Optical Recording and Communications

Question:

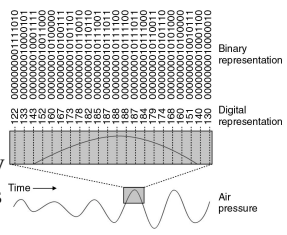
When you submerge a digital watch in water and tilt it just right, the watch's face appears to be a perfect mirror. Is the mirror reflection from the outer (front) surface of the watch face or from the inner (back) surface?

Review of Digital Representation

- A physical quantity is measured
- The measured value is represented by several digits
  - Binary digits are most common
  - Binary digits have only two values: 0 and 1
- Each digit is represented by a physical quantity
- Discrete values of physical quantity represent a digit
- Good noise-immunity and allows error correction

Digital Audio

- Represent air pressure fluctuations as current
- Measure current many times per second
- Convert current measurements to binary
- Use these binary values to represent sound

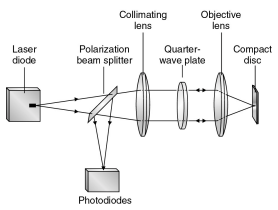


Optical Recording

- Media types:
  - Compact Disc (CD)
  - Laser Disc
  - Digital Video/Versatile Disc (DVD)
- Reading technique:
  - Reflect laser light from optical surface
  - Measure reflected intensity to obtain information

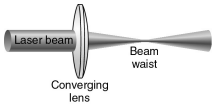
Playback Techniques

- Laser light is focused on disc aluminum layer
- Reflection is weaker from ridge than flat
- Reflected light is directed to photodiodes
- Light intensity indicates ridges or flats



Playback Issues

- Light must hit ridges perfectly
  - Feedback optimizes position of light spot
- Light must hit only one ridge
  - Use laser light
  - Focuses laser to diffraction limit
  - Feedback focuses laser on layer
- Ridge must be large enough to detect
  - Ridge can't be much smaller than light wavelength



Advantages of Digital Recording

- Freedom from noise and media damage problems
  - Digital representation avoids information loss
  - Error correction ensures clean transfer of information
  - Surface contamination doesn't matter (much)
- High information density
  - Optical density greatly exceeds mechanical density
  - Data compression is possible
- Perfect, loss-less copies are possible

Optical Communication

- Light transfers info from source to destination
- Both analog and digital representations possible
  - Analog is used to monitor some processes remotely
  - Digital is the dominant representation
    - Noise immunity and error correction
    - Compression
    - Sharing a single communication channel is common

Transmission Techniques

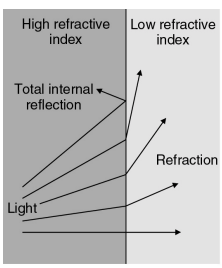
- Basic Concept
  - Light source intensity encodes information
  - Light sensor detects and decodes information
- Direct line-of-sight
  - Infrared remote controls
  - Infrared computer links
- Fiber transmission systems
  - Optical cables and networks

Components

- 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)

Total Internal Reflection

- As light goes into material with a lower index of refraction, it bends away from the perpendicular
- When the bend exceeds 90 degrees, the light reflects instead
- The reflection is perfect – total internal reflection



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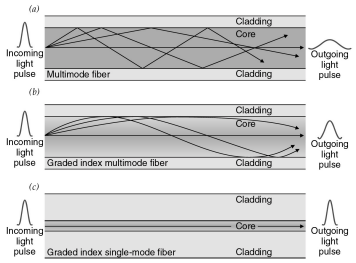
Optical Fibers

- An optical fiber consists of a high-index glass core in a low-index glass sheath
- When light tries to leave the high-index 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

Optical Fiber Types



Communication Issues

- Light must remain together during passage
  - Dispersion and path differences are bad
  - Use laser light (monochromatic)
  - Use low-dispersion glass at its best wavelength
  - Use narrow (single-mode) fiber
- Light attenuates during the trip
  - Use low-loss glass
  - Amplify the light periodically
  - Use fiber laser amplifiers

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