

# Optical Drives

Last updated 3/30/21

# Optical Disks

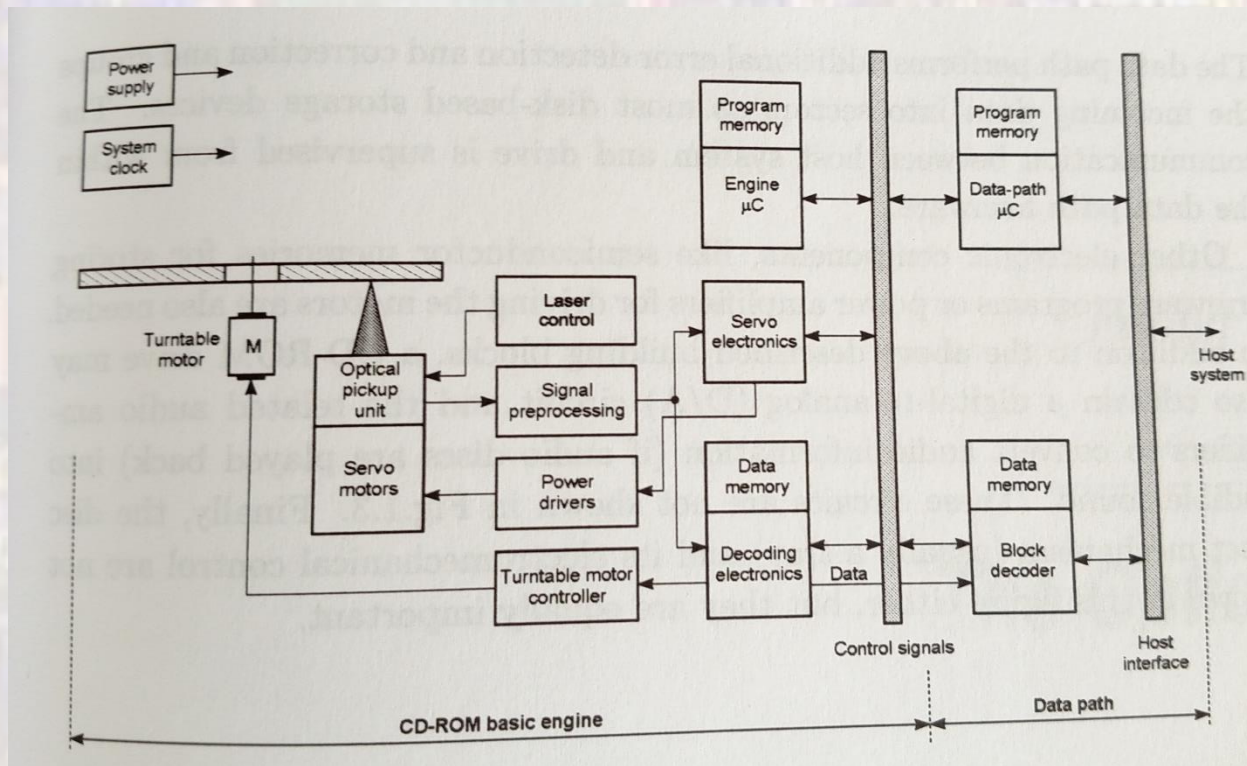
- CD
  - Originally developed to replace LPs
    - Late 70's
    - Audio
    - Smaller
    - Longer life – no wear damage
    - Manufactured

# Optical Disks

- CD
  - Multiple variations
    - CD-DA – Digital Audio
    - CD-ROM – Read only
    - CD-R – Write once
    - CD-RW – Write many

# Optical Disks

- CD
- Functional block diagram - Read



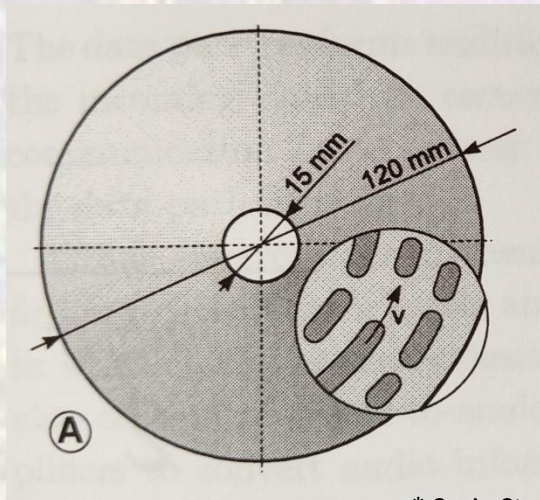
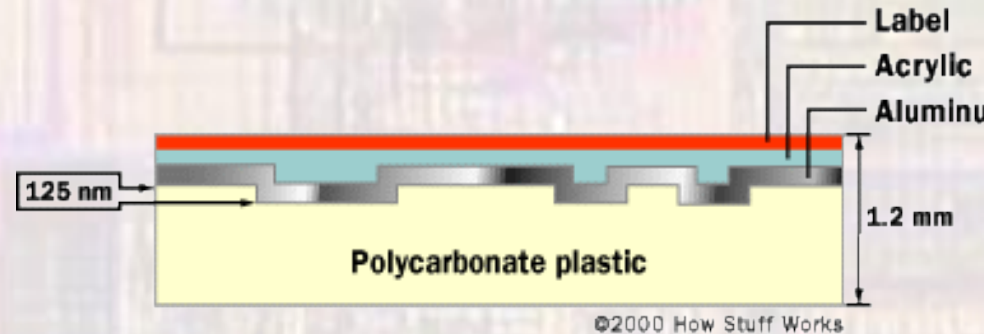
\* Sorin Stan

# Optical Disks

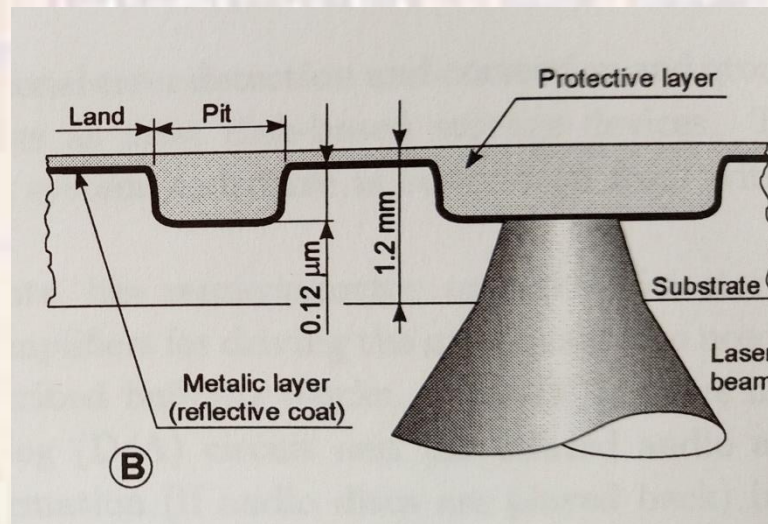
- CD - Mechanical

- CD-DA and CD-ROM

- Data is pressed onto the disk
- Spiral tracks – 1.5 $\mu\text{m}$  to 1.7 $\mu\text{m}$  centers
- Pits and Lands
  - Pits – 0.6 $\mu\text{m}$  wide
  - Pits – 0.9 $\mu\text{m}$  – 3.3 $\mu\text{m}$  long



\* Sorin Stan



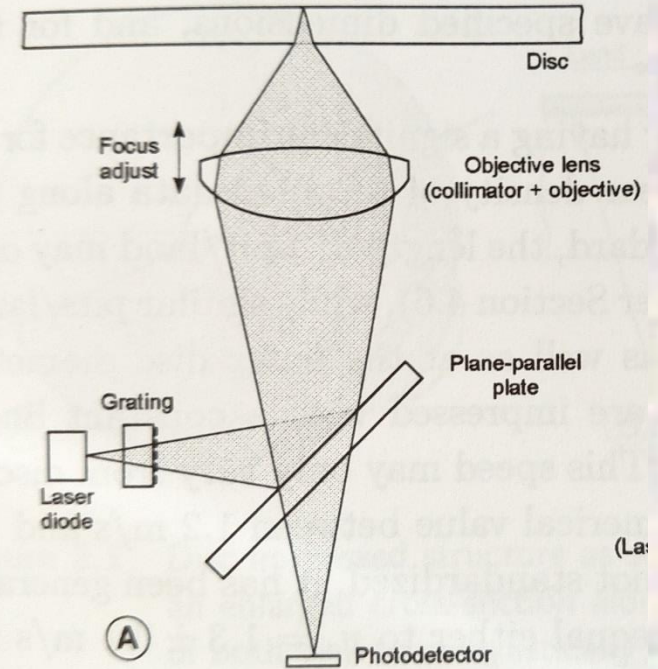
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# Optical Disks

