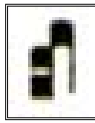


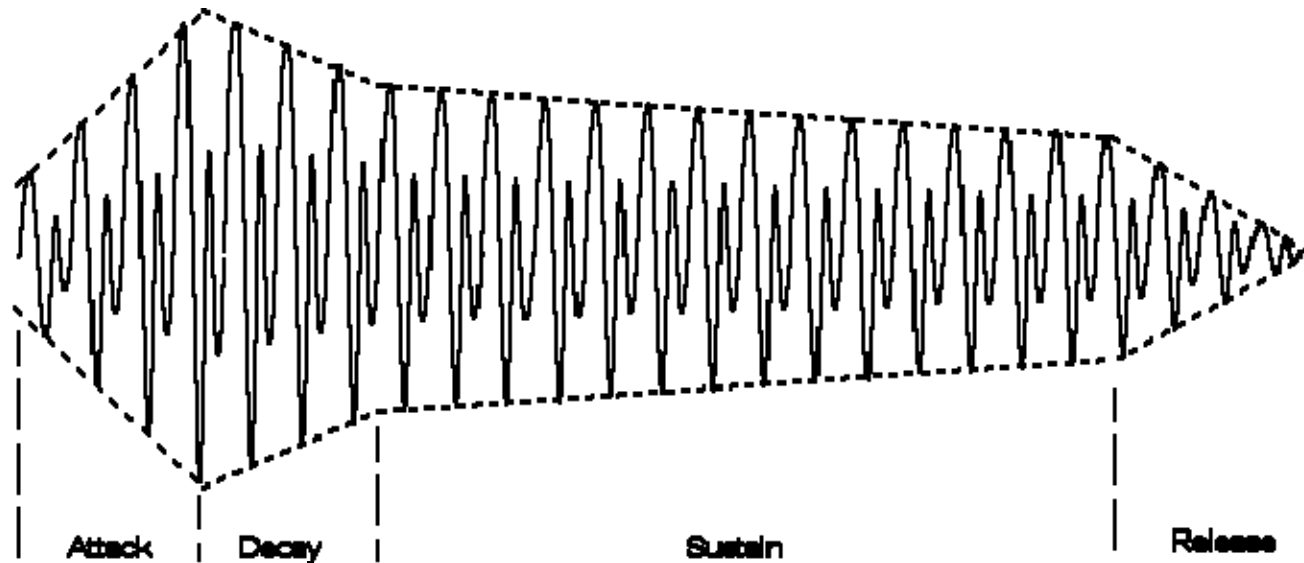
U6 Music Technology > How Synthesizers Work



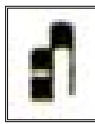
P A Siepmann
Uppingham School Music Department
<http://www.petersiepmann.net>



- A synthesizer is an electronic musical instrument that
- uses filters and tone generators to create waveforms
 - these waveforms are then processed to generate sound

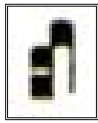


Modern synthesizers can closely reproduce the sound of some instruments, but many keyboard players use them for their characteristic sound.



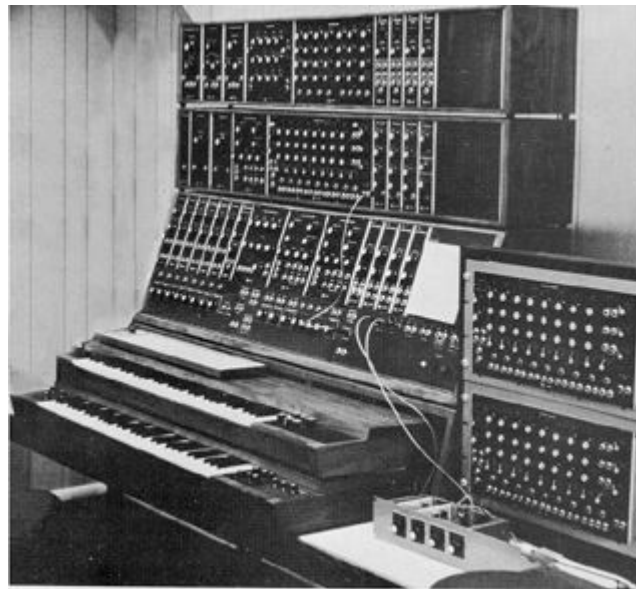
Synthesizers are often controlled with a piano-style keyboard, leading such instruments to be referred to simply as "keyboards". Several other forms of controller have been devised to resemble violins, guitars and wind-instruments. Synthesizers without controllers are often called "modules", and can be controlled using MIDI (more about this next term!).



