PCM Modulation and Demodulation

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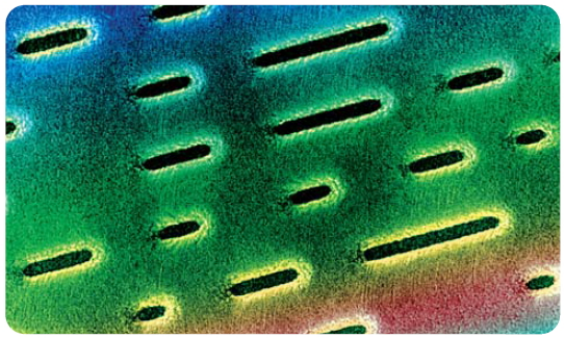
Pulse Code Modulation (PCM)

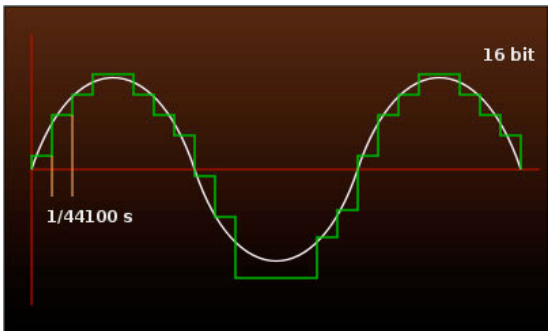
- Pulse-code modulation (PCM)
  - digital representation of an analog signal
  - magnitude of signal is sampled regularly at uniform intervals
  - quantized to a series of symbols in a numeric (usually binary) code.
  - In short, PAM + Quantizer
- Applications:
  - Telephone systems
  - Digital audio standards – CD, computer, etc.

Application of PCM - Compact Disc

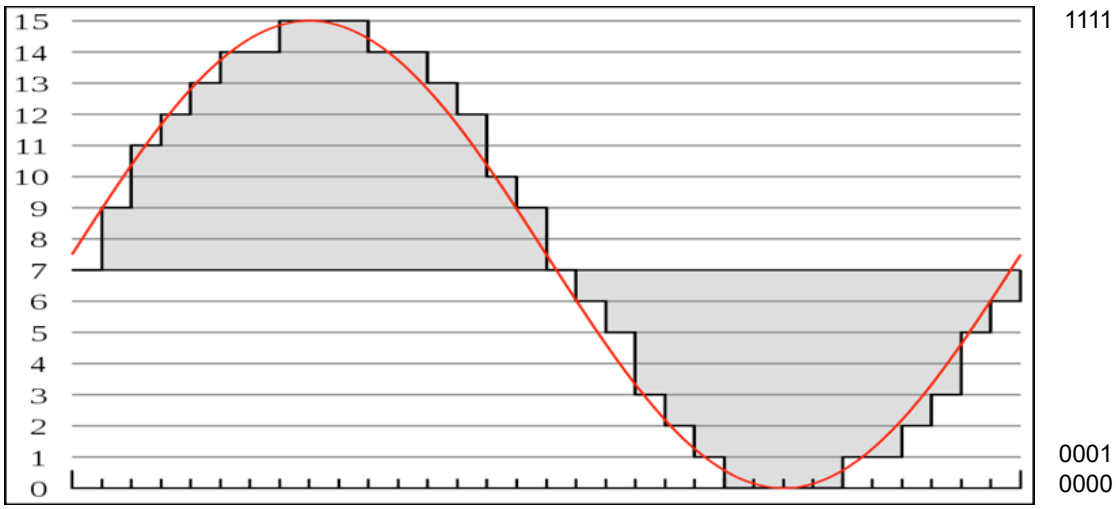
- In history of CD
  - 16 bits, 44.1KHz, 74 minutes



COMPACT disc DIGITAL AUDIO



PCM Illustration



- Sampling and Quantization
- 4-bit PCM (guess why it has this name)

Limitations

- Because PCM is basically “Sampling + Quantization,”
  - Sampling rate: faster than Nyquist frequency
  - Quantization: quantization noise (distortion)