- CD - Mechanical

- Simplified Optics

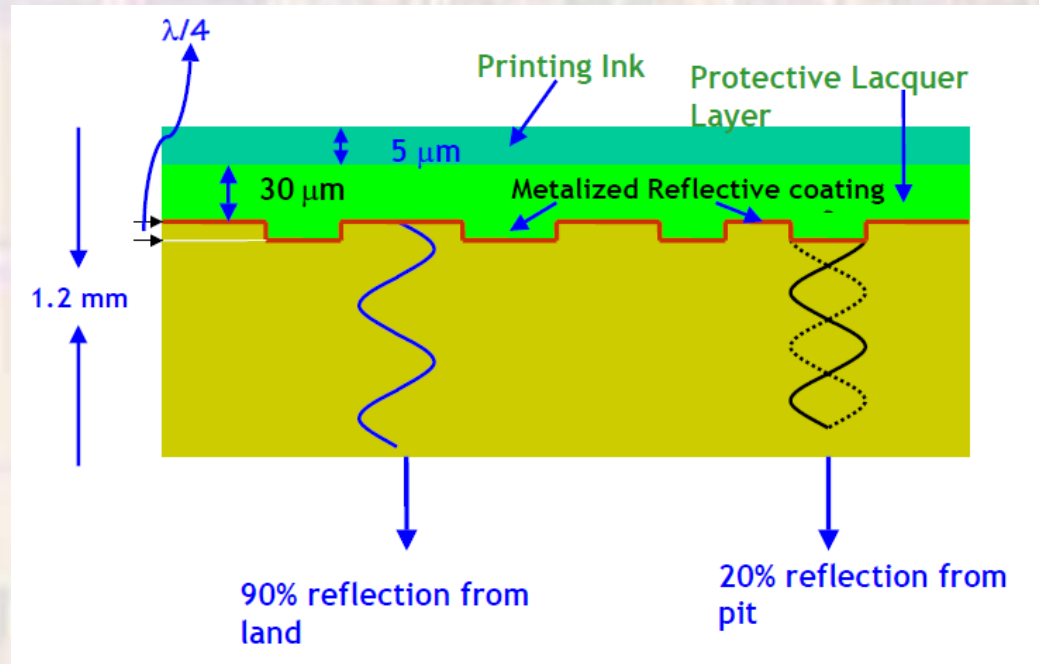
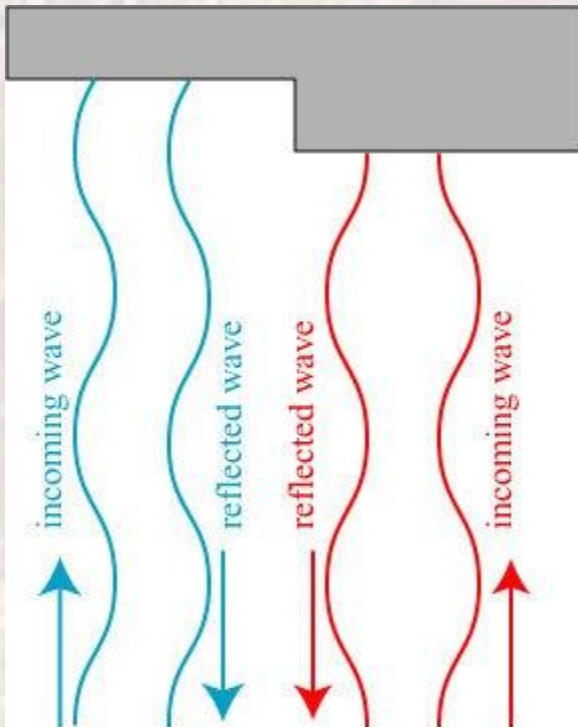
- 780nm laser
- 3mW output
- Split into 3 beams
- Reflects off CD and back onto a multi sensor detector
- The pits are designed to cause a quarter wavelength destructive interference → low reflected signal



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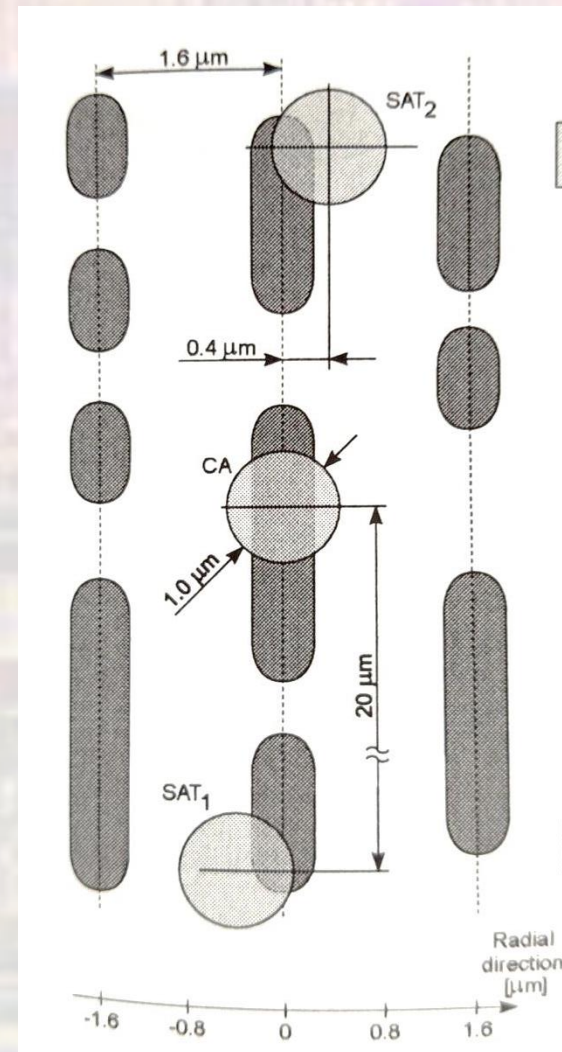
# Optical Disks

- CD - Mechanical
- Interference



# Optical Disks

- CD - Mechanical
  - 3 beam configuration
    - 1 central beam – data
    - 2 radial beams – tracking