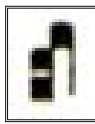


History

Robert Moog introduced the first commercially available modern synthesizer in the 1960s (Moog modular, 1965; MiniMoog, 1969)



Watch http://www.youtube.com/watch?v=ynX6WmvxI_8&p=61B821980234F18C&playnext=1&index=6



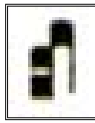
In the 1970s the development of miniaturized solid-state components allowed synthesizers to become self-contained, portable instruments.

By the early 1980s companies were selling compact, modestly priced synthesizers to the public.

This, along with the development of Musical Instrument Digital Interface (MIDI), made it easier to integrate and synchronize synthesizers and other electronic instruments for use in musical composition.

In the 1990s synthesizers began to appear as computer software, known as software synthesizers.





The synthesizer's impact on music

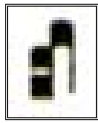
Early influences

- The Monkees - first to release an album featuring a Moog (1967)
<http://www.youtube.com/watch?v=0FO3YrBscml>
- Walter/Wendy Carlos: Switched-On Bach (1968)
 - influenced numerous musicians of that era and is one of the most popular recordings of classical music ever made.
- The Beatles: Abbey Road (1969)
<http://www.youtube.com/watch?v=dWILPJG9Cvg>

Emergence of Synthpop (late 1970s)

- Kraftwerk
<http://www.youtube.com/watch?v=5c81X6BiI0Y>
<http://www.youtube.com/watch?v=tD5P7RsC9TI> (!)





Types of synthesis

Additive synthesis

- builds sounds by adding harmonically related waveforms together
- Hammond Organ

<http://www.youtube.com/watch?v=hopUp1qBbJ4>

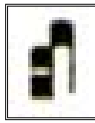


Subtractive synthesis

- filtering harmonically rich waveforms
- basis of early synthesizers such as the Moog

FM synthesis

- two or more signal generators to create and modify a voice
- one signal that 'modulates' the characteristics of another 'carrier' signal

