Big Idea (Week 8): Hardware for Digital Audio

We can build a physical machine that can be programmed with a sequence of numbers to perform any computation. With appropriate support for sound input and output, it can perform any audio signal processing task, including the processing we need for mp3 encoding and decoding that we have been studying for the past several weeks. As we have developed in this course, it is necessary to process data at a 44KHz sample rate to achieve high fidelity encoding and decoding without distortion. Modern integrated circuits run fast enough that very modest digital hardware can be shared in time to perform this computation and meet the require "real time" requirements for audio encoding and decoding.

We should now be comfortable that we can take sound (pressure waves), convert them to voltages, then convert those voltages to a series of digital samples (numbers) to represent the sound. Conversely, we can take digital samples and convert them back to voltages and pressure waves. In between, we can use computations to compress the digital samples so they can be represented compactly and similarly use other computations to reverse this process.

Today, we see that the physical machine required to perform this processing is relatively simple and can be built economically from the digital processing technology engineers have optimized over the past several decades. In particular, we need a few key building blocks:

- a microphone to convert pressure waves to voltages
- an Analog-to-Digital (A/D) conversion circuit to convert from analog signals to digital numbers
- a non-volatile storage to hold the compressed set of numbers representing a sound (*e.g.* a song or podcast)
- a memory for holding intermediate values in our computation
- one or more universal computing elements to implement digital computations (including arithmetic and logical operations)
- some sequencing/control to orchestrate the computation and data movement
- interconnect among the memories, I/O devices, and computing element(s)
- a Digital-to-Analog (D/A) conversion circuit to convert from digital numbers back to analog signals
- a speaker to convert voltages back to pressure waves

All the computation and storage, from input voltages to output voltages can be integrated into a single integrated circuit.