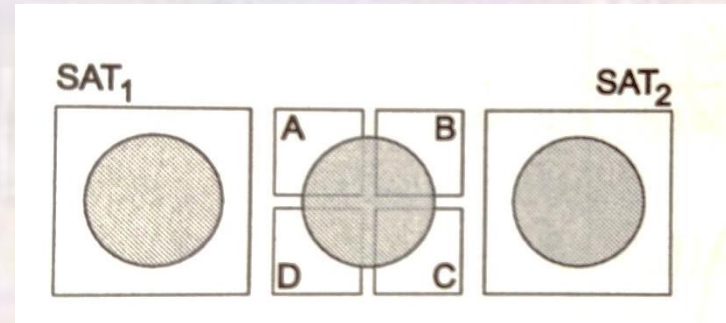


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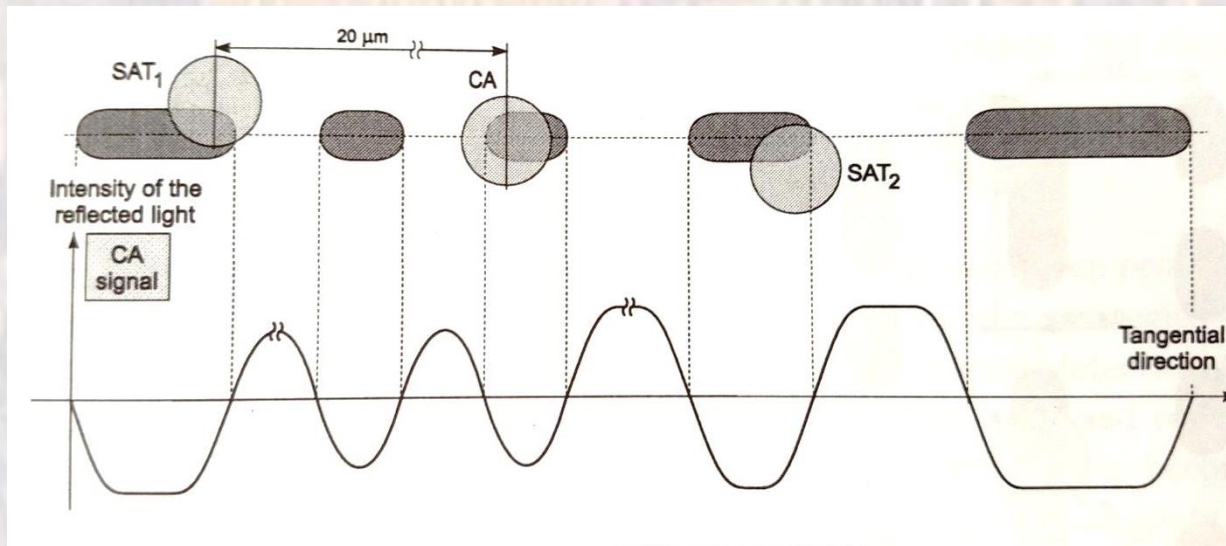


# Optical Disks

- CD - Mechanical
  - 3 beam detector
    - Astigmatic focus detection
      - Central spot signal =  $F_n(A,B,C,D)$
    - Twin spot radial detection



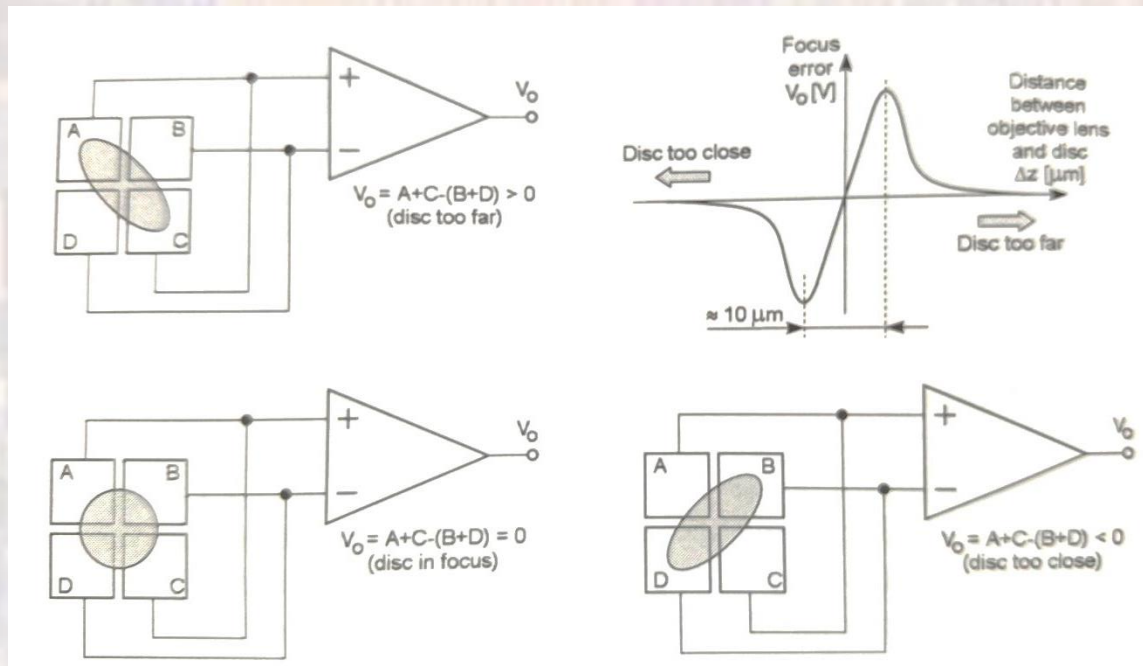
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# Optical Disks

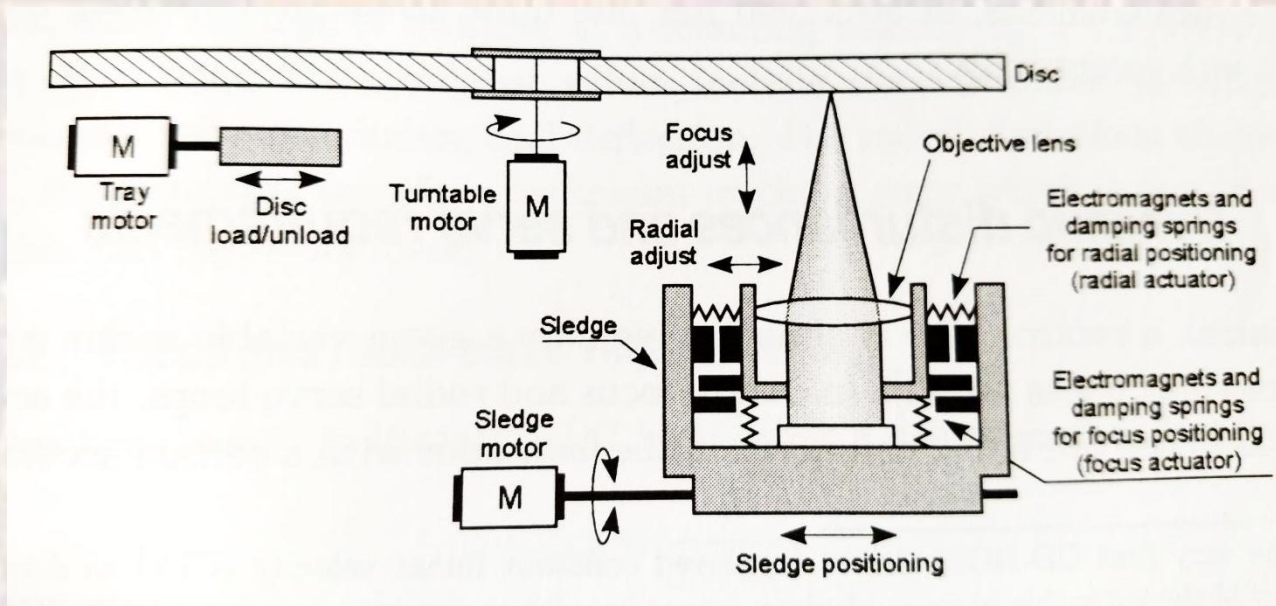
- CD - Mechanical
  - Astigmatic focus detection
    - Astigmatism intentionally introduced into the optics (rotation of focus)



