On Sound Synthesis

Ángel Faraldo

Some Introductory Quotes

"We have also sound-houses, where we practice and demonstrate all sounds and their generation."

Francis Bacon (1626), *The New Atlantis*

Andrew Hugill (2006, 2017): "The origins of electronic music". In Nick Collins & Julio d'Escriván (eds): *The Cambridge Companion to Electronic Music.* Cambridge University Press

“The raw material of music is sound.”

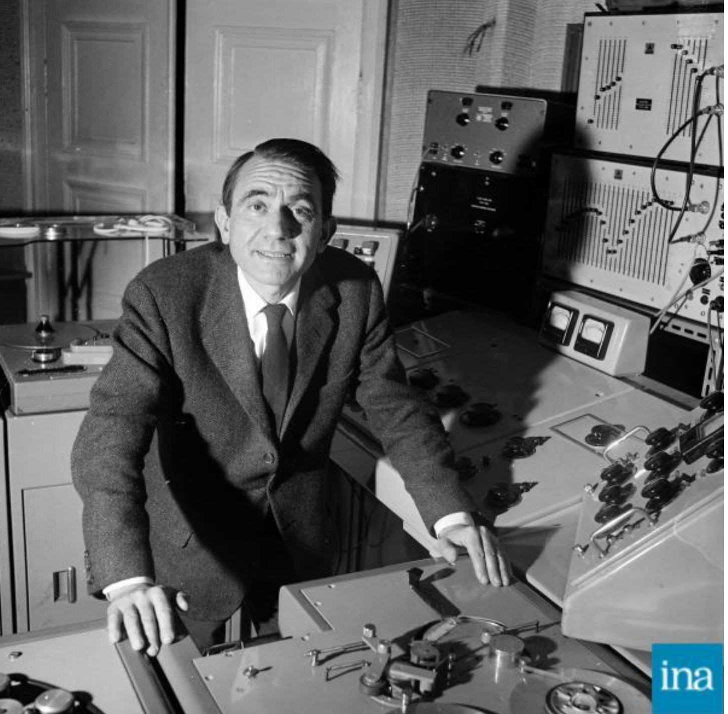
Edgar Varèse (1936), *The Liberation of Sound*

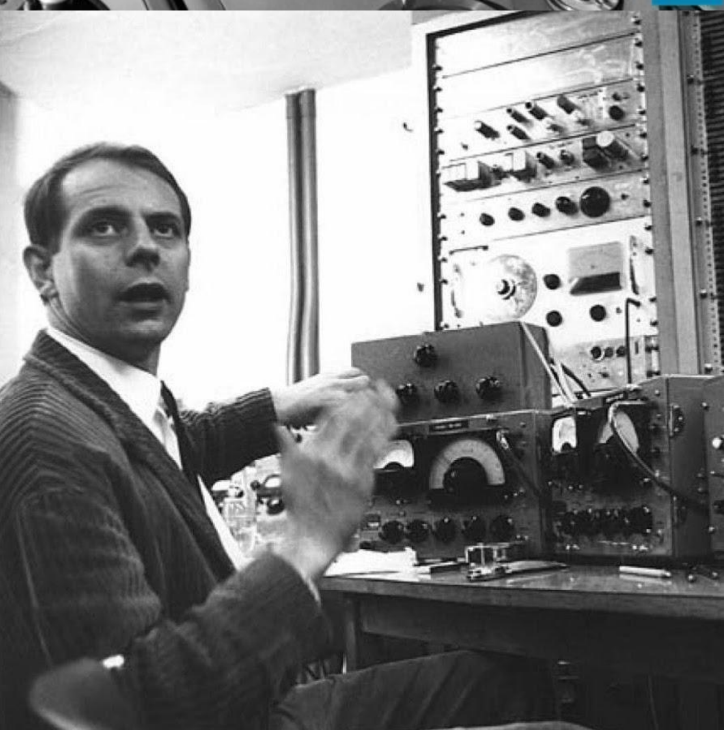
“I need an entirely new medium of expression: a sound-*producing* machine, not a sound-*reproducing* one.”

Edgar Varèse (1939), *Music as an Art-Science*

Arnold Schoenberg (1909) *Fünf Orchesterstücke #3 Op. 16*

Luigi Russolo, *Awakening of a City*





Early Schools of Electronic Sound

Early approaches to electronic music making have pervaded the electronic music history and are still the fundamentals of MOST SOUND SYNTHESIS TECHNIQUES.