Illustration: Quantization Error in Image

- Lena image quantized using 16, 8, 4, and 2 bits/pixel

Illustration: Impact of Quantization Level

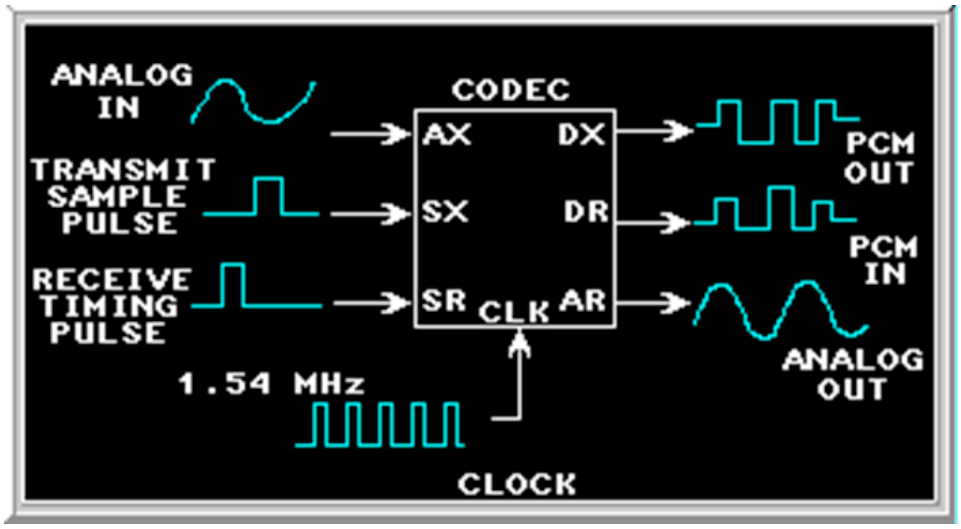
- Listen to music (MP3) with different quantization levels (bitrates)

- Examples:
  - 128Kbps Hey Jude_128Kbps.mp3
  - 64Kbps Hey Jude_64Kbps.mp3
  - 32Kbps Hey Jude_32Kbps.mp3
  - 16Kbps Hey Jude_16Kbps.mp3
  - 8Kbps Hey Jude_8Kbps.mp3

- Can you feel differences?

In Experiments,

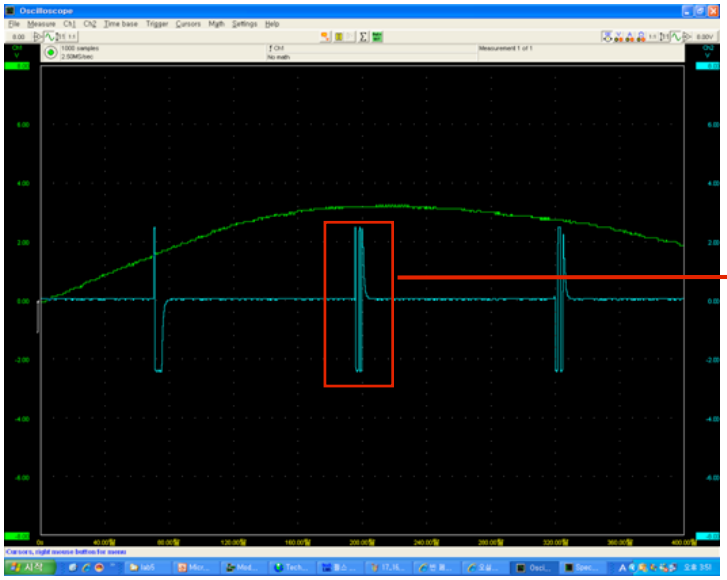
- CODEC (COder and DECoder)

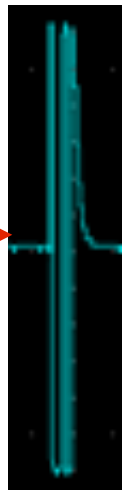


In Experiments,

- Abbreviation:
  - Analog input = AX
  - Encoded PCM = DX (Digital TX)
  - Transmitted DX needs to enter DR (Digital RX)
  - Received PCM signal (DX) is recovered from AR