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# Optical Disks

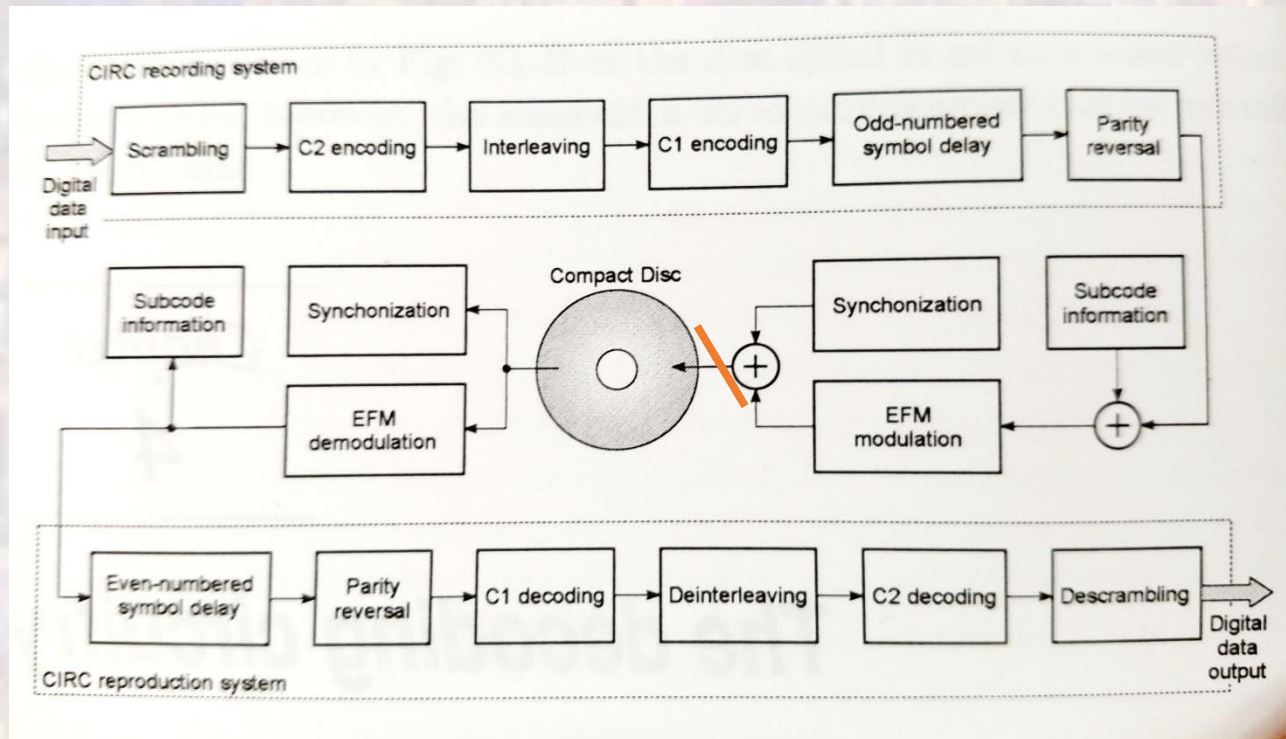
- CD - Mechanical
  - Laser/Detector actuators
    - Electromagnetic focus and fine positioning control
    - Sledge motor for course (tracking) radial control
    - Servo-loop control



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# Optical Disks

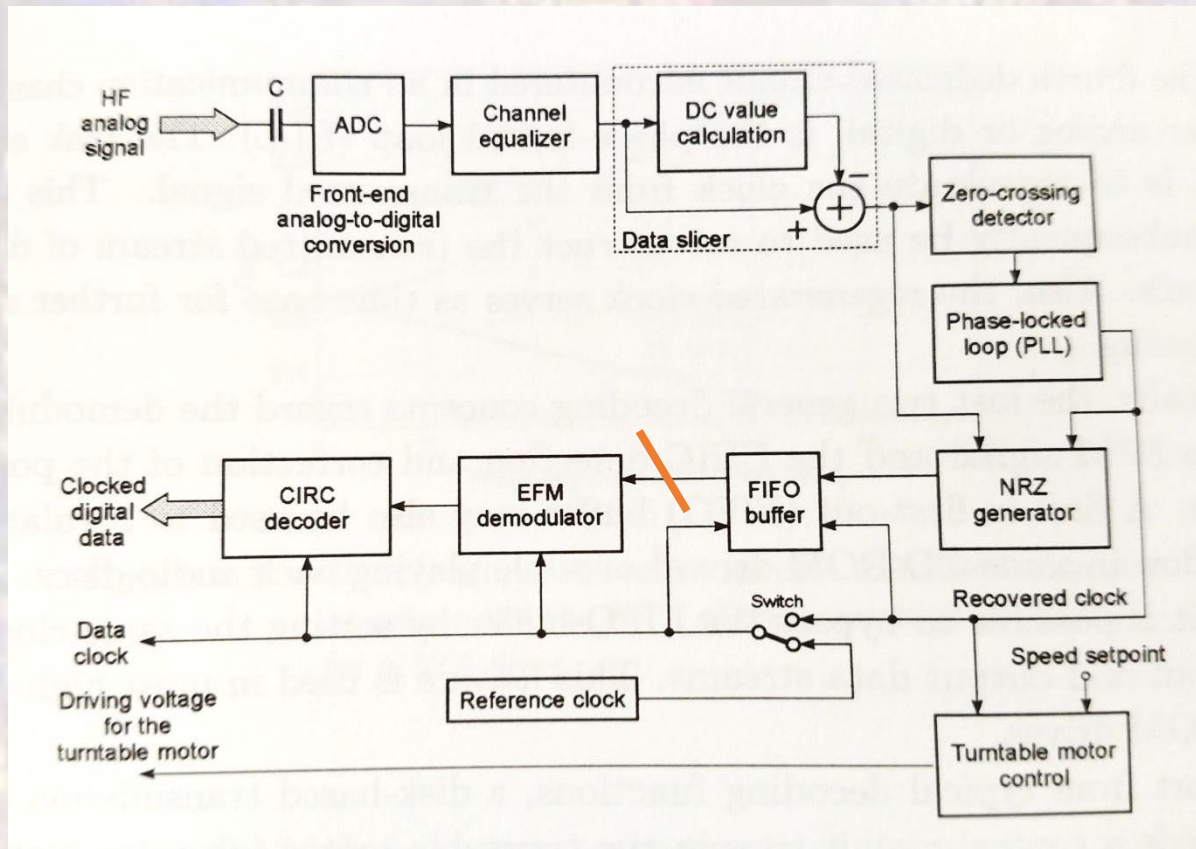
- CD – Data Channel



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# Optical Disks

- CD – Data Channel - Read



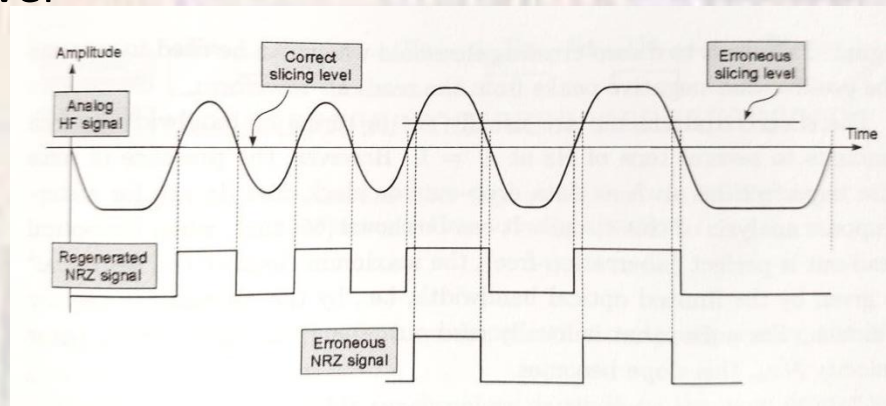
\* Sorin Stan

# Optical Disks

- CD – Data Channel - Read
  - ADC
    - Early conversion to digital
    - ??? Resolution
    - ??? Input resolution
  - Channel Equalizer
    - Shapes the signal due to optical distortion
    - High Pass characteristic
    - Variable – to support CAV operation (constant angular velocity)

# Optical Disks

- CD – Data Channel - Read
  - Data Slicer
    - Determine a level to consider as the transition level from 0 to 1
    - Signal from the laser is AC coupled
    - Calculate the DC level of the signal
  - Zero Crossing Detector
    - Create a digital signal associated with the locations the signal crosses the slicing level



# Optical Disks

- CD – Data Channel - Read
  - Clock Recovery
    - PLL based
    - Aided by modulation scheme
  - NRZ Generator
    - Detects the changes and no-changes in the digital stream
    - No-change  $\rightarrow$  0
    - Change  $\rightarrow$  1
  - FIFO
    - Buffer to control output stream
    - When full – stop reading



# Optical Disks

- CD – Data Channel - Read
  - EFM Demodulator
    - Eight to Fourteen Modulation
    - RLL Code (2,10)
      - 8 bit data  $\rightarrow$  14 bit symbol
      - Shortest pit/land =  $0.3\mu\text{m} \times 3$
      - Longest pit/land =  $0.3\mu\text{m} \times 11$
    - 3 merging bits are placed between each 14 bit symbol
      - Removed by the demodulator