The Post War FRENCH Model

a) **Sound Recording and Processing Techniques**

"The Well Tempered Microphone"

c) **Tape Splicing** (cut, paste, reverse, manual envelopes, proto-granular synthesis).

d) Tape-based **effects** (delays, multi-heads, flangers, choruses…)

e) Origins of **accumulative compositional forms (layering)**!

The Post War GERMAN Model

Basic electronic components:

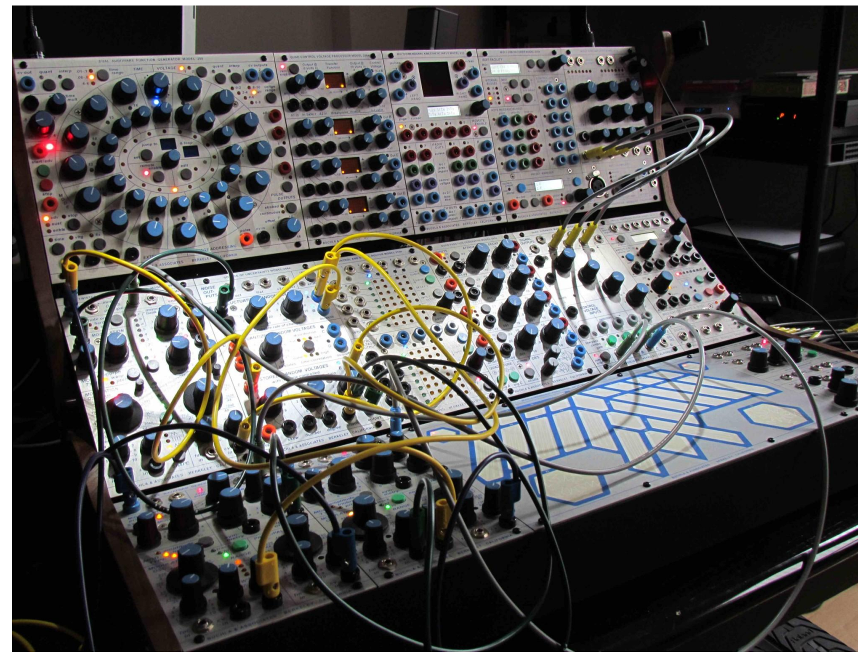
a) **Sound Generators** (oscillators, noise generators)
b) **Filters**
c) **Amplifiers**
d) **Envelope Generators**
    i) Periodic (Modulators, LFO's)
    ii) Triggers (ADSR, etc.)
e) **Ring Modulation**