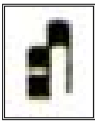


Physical modeling synthesis

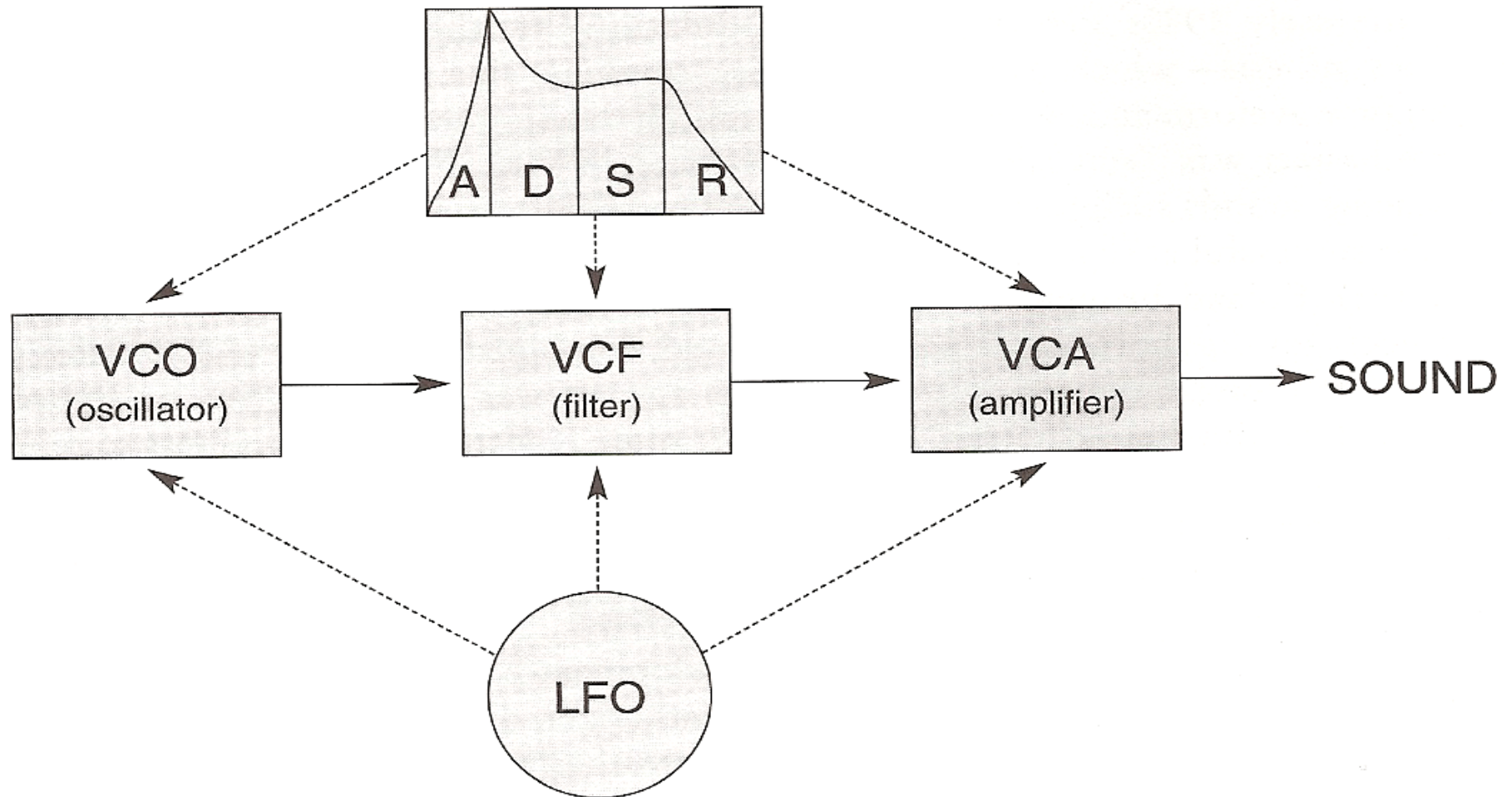
- using a set of equations and algorithms to simulate the waveform of a real instrument

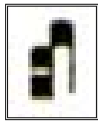
Sample-based synthesis - “sampling”

- record a real instrument as a digitized waveform, and then play back its recordings at different speeds to produce different tones



Components of Synthesis



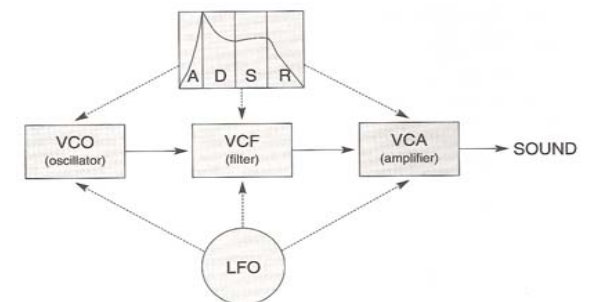


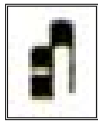
1. The Oscillator

- Provides the sound source
- Originally analogue wave forms produced by a VCO (voltage controlled oscillator)
- Replaced more recently by sampled or physically modelled waveforms produced using DCO (digital control oscillator)
 - o Better control over tuning

2. The Filter

- 'Shapes' the sound (bright, dull, etc.)
- In analog synthesizers, this was done using a VCF (voltage controlled filter)
- In subtractive synthesis, the filter removes high/low frequencies from the original signal.



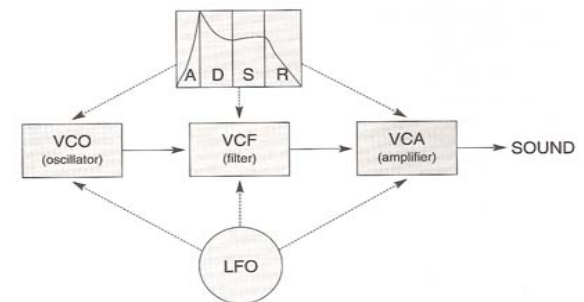


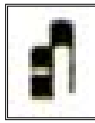
3. The Amplifier

- Preamp that boosts the electronic signal using a **VCA** (voltage controlled amplifier) before passing it to an external amplifier.

