Recap

Design a DAC
Experimental method
Output a sine wave

Overview

Use DAC to create sounds
What are the fundamental limitations?
Precision,
Sampling rate,
Memory size,
Processor calculations
Testing

Need software to create sounds. Frequency is the pitch
Amplitude is the loudness. Shape is the voice.

- Humans can hear from about 25 to 20,000 Hz.
- Middle A is 440 Hz
- Other notes on a keyboard are determined
  - $440 * 2^{N/12}$
  - "N" is number of notes up or down from middle A.
- Middle C is 261.6 Hz.
- music contains multiple harmonics

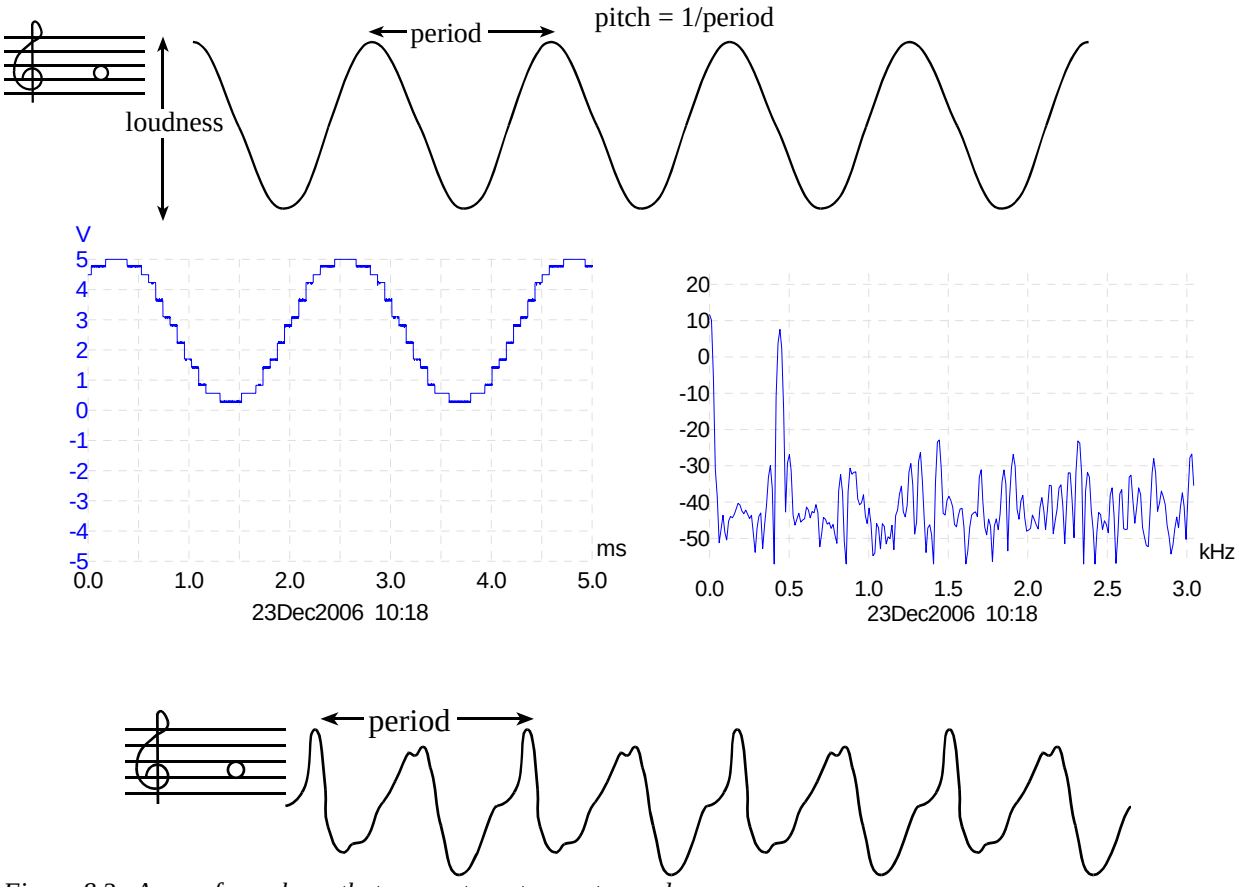

Figure 8.3. A waveform shape that generates a trumpet sound.