# Optical Disks

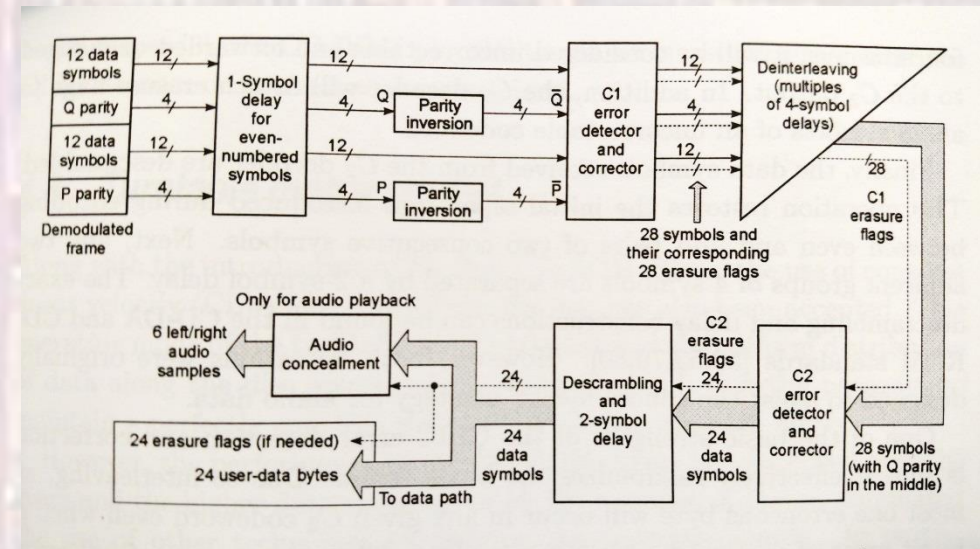
- CD – Data Channel - Read

- CIRC

- Cross Interleaved Reed-Solomon Code
- Error Detection and Correction
- Linear Block Codes
  - C1 – 24 data + 4 parity (from C2) bytes
  - C2 – 24 data bytes

- Parity

- 2 sets of 4 bytes
- one set for each C1/C2



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# Optical Disks

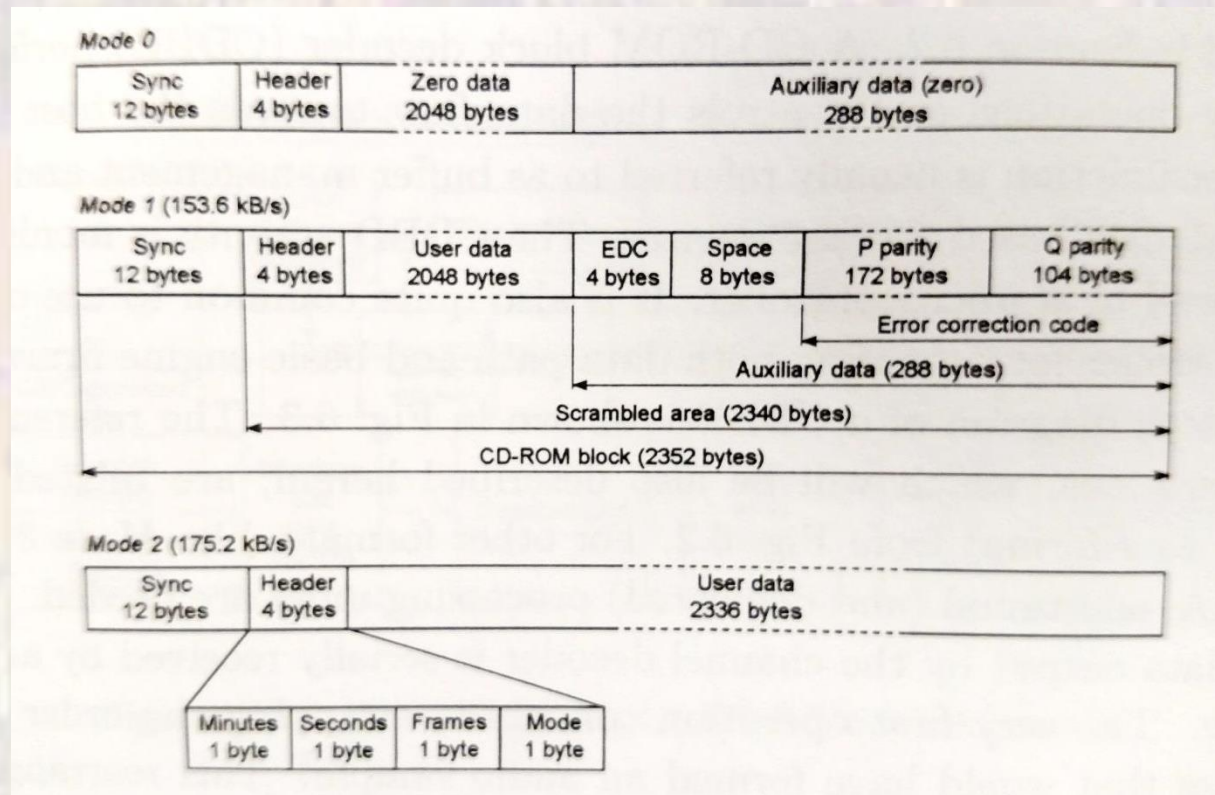
- CD – Data Channel - Read
  - Subcode
    - Contains additional information
      - Audio vs data
      - Music title
      - Marks data blocks on a CD-ROM
      - Position on the disk
    - 8 logical subcode channels (P-W)
    - 1 byte in every frame
    - Combines bytes from 98 consecutive frames

# Optical Disks

- CD – Audio - Framing
  - 24 bytes of user data
    - $2 \times 12$
  - 8 Bytes of CIRC
    - $2 \times 4$
  - 1 Subcode Symbol
    - 33 Bytes
- EFM Coding
  - $8 \rightarrow 14$
  - 3 merging bits
    - 17 bits / byte
    - 561 channel bits
- 27 sync bits → 588 bits / frame

