

Optical Recording and Communications

Introductory Question

- When you submerge a digital watch in water and tilt it just right, the watch's face appears to be a perfect mirror. This mirror reflection is from
 - A. the outer (front) surface of the watch face
 - B. the inner (back) surface of the watch face

Observations about Optical Recording and Communications

- Optical disks can store lots of audio or video
- That audio or video is of the highest quality
- Optical disks continue to play perfectly for years
- Playback of optical disks involves lasers
- Lasers and fibers are used in communication

5 Questions about Optical Recording and Communication

- How is information represented digitally?
- How is information recorded on an optical disk?
- How is information read from an optical disk?
- How can light carry information long distances?
- Why does light follow an optical fiber's bends?

Question 1

- How is information represented digitally?

Review of Digital Representation

- Audio or video info is a sequence of numbers
- Each number can be represented digitally
 - by putting specific symbols in a set of digits.
 - Digital representations often involve binary digits, which can each hold only two symbols: 0 and 1.
 - Each symbol is a discrete value of a physical quantity
- Digital representations have
 - good noise-immunity
 - and permit error correction (elimination of noise).

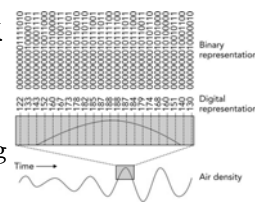
Clicker Question

■ The Napoleonic semaphore telegraph sent information using towers with two long vanes which could have 7 different orientation. A chain of telegraph towers and operators with telescopes passed information quickly across France. Was this digital optical communication?

- A. Yes
- B. No

Digital Audio

- The air pressure in sound is measured thousands of times per second
- Each measurement is represented digitally using about 16 binary digits, each a 0 or a 1.

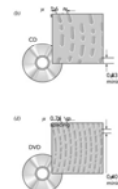


Question 2

■ How is information recorded on an optical disk?

Structure of CDs and DVDs

- These disks have spiral tracks in reflective layers
- Each track contains pits and flats
- Digital symbols consist of the lengths of the pits and flats
- The track structure is made as small as can be detected by the playback system, so as to maximize the density of information.

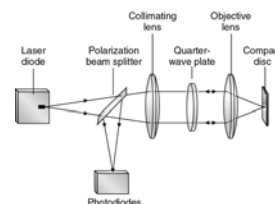


Question 3

■ How is information read from an optical disk?

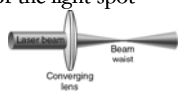
Playback Techniques

- Laser light is focused on the shiny layer
- Reflection is weaker from a pit than from a flat
- Reflected light is directed to photodiodes
- Reflected light intensity indicates pits or flats



Playback Issues

- Light must hit pits perfectly
 - Feedback optimizes the position of the light spot
- Light must hit only one pit
 - Use laser light—a single wave
 - Use a converging lens to focus that wave to a spot
- The wave forms a “waist”—its minimum width
 - Wave limits on focusing are known as diffraction
 - Waist can’t be much smaller than a wavelength
 - so pit size can’t be much smaller than a wavelength.



Clicker Question

- Light is used to construct computer chips and, as the features on those chips get smaller, the wavelength of the light must get shorter because shorter wavelength light
 - A. is brighter.
 - B. is dimmer.
 - C. carries more energy per photon.
 - D. can be focused to smaller spots.

Advantages of Digital Recording

- Freedom from noise and media damage issues
 - Digital representation avoids information loss
 - Error correction ensures clean information
 - Surface contamination doesn’t matter (much)
- High information density
- Data compression is possible
- Perfect, loss-less copies are possible

Question 4

- How can light carry information long distances?

Optical Communication

- Both analog and digital representations possible
- Analog representation
 - often involves AM modulation of the light
 - and is often used for remote process monitoring.
- Digital representation
 - often uses pulses with discrete amplitudes as symbols
 - and provides noise-immunity, error correction, compression, and channel-sharing.

Transmission Techniques

- Light in air: direct line-of-sight
 - Infrared remote controls
 - Infrared computer links
- Light in optical fibers: arbitrary paths
 - Optical cables and networks

The Components of Optical Communications

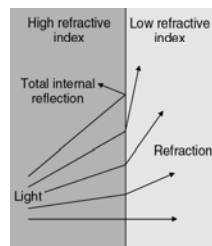
- Transmitters
 - Incandescent lamps (poor performance)
 - Light Emitting Diodes (adequate performance)
 - Laser Diodes (high performance)
- Receivers
 - Photoresistive cells (poor performance)
 - Photodiodes (high performance)
- Conduits
 - Optical Fibers (ranging from poor to high performance)

Question 5

- Why does light follow an optical fiber's bends?

Total Internal Reflection

- As light enters a material with a lower index of refraction, it bends away from the perpendicular
- If that bend exceeds 90° , the light reflects instead
- That reflection is perfect: total internal reflection



Introductory Question (revisited)

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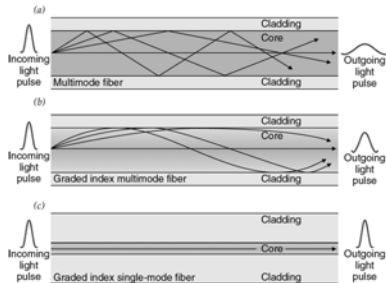
Optical Fibers

- An optical fiber consists of a high-index glass core in a low-index glass sheath
- When light tries to leave the core at a shallow angle, it experiences total internal reflection
- Light bounces endlessly through the core and emerges from the end of the fiber
- If the glass is pure and perfect enough, the light may travel for many kilometers through the fiber

Communication Issues

- Information is sent as a stream of digital symbols
 - Those symbols are usually pulses of light
 - If pulses spread out and overlap, information is lost
- To keep pulses from spreading in time
 - all the light must follow a single path through fiber
 - all frequencies of light must travel at the same speed
- The fiber's structure and materials are critical
- To limit possible paths, use a "single mode" fiber

Optical Fiber Types



Clicker Question

- Multimode fibers are great for carrying light for illuminating purposes. If you use one to carry digital information long distances, however, it will seriously limit
 - A. how many symbols you can send each second.
 - B. how bright each symbol can be.
 - C. how big each symbol can be.
 - D. how thick each symbol can be.

Communication Issues

- To limit frequency-related spreading of pulses
 - minimize dispersion with monochromatic laser light
 - in low-dispersion glass at its optimal wavelength.
- Since light attenuates as it passes through fiber
 - use low-loss glass
 - and amplify the light periodically,
 - using fiber laser amplifiers.
- Systems using different colors can share a fiber!

Summary about Optical Recording and Communication

- Optical disks store information as pits and flats
- Focused laser light reads that information
- Digital representations allow perfect playback
- Optical fibers carry information as light