**Low-pass filter as a rudimentary DAC**

1. 1-pole LPF: RC circuit

Start with schematic including input and outputs (PWM and smoothed PWM). Also explain unity-gain buffer and include schematic of RC + buffer.

Transfer function:

Bandwidth:

Solving for omega gives the bandwidth frequency as a function of R and C:

or

Define

Equivalently,

For a given musical pitch, +/- 5 cents is an acceptable variation in pitch. The VCO is calibrated to 1V/octave or, equivalently, 1/12 V per semitone. A cent is 1/100th of a semitone, or 0.83333333 mV. A range of +/- 5 cents (10 cents) corresponds to 8.3333 mV

The Arduino Uno’s PWM-enabled pins output at 490 Hz or approximately 3079 rad/s, except pins 5 and 6, which output at 980 Hz or approximately 6158 rad/s. Taking , solve for :

With a time constant = 0.196 s, the cutoff frequency of this filter is or .

1. 2-pole LPF: Sallen-Key filter