# Optical Disks

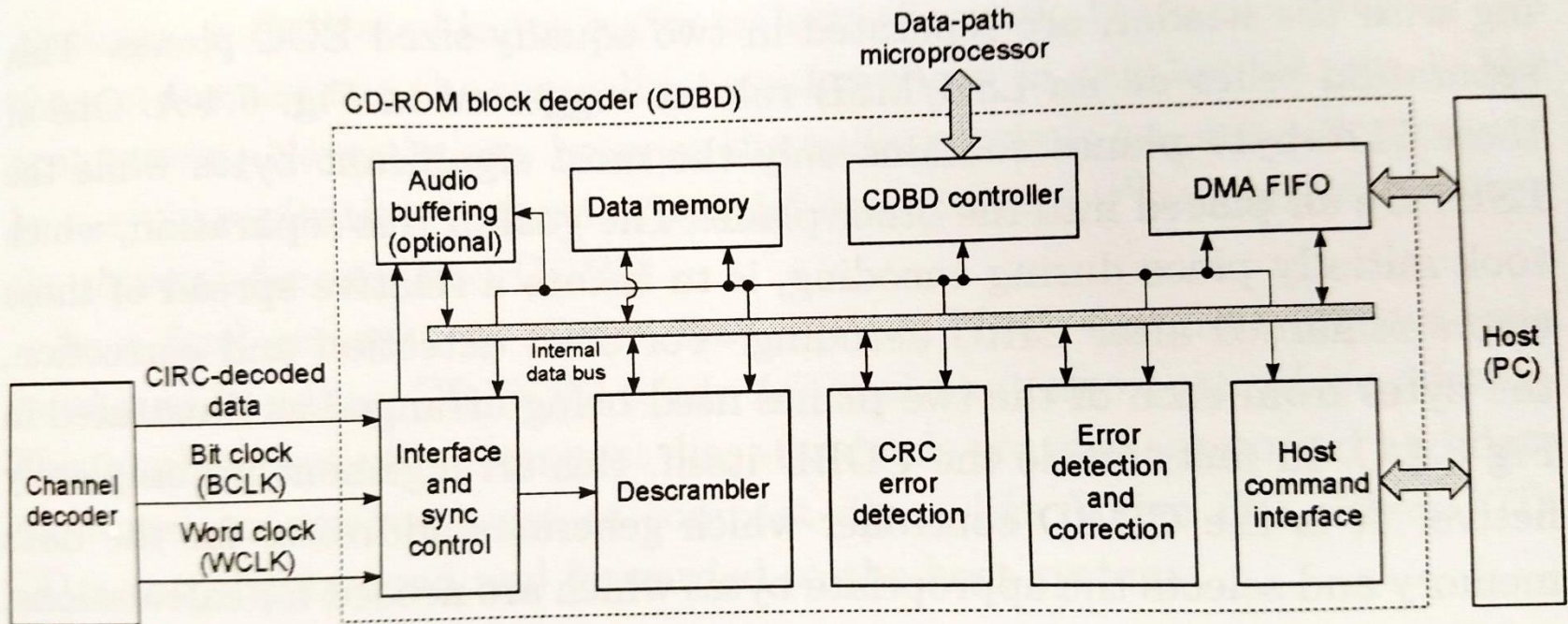
- CD – ROM - Framing
- 3 modes



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# Optical Disks

- CD – Data ROM – additional processing



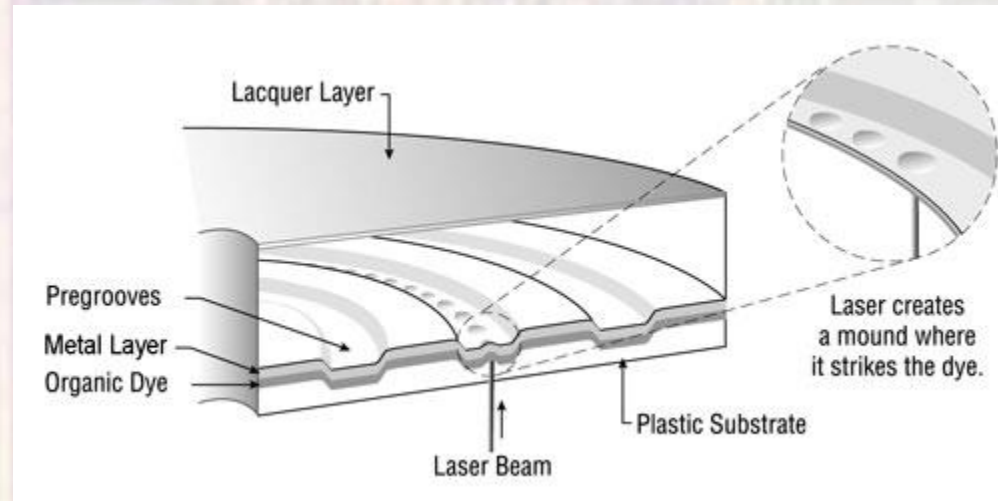
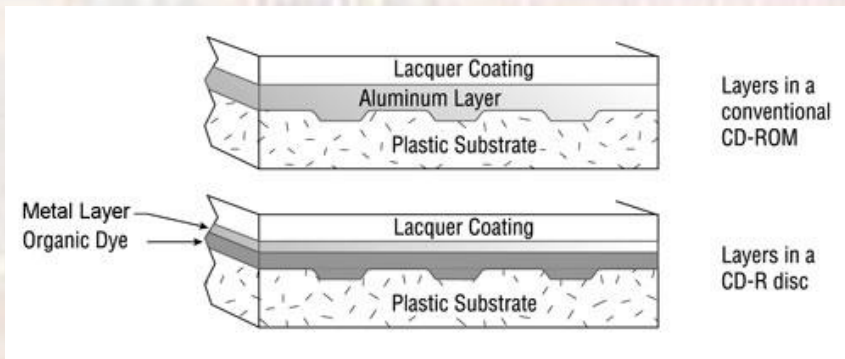
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# Optical Disks

- CD – R

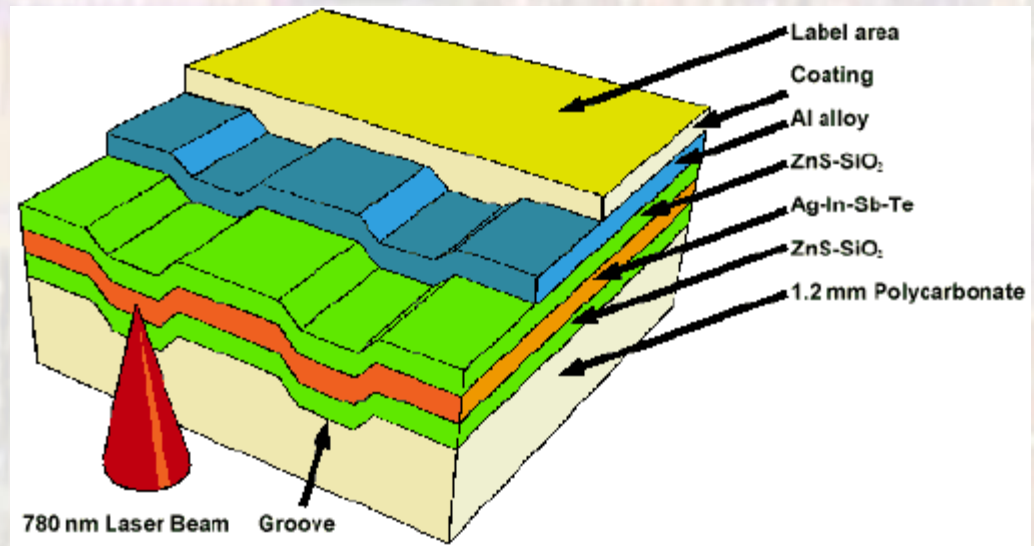
- Write once

- Higher power laser for writing
- Pre-grooved
- Laser modifies the Dye layer (normally transparent)
  - Changes it to opaque – looks like a pit
  - Causes expansion in the polycarbonate – looks like a pit



# Optical Disks

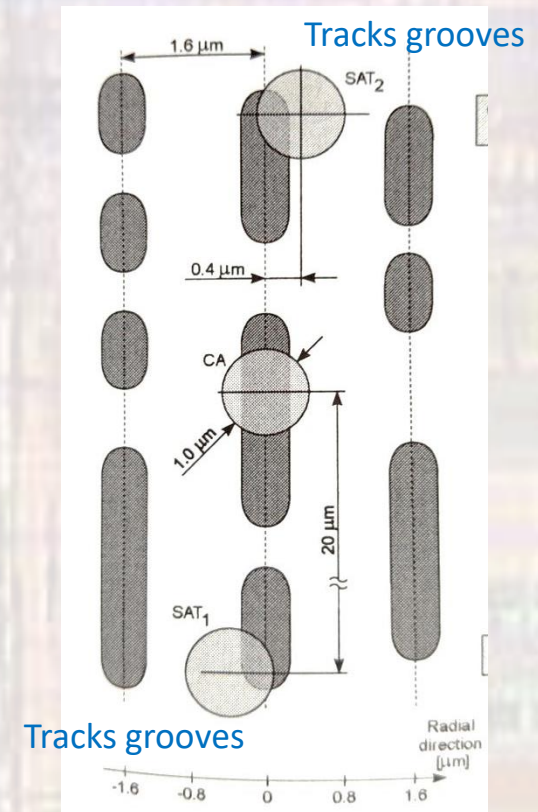
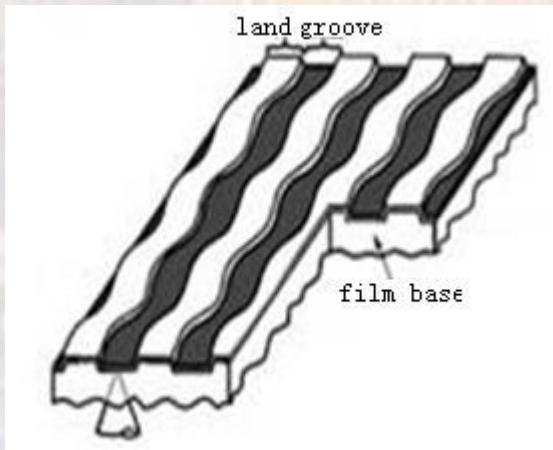
- CD – RW
  - Read/Write
    - Higher power laser for writing
    - Pre-grooved – used for tracking
    - Laser modifies the Phase Change material
      - Highest power changes it to amorphous - opaque
      - Medium power changes it to crystalline - transparent





# Optical Disks

- CD – R and RW
- Pre-groove Wobble
  - ATIP – Absolute Time In Pre-groove
  - Pre groove has a 140.6Kz wobble
  - Used for tracking, time reference



