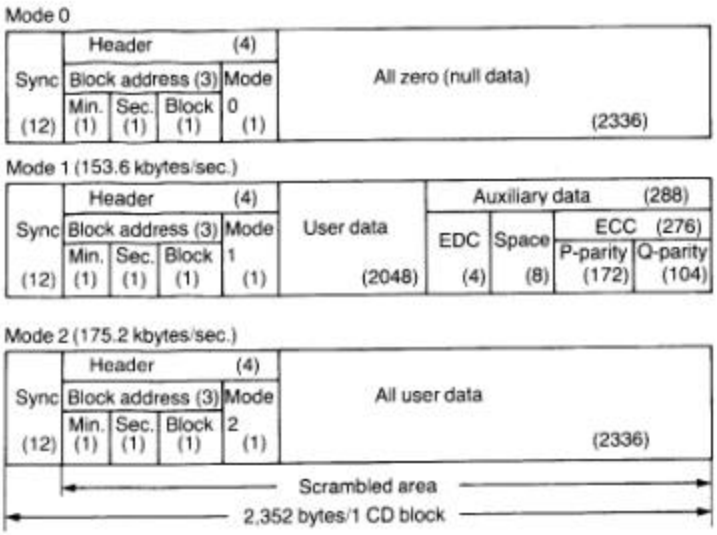


The CD-ROM

- The CD-ROM was developed to store data base, software, etc. (non audio data)
- CD-I is a specific application of CD-ROM
- CD-R is a write-once format allowing users to store their own data
- A CD-ROM can be detected automatically (through the Q-channel)
- A **frame** is to small to store general data efficient, therefore **98 frames a grouped** (24 Bytes x 98 = **2352 Bytes**)

- This **98 frames** are called a **sector**
- Audio data is replaced by user data that occupy 2048 bytes; the remaining 304 bytes are used for synchronization, headers, mode selection, and extended error detection and correction

The 3 CD-ROM formats



- Mode 0: Null data
- Mode 1: 2048 bytes user data
- Mode 2: 2336 bytes user data
- Difference between Mode 1 & 2:
  - additional layer of error detection (EDC) & error correction (ECC); independent of CIRC system
  - very often used quality limits: E22 & E32 = 0