

# EE 120 Guest Lecture Day!

- First hour, Alex Devonport
    - Signals & Synthesizers: a tour of the Moog Werkstatt-01
  - Second hour, Prof. Miki Lustig
    - A "pitch" for EE 123, Digital Signal Processing (you should take it!)
    - A software-defined radio (SDR) demonstration.
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## Signals and Synthesizers: the Moog Werkstatt-01.

The Moog Werkstatt-01 is a **modular analog synthesizer**.

What does that mean?

- **Synthesizer**: an electronic signal processing tool that musicians use to make new sounds.
- **analog**: All signals and signal processing are in continuous time.
- **modular**: Not just "one big circuit"; made of independent systems that you can interconnect at will.

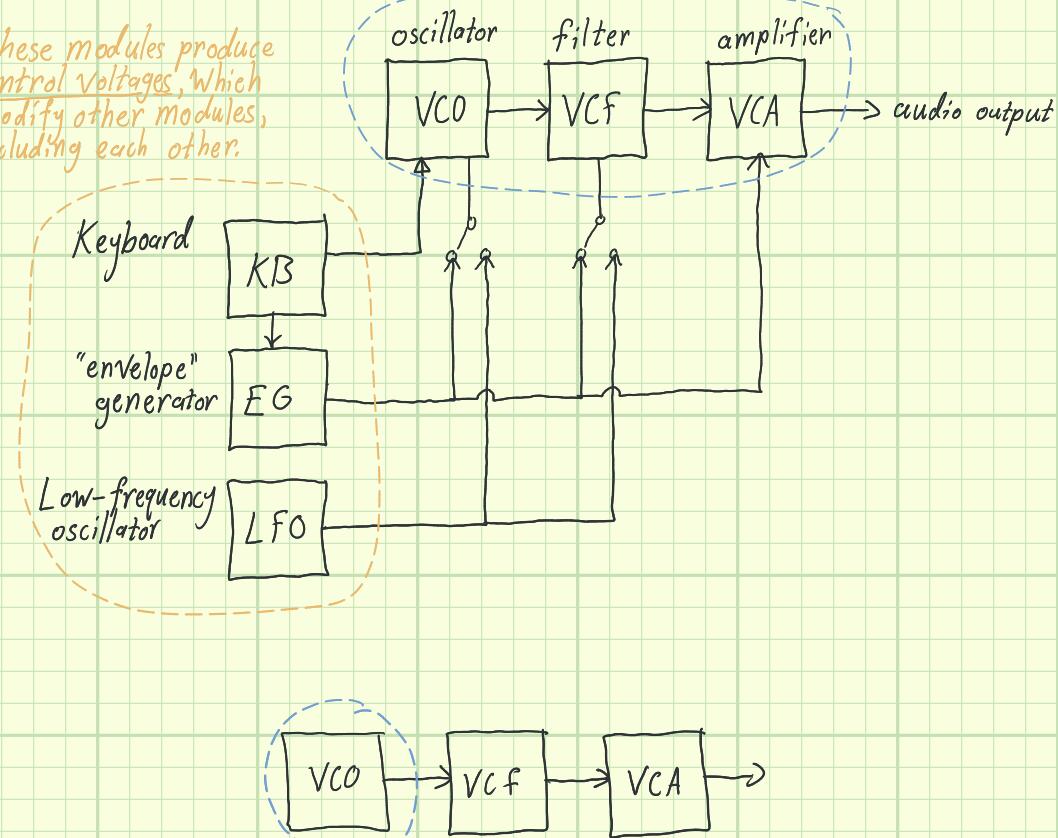
What does an analog synthesizer have to do with EE 120?

- Helps us gain intuition on time-frequency relationships.
- We can look at two perspectives on signals:
  - engineers: primarily "time-domain", frequency-domain view (Fourier transform) is auxiliary
  - musicians: primarily "frequency-domain", time-domain almost never considered
- Analyze signals with high-precision frequency analysis equipment: **your ears!**

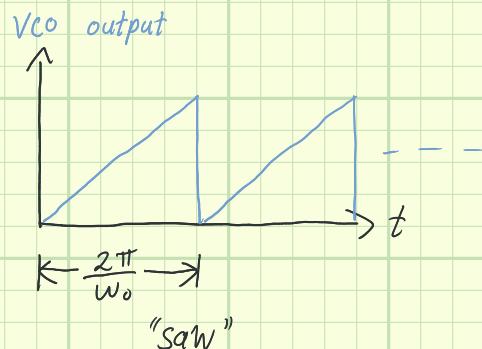
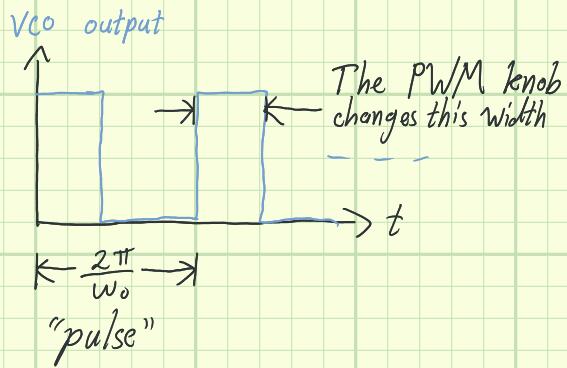
The Werkstatt's hardware is divided into six modules.