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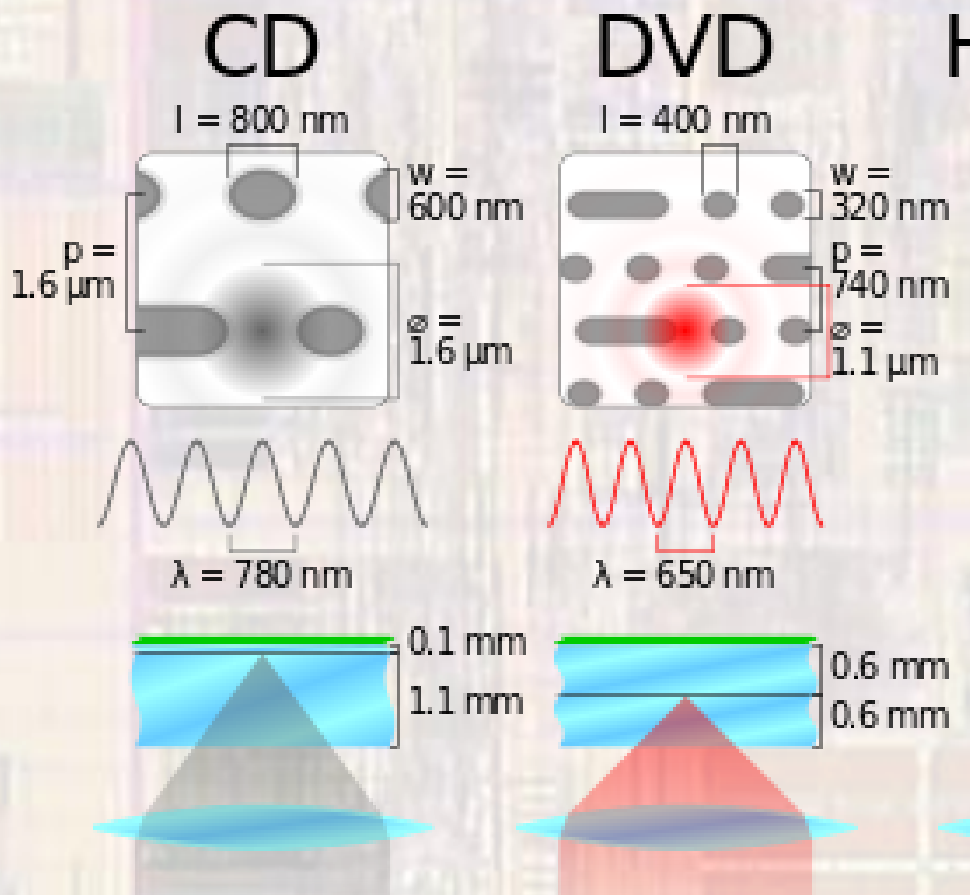
# Optical Disks

- DVD

- Digital Versatile Disk

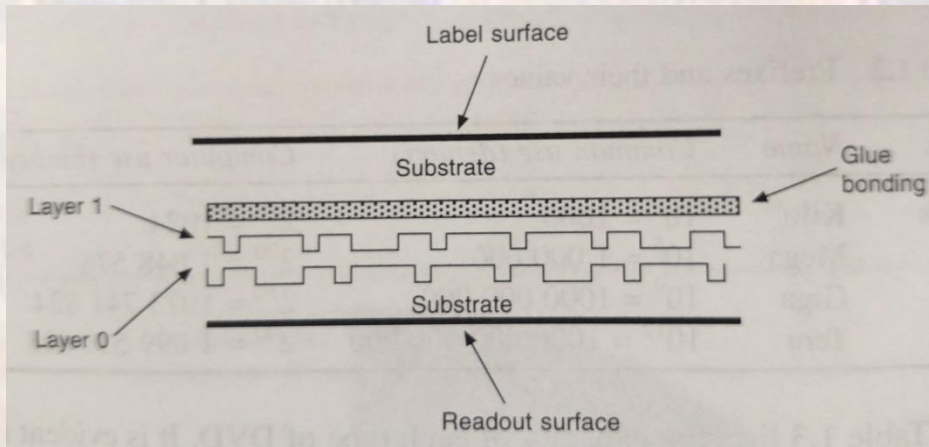
- Digital Video Disk

- Similar to CD
- Smaller Pit/Land, Pitch
- 650nm Laser



# Optical Disks

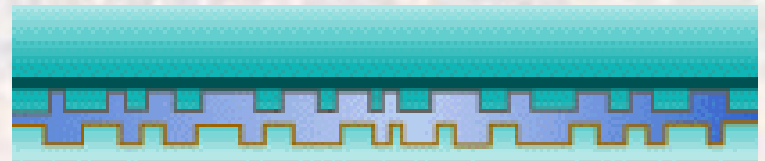
- DVD
  - Sandwich Construction
    - 2 thin disks bonded together
    - Can have 2 layers / side
  - Outer layer must be transparent



## Single-sided, single layer (4.7GB)



## Single-sided, double layer (8.5GB)



## Double-sided, double layer (17GB)

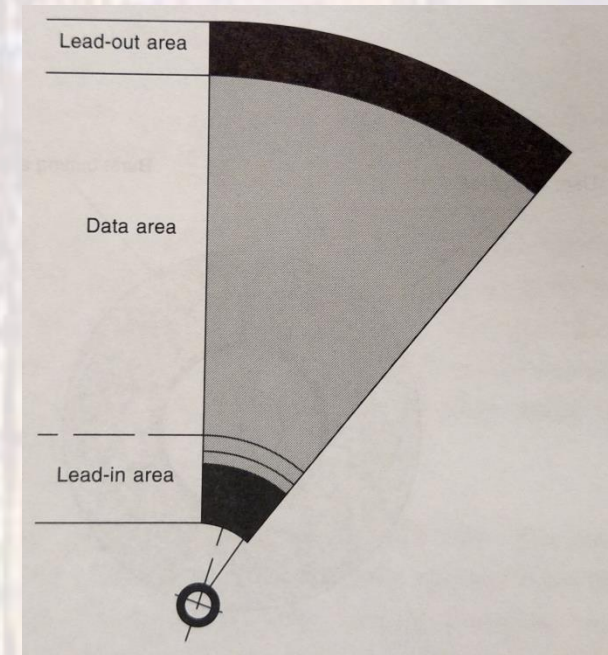
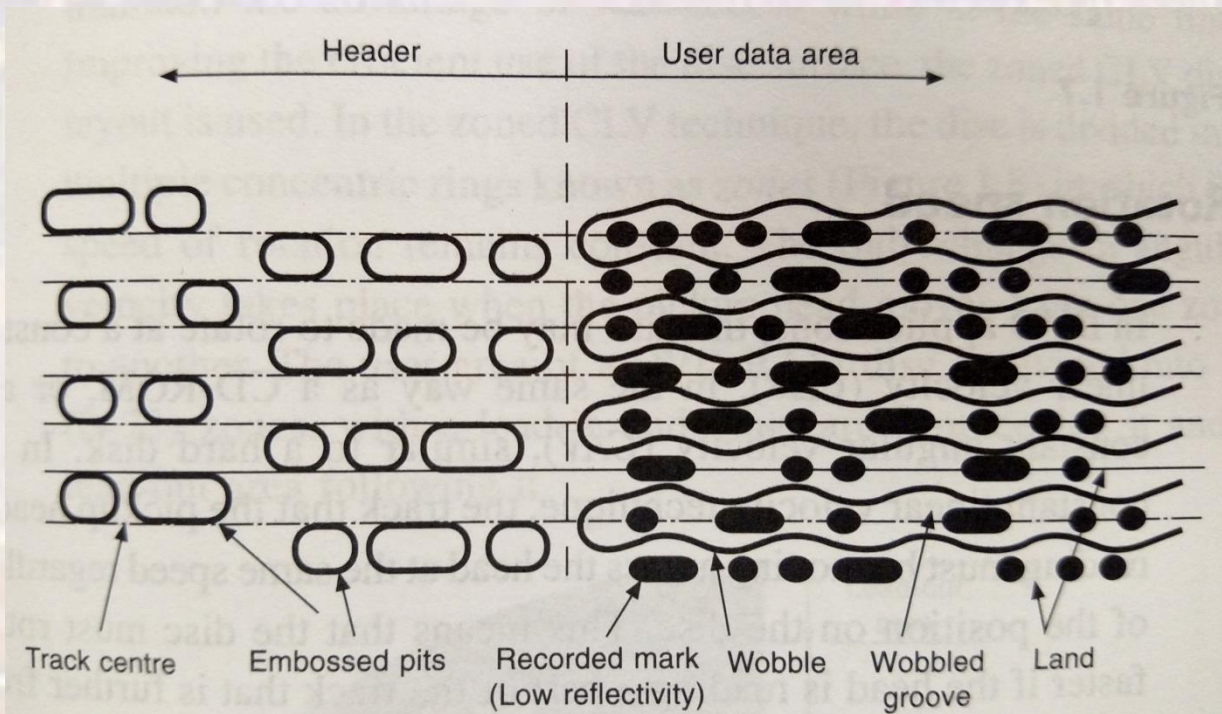