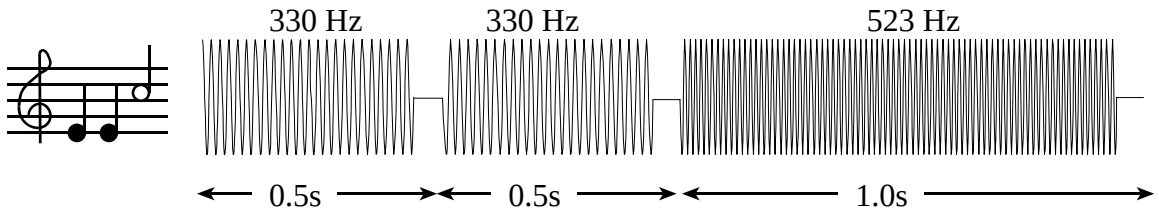

Figure 8.4. You can control the amplitude, frequency and duration of each note (not drawn to scale).

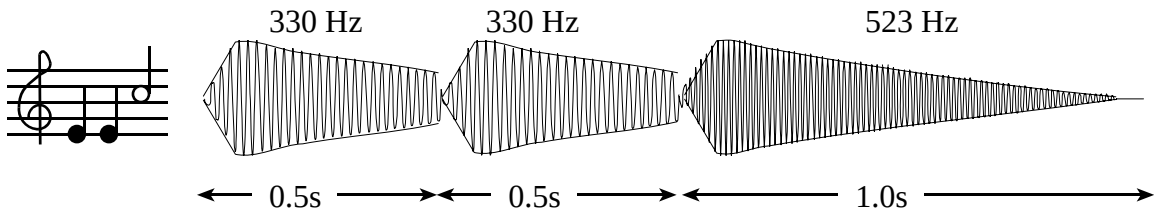

Figure 8.5. The amplitude of a plucked string drops exponentially in time.

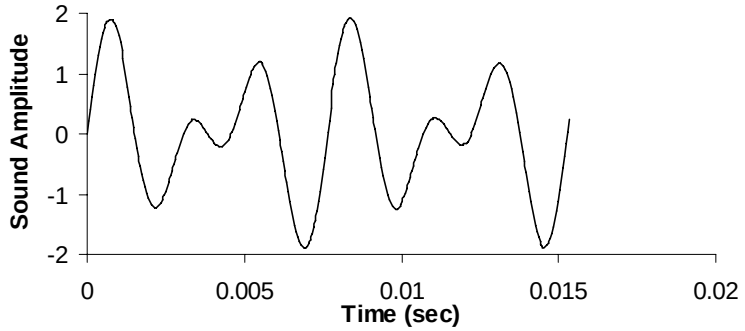

Figure 8.6. A simple chord mixing the notes C and G.

How much memory does it take to store a song
- 3 minutes
- Stereo channels
- 44 kHz
- 12-bit per channel

How many bus cycles does it take to output one value?
- Fetch data from memory
- Decompress
- Filter/amplify/mix/envelop
- DAC speed

How do we test Lab 8?
Static testing
- Complete coverage 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15
- Corner testing 0,1,2 13,14,15

Interval 0 4 8 12
Voltmeter in AC mode is measure of noise

$$\text{RMS} = \sqrt{\frac{1}{n}\sum_{i}(V_i - \overline{V})^2}$$

Dynamic testing
Oscilloscope (voltage versus time)
Spectrum analyzer (voltage versus frequency)

The bottom line

DAC and OC interrupts create waveforms
DAC and ADC have the same two fundamental limits
Sampling rate: signal has 0 to ½ fs
Number of bits: Resolution = Range/Precision
Static testing versus dynamic testing