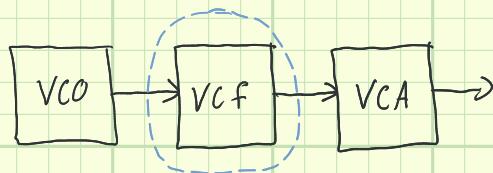
These modules produce and process audio.

These modules produce control voltages, which modify other modules, including each other.



The Voltage-controlled Oscillator (VCO) produces the base audio signal. A control voltage determines the fundamental frequency ( $\omega_0 \propto Z^{CV}$ ), and we have two choices of waveform: "pulse" and "sawtooth".

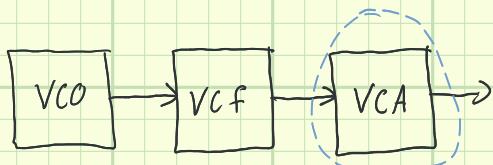
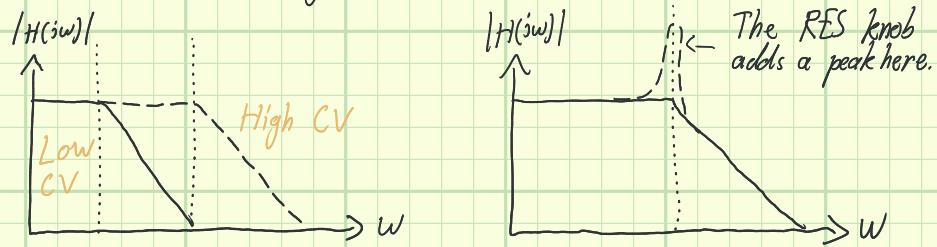




The Voltage-controlled filter (VCF) is a fourth-order lowpass filter that takes the base audio from the VCO as its input. Its transfer function is (approximately)

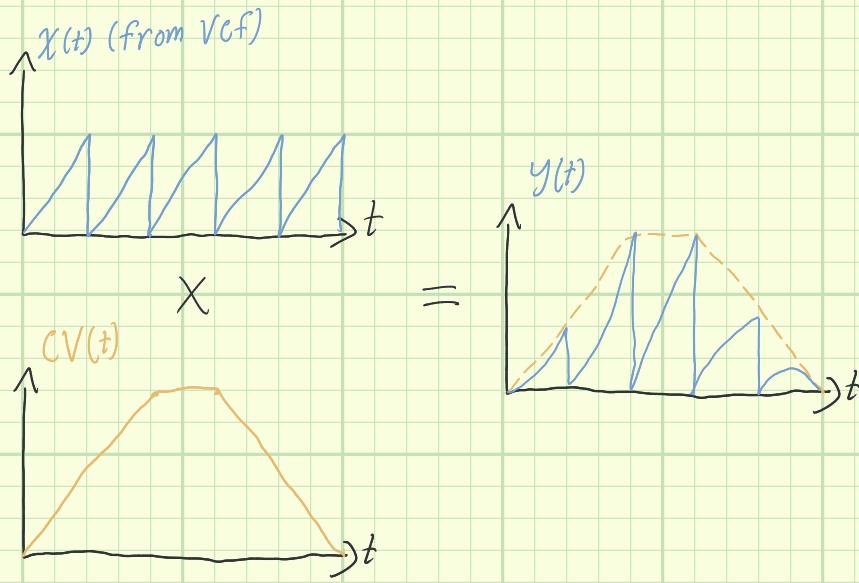
$$H(j\omega) = \frac{1}{(1 + j\omega/\omega_c)^4}$$

Where the cutoff frequency  $\omega_c$  is set by a control voltage ( $\omega_c \propto 2^{CV}$ ).



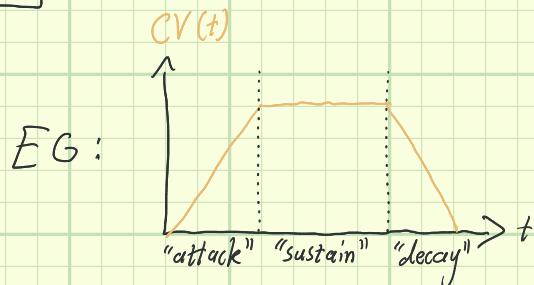
The Voltage-controlled Amplifier (VCA) determines the final amplitude, or "envelope", of the signal. It takes the filtered audio from the VCF as input, and outputs to the audio jack.

The gain is set by a control voltage ( $y(t) = X(t) \times CV(t)$ ).

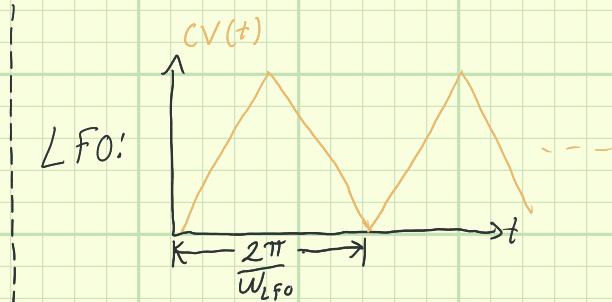




The Envelope generator (EG) and Low-frequency oscillator (LFO) don't produce sounds themselves, but make **control voltages** that modify how the other modules behave.



You saw how this affects the VCA.



This can be used on the VCO to add vibrato, among other things.

The module interconnections are not fixed. You can use the **patch headers** to add new connections.

Say you wanted to modulate the VCA gain with the LFO, to make the sound "wobble". A patch will do it!