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# Optical Disks

- DVD

- Disk Construction

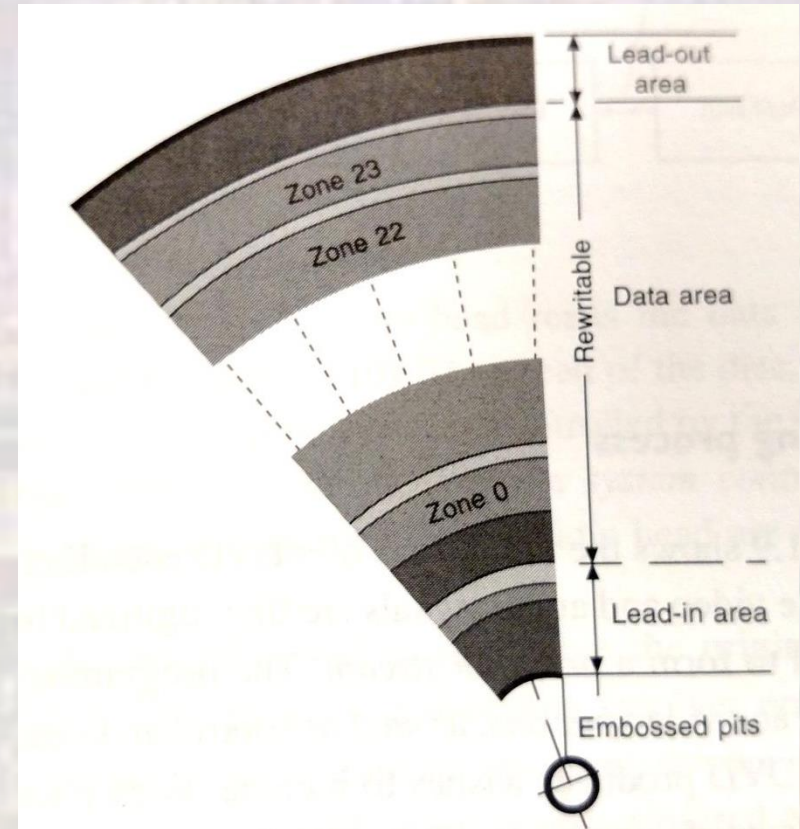


# Optical Disks

- DVD

- Rotation

- CLV Constant linear Velocity
  - Sequential data – Movies
- CAV Constant Angular Velocity
  - Fast access
  - Inefficient
- Zoned CLV
  - CLV within zones



# Optical Disks

- DVD - Framing
  - DVD Video
    - Video Stream
    - 8 types of Audio Streams
    - 32 types of Sub Picture Streams
    - PCI (Presentation Control Information) Stream
    - DSI (Data Search Information) Stream
  - 2K Byte data chunks in each stream (2048B)
  - Header and ECC added to make 2064 Bytes (PES packet)
    - Header includes location information

# Optical Disks

- DVD - Framing
  - Forward Error Correction
    - Very powerful error detection and correction
    - Can correct a burst of up to 2800 Bytes (6mm linear damage)
    - Leads to a 2418 Byte Sector

# Optical Disks

- DVD - Framing
  - NRZI and 8 to 16 encoding
    - EFM + (8-14  $\rightarrow$  8-16)
    - Doubles the size of the sector
    - 4836 Bytes (Data Channel)



# Optical Disks

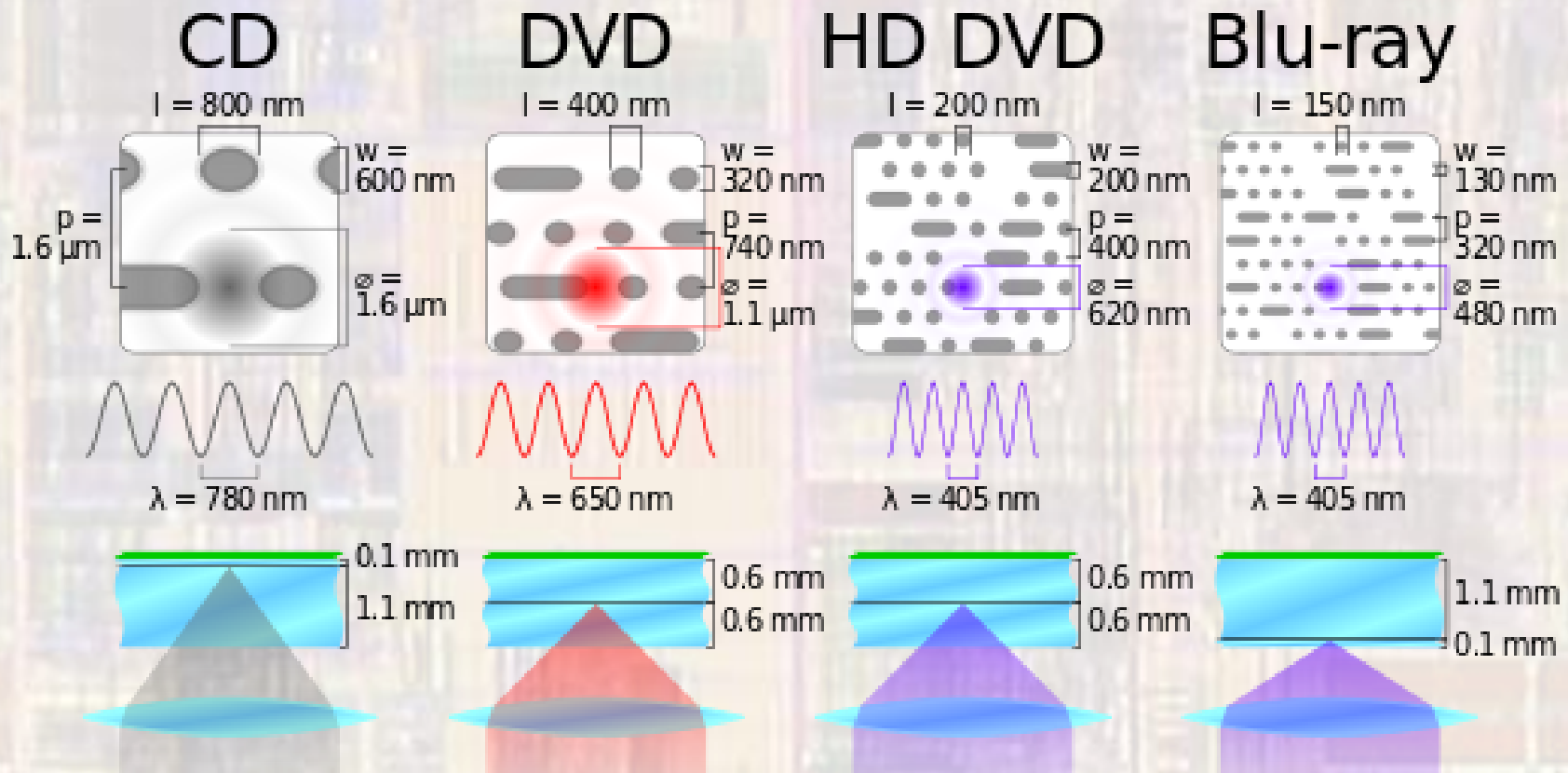
- DVD - Framing
- UDF – Universal Disk Format
  - Defines **data structures** such as volumes, file blocks, sectors, CRC's, paths, records, allocation tables, partitions, and character sets, as well as methods for recording, writing, and other applications.

# Optical Disks

- DVD – R/RW
  - Same approach as CD-R/RW

# Optical Disks

- Blu-Ray



# Optical Disks

- DVD/Blu-Ray
  - Triple layer disk
    - DVDx2
    - BR