4. The Modulator

- Most commonly uses a **LFO** (Low Frequency Oscillator)
- This does not itself make an audible sound, but modulates the source wave
- Usually it causes slight oscillations in pitch, i.e. *vibrato*.
- Sometimes the LFO can also modulate the filter (usually causes a slow 'sweeping' effect) and the amplifier (causing oscillations in volume - *tremolo* effect).

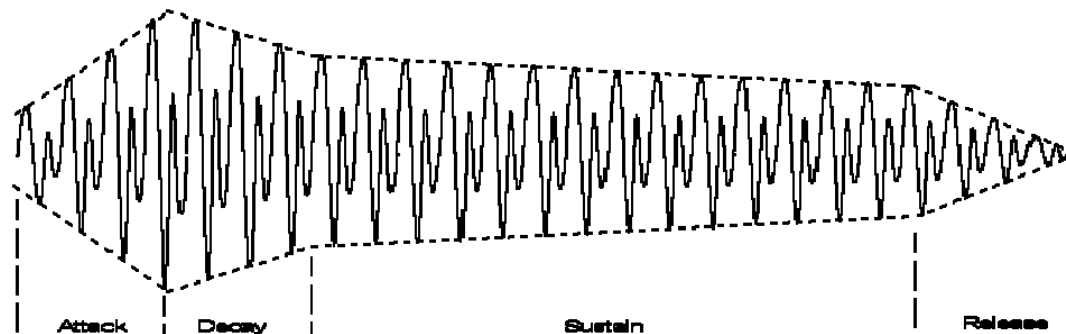


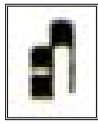


5. The Envelope

The attack and decay of a sound have a great effect on the instrument's 'sonic identity'. An envelope generator is used to control these aspects of the sound, and has four components:

- i) Attack time is the time taken for initial run-up of level from nil to peak, beginning when the key is first pressed.
- ii) Decay time is the time taken for the subsequent run down from the attack level to the designated sustain level.
- iii) Sustain level is the level during the main sequence of the sound's duration, until the key is released.
- iv) Release time is the time taken for the level to decay from the sustain level to zero after the key is released.

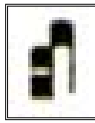




Try it!

using the MiniMogueVA - an example of VST (virtual studio technology)

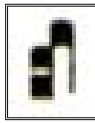
Go to the Public Drive, then Academic Departments\Music\PAS\U6 Tech
And click on the purple diamond icon



Control interfaces

Modern synthesizers are usually integrated controllers, where the sound synthesis electronics are integrated into the same package as the controller. However many early synthesizers were modular and keyboardless, while most modern synthesizers may be controlled via MIDI, allowing other means of playing such as:

- Fingerboards and touchpads
- Wind controllers
- Guitar-style interfaces
- Drum pads
- Music sequencers
- Non-contact interfaces (akin to theremins)



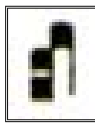
Fingerboard controller

A ribbon controller or other violin-like user interface may be used to control synthesizer parameters. The ribbon controller has no moving parts. Instead, a finger pressed down and moved along it creates an electrical contact at some point along a pair of thin, flexible longitudinal strips whose electric potential varies from one end to the other.



See also *Ondes Martenot*

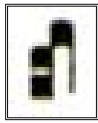
<http://www.youtube.com/watch?v=Yy9UBjrUjwo>



Wind controllers

These may be analog or MIDI controllers or may include built-in synthesizers. In addition to a key arrangement, the controller has breath-operated pressure transducers, and may also velocity sensors and bite sensors, etc.





Other controllers

The *Talkbox* is a mouth-controlled effects box.



- Sound from the amplifier is reproduced by the speaker in the Talkbox and directed through the tube into the performer's mouth.
- The shape of the mouth filters the sound, with the modified sound being picked up by the microphone. The shape of the mouth changes the harmonic content of the sound.
- The performer can mouth words, with the resulting effect sounding as though the instrument is speaking. This “shaped” sound exits the performer's mouth, and when it enters a microphone, an instrument/voice hybrid is heard.

http://www.youtube.com/watch?v=An9_LG3Mc08#t=2m30s

<http://www.youtube.com/watch?v=YHnnnexSx-A>