SUBTRACTIVE SYNTHESIS

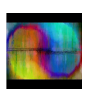
Analog Synth Battle

MOOG

BUCHLA



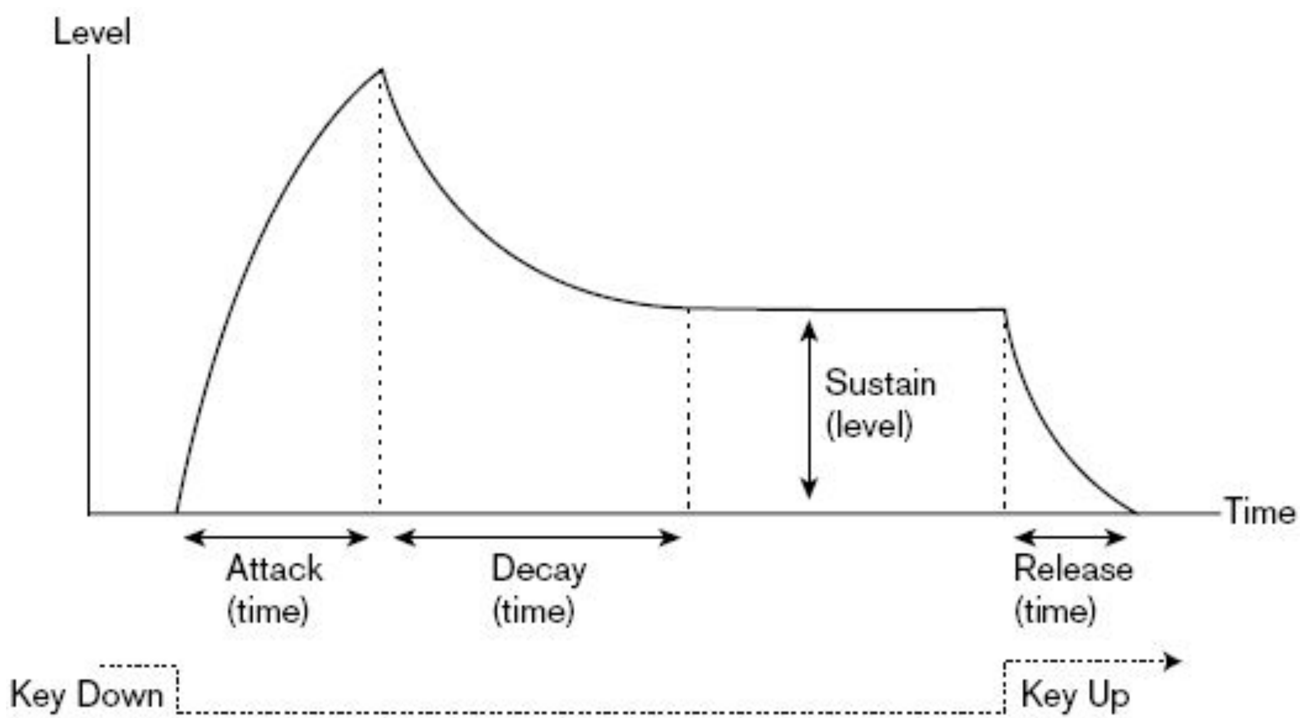
“Classic” Modular Synthesiser Paradigms

Who	**Robert Moog**	**Don Bucla**
where	East Coast (NY)	West Coast (CA)
orientation	comercial	experimental
control	**piano keyboard**	**VC sequencer**
composer	Walter Carlos	Morton Subotnick
relevant work	 *Switched on Bach (1968)*	 *Silver Apples of the Moon (1967)*

Envelopes

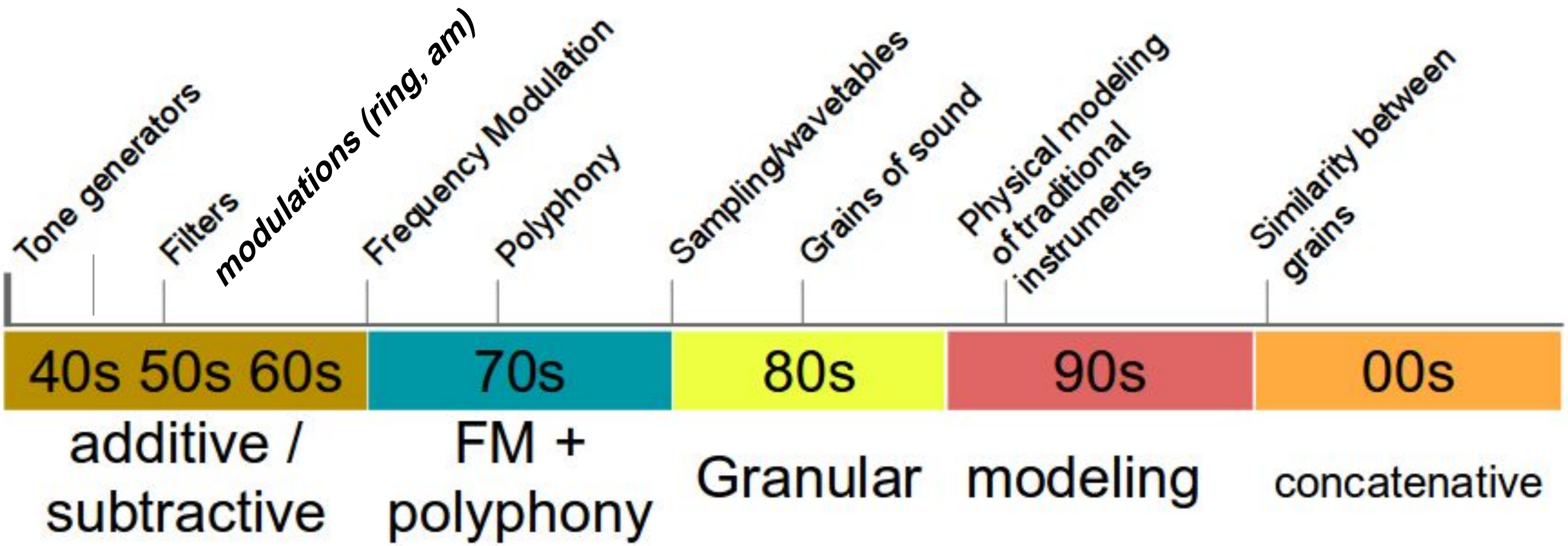
Typical growth and extinction curves used for controlling the amplitude of a signal and other sound parameters.

Human ear tends to prefer exponential curves (as opposed to linear).



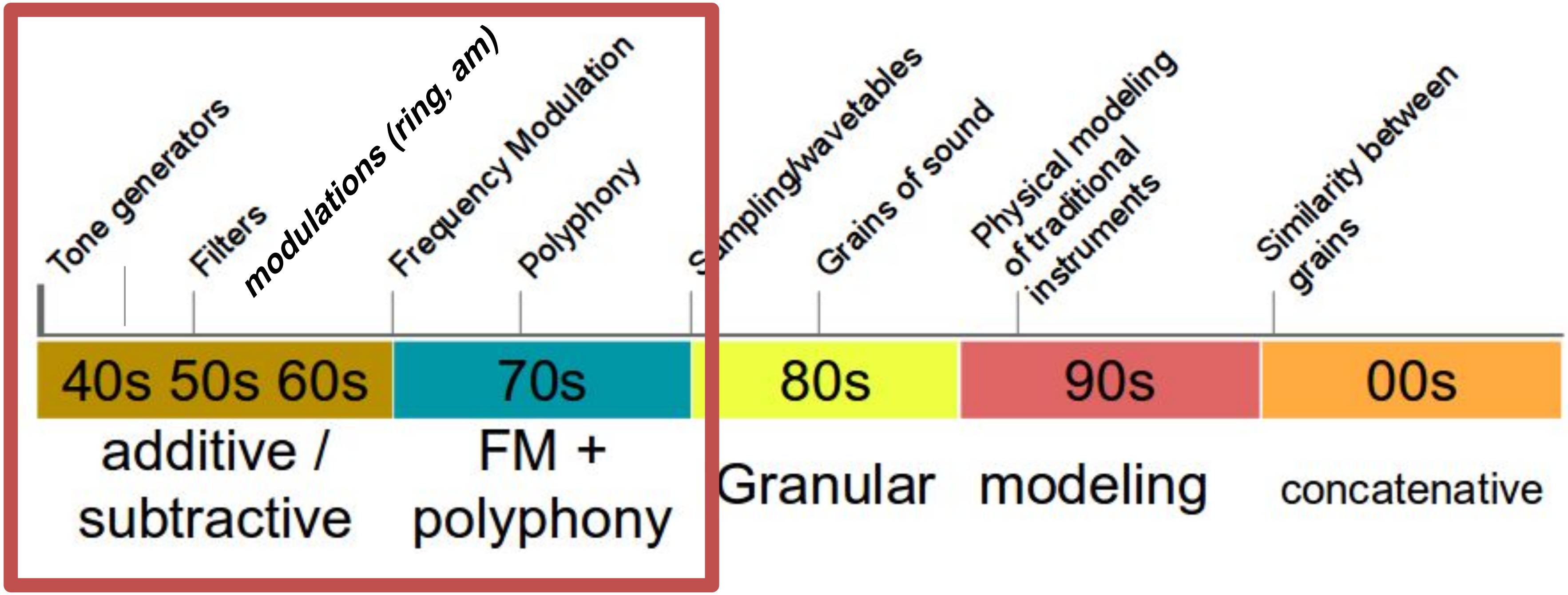
Review of Synthesis Techniques

A Chronology of Sound Synthesis Techniques



Thanks to Daniel Gómez for this slide ;-)

A Chronology of Sound Synthesis Techniques



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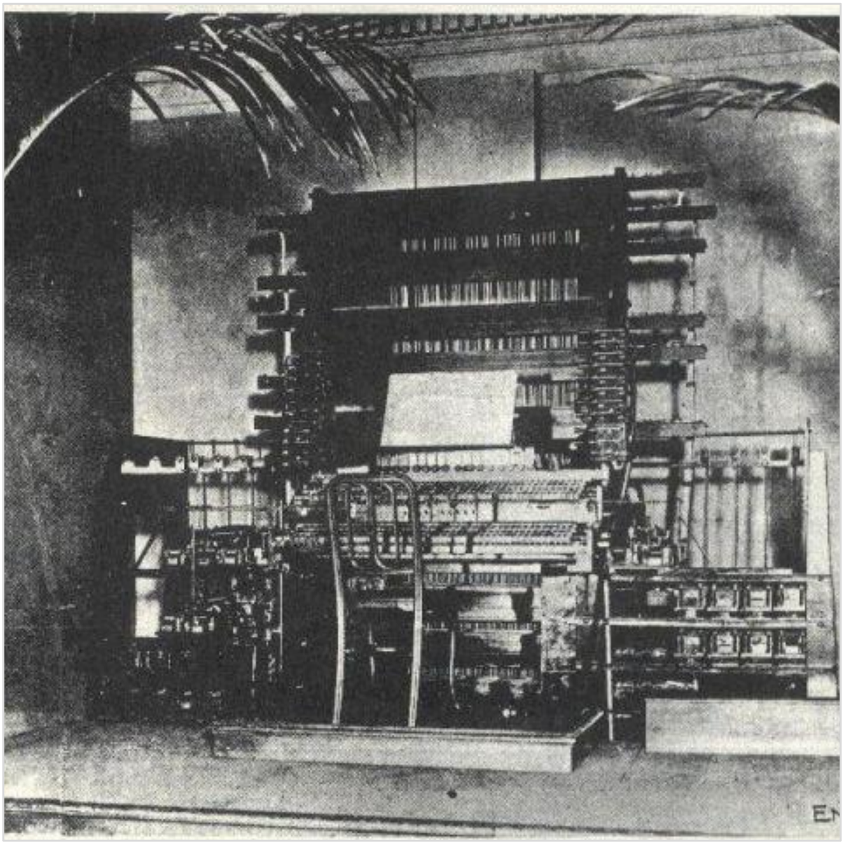
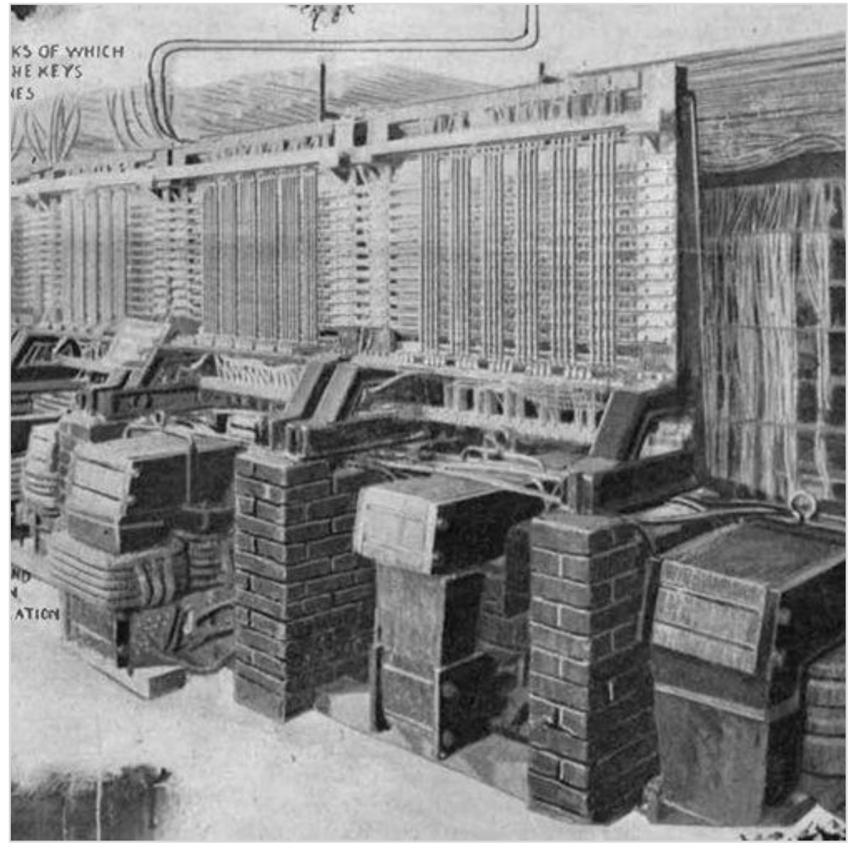
Additive Synthesis


SWELL
PEDAL
COMMUNION SERVICE IN D
KENNETH LEIGHTON
St Mary Redcliffe
CHOIR





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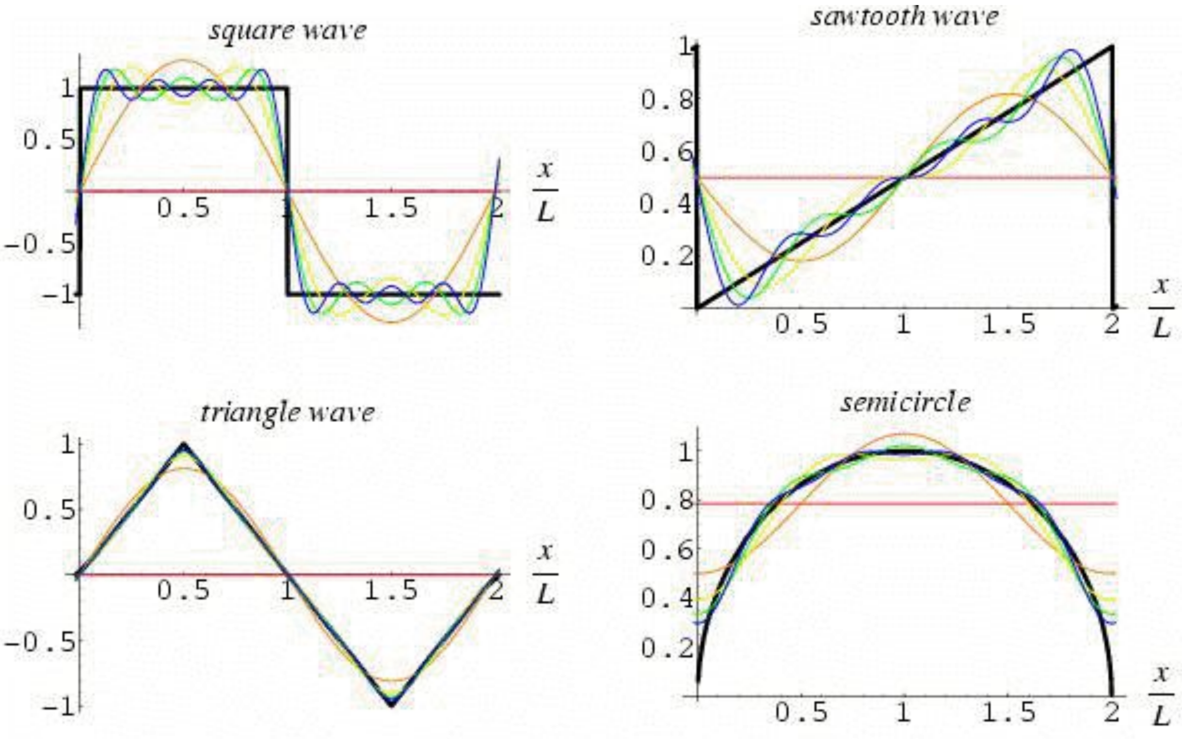
Fourier Theorem

Any periodic signal can be constructed with sinusoids!

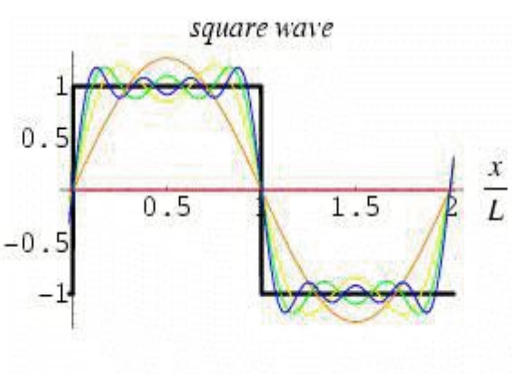
“Any periodic function f(x) which is reasonably continuous may be expressed as the sum of a series of **sine** or **cosine** components”

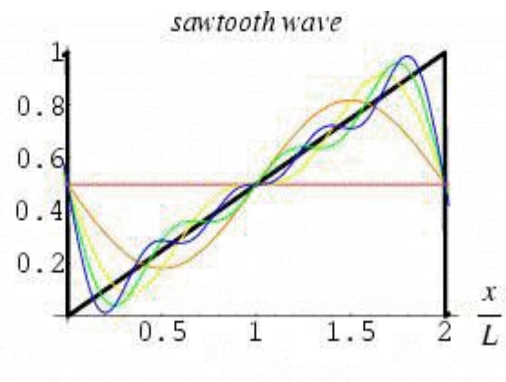
Waveform and sinusoids

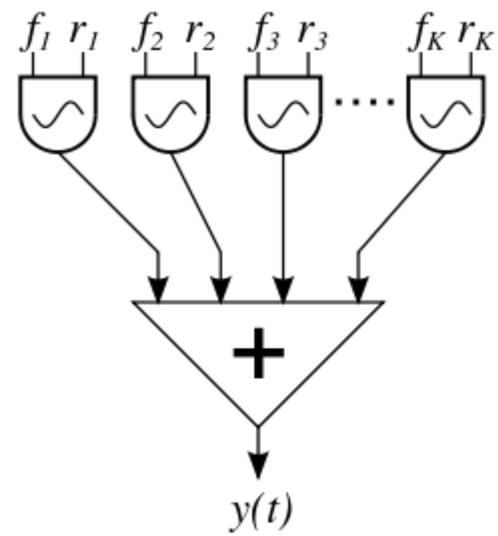
Any periodic signal can be constructed with sinusoids.

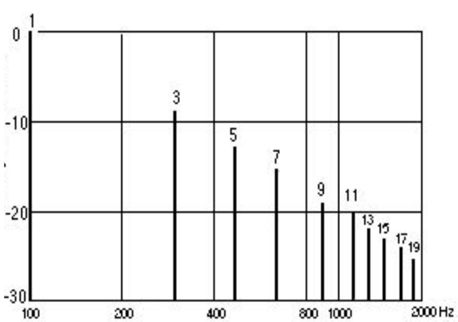


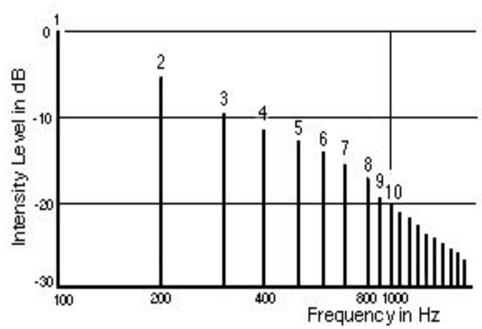
Additive Synthesis - Waveform and Spectra











Considerations on Timbre

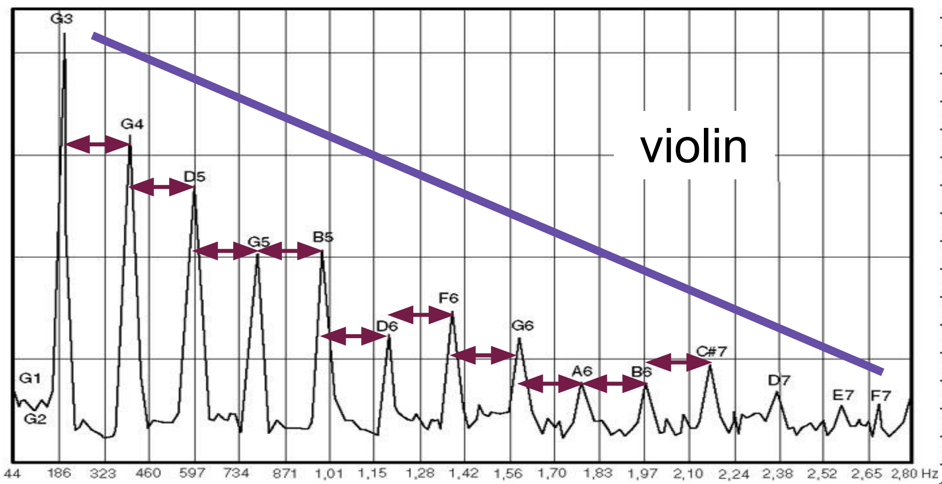
If we change the form of a sound wave we affect its timbre.

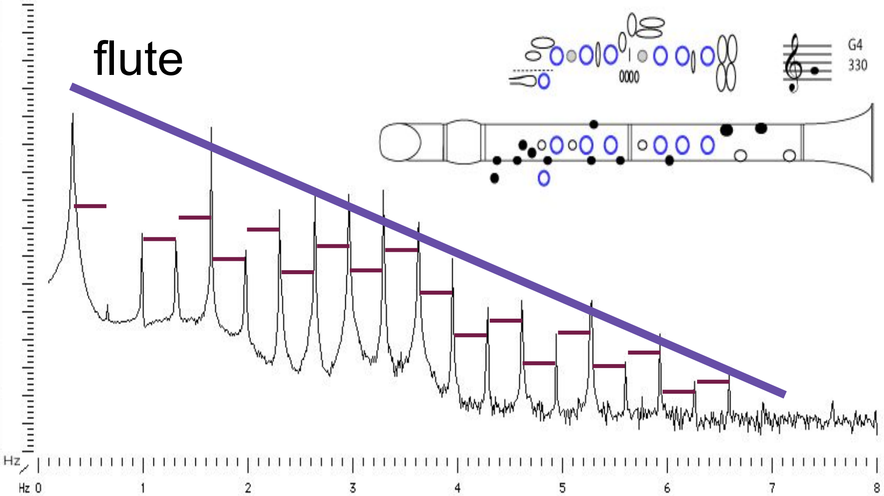
Timbre and waveform are tied together

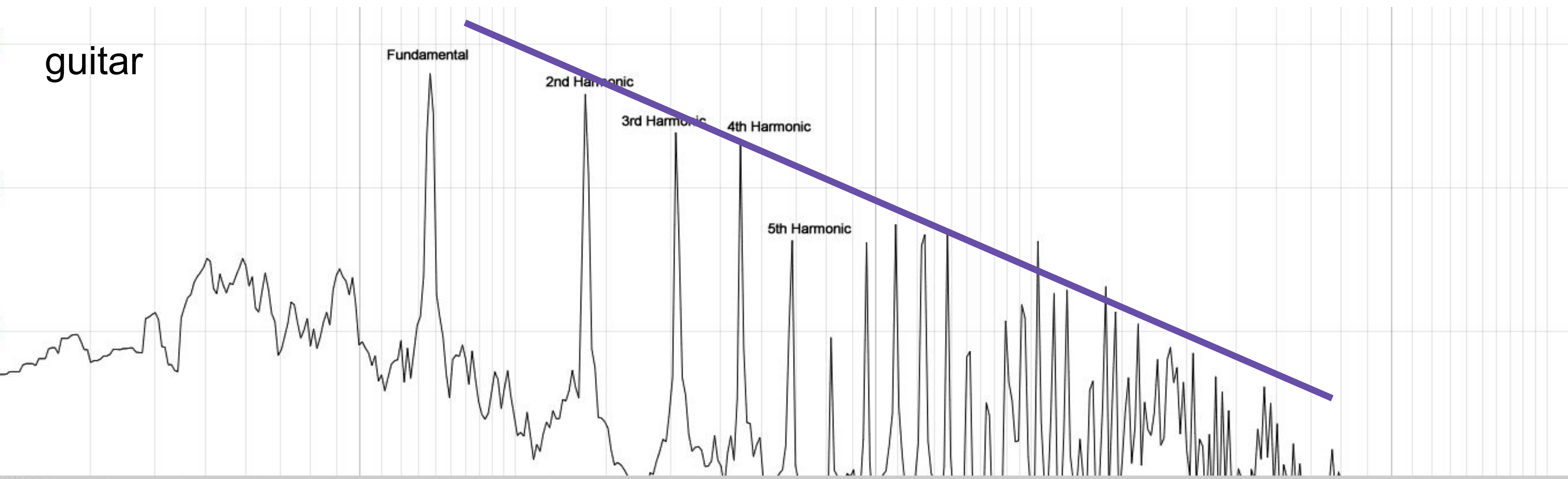
Timbre = waveform = sinusoids

By timbre we mean the characteristic of a sound which is not its amplitude, frequency or location. Two sounds can have exact same amplitude, frequency and location but be recognized as different. i.e “the color of a sound.”

Timbre / acoustic instruments

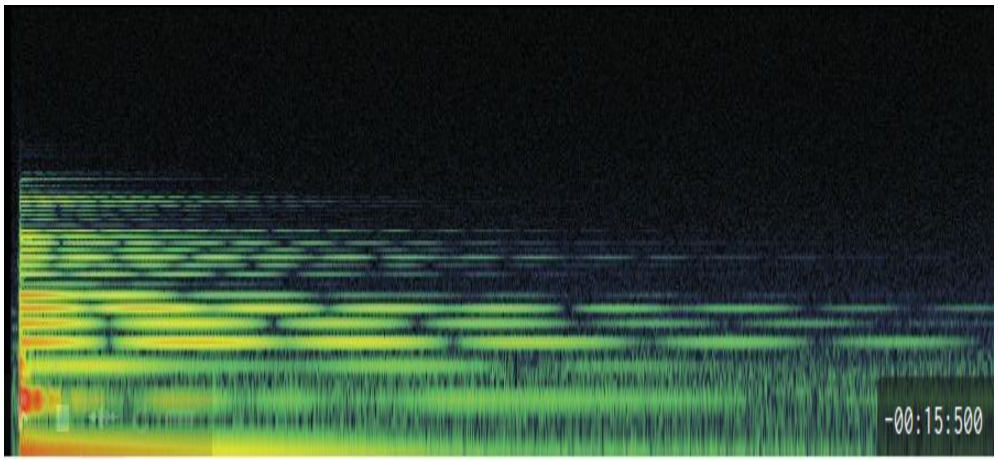




