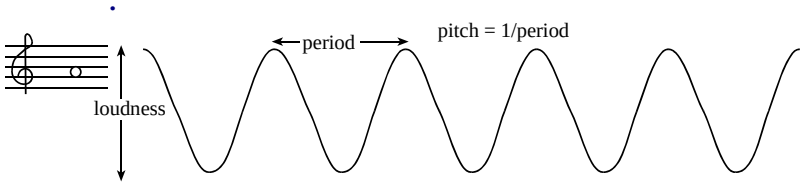
Recap

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

- 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

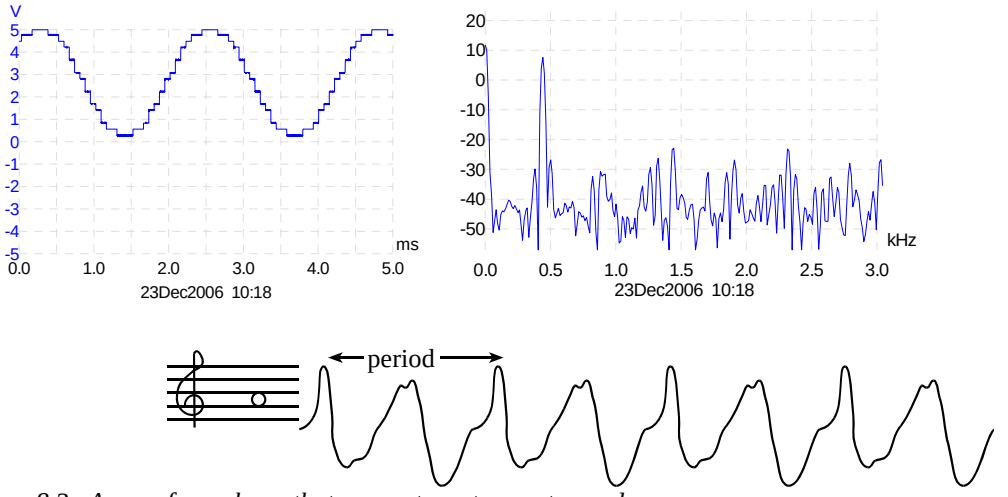


Figure 8.3. A waveform shape that generates a trumpet sound.

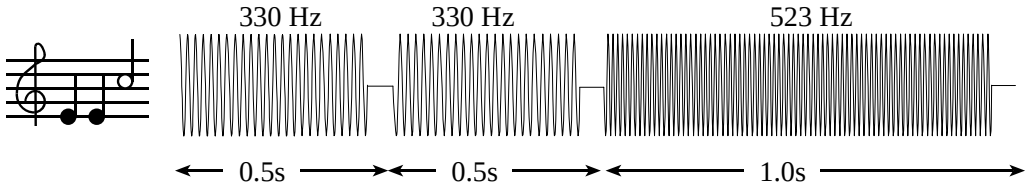


Figure 8.4. You can control the amplitude, frequency and duration of each note (not drawn to scale).

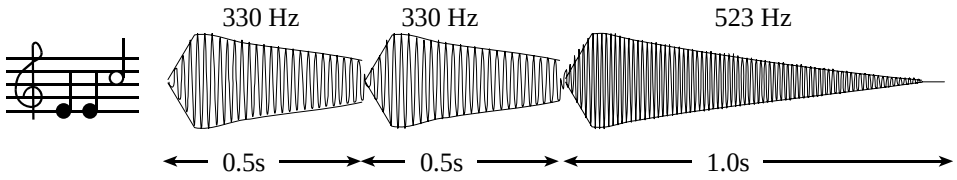


Figure 8.5. The amplitude of a plucked string drops exponentially in time.

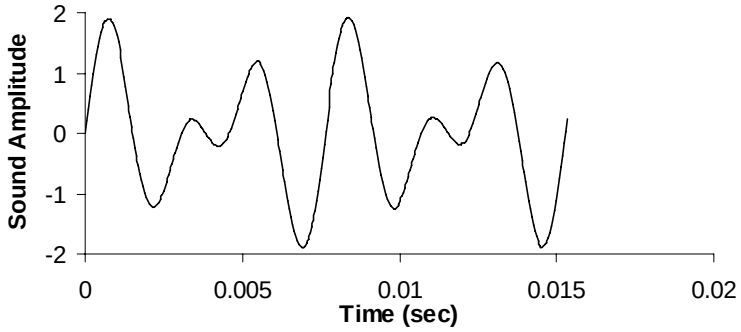


Figure 8.6. A simple chord mixing the notes C and G.

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**