PCM - Modulated Signal

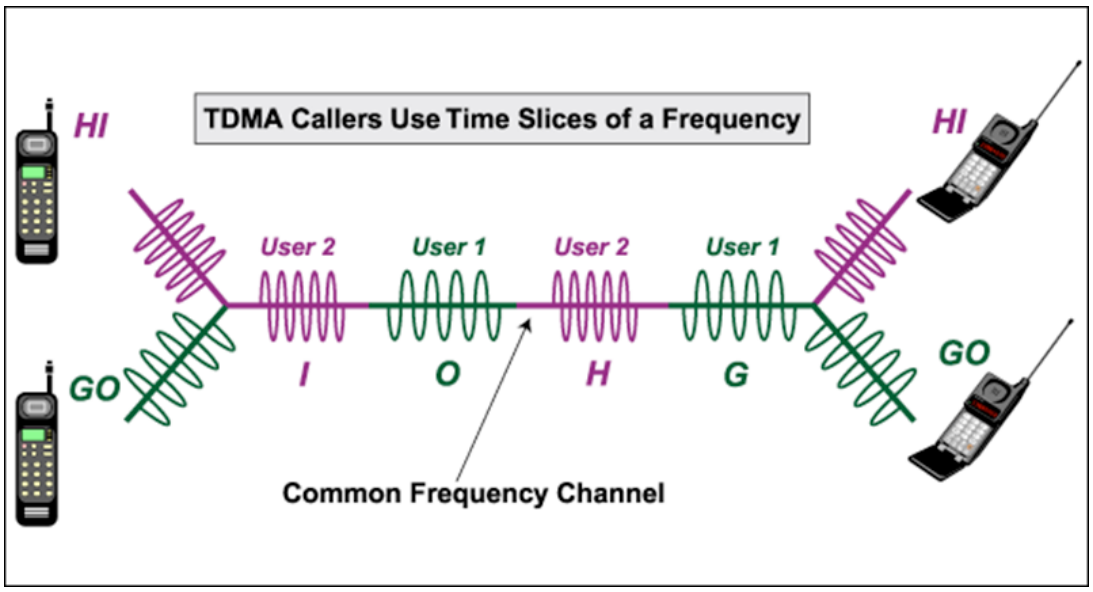




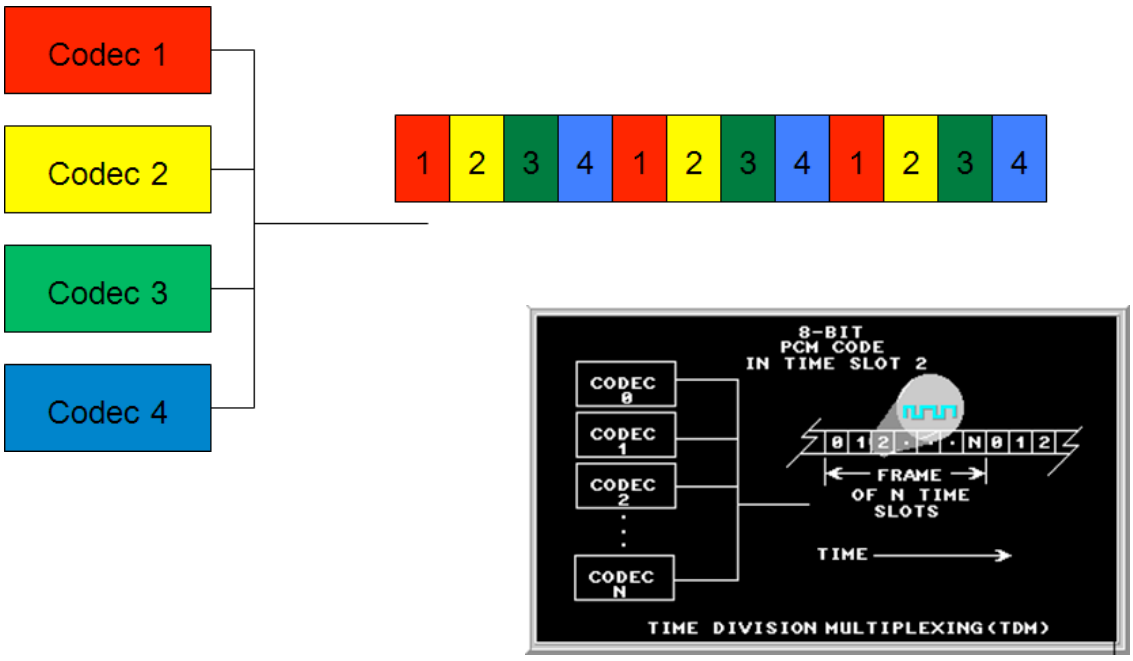
may mean PCM, e.g., 10011010

Recall: Multiplexing

- **Definition:** multiplexing (also known as muxing) is a process, where multiple analog message signals or digital data streams are combined into one signal over a shared medium.

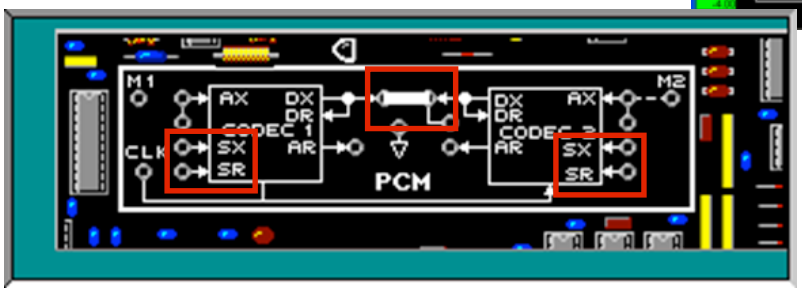


In Experiments,



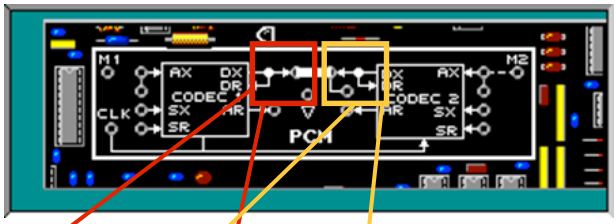
In Experiments,

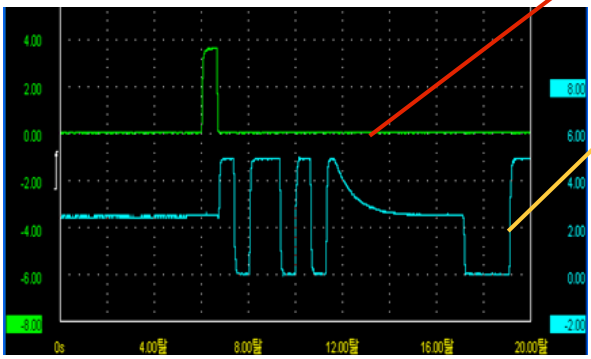
- PLEASE be careful with “arrows” (where to go) on board
- SX and SR have slightly different timing
  - Time-shifted version of PCMs
  - Multiplexing!

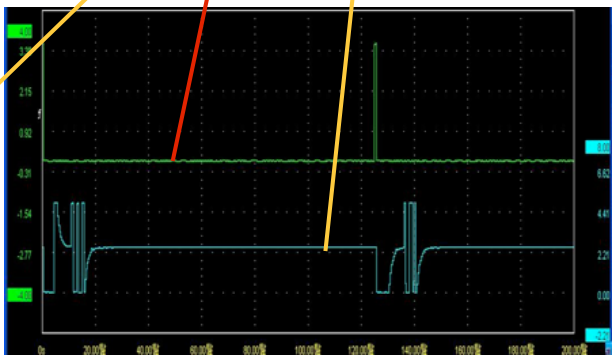


In Experiments,

- NOTE: For TDM, only check whether two PCM signals are correctly multiplexed:
  - Around page 40-43, your LABVOLT system controls experiment boards, so that you can have:







Final Remarks

- Note:
  - In you experiment procedure software, some mistakes are included (especially in figures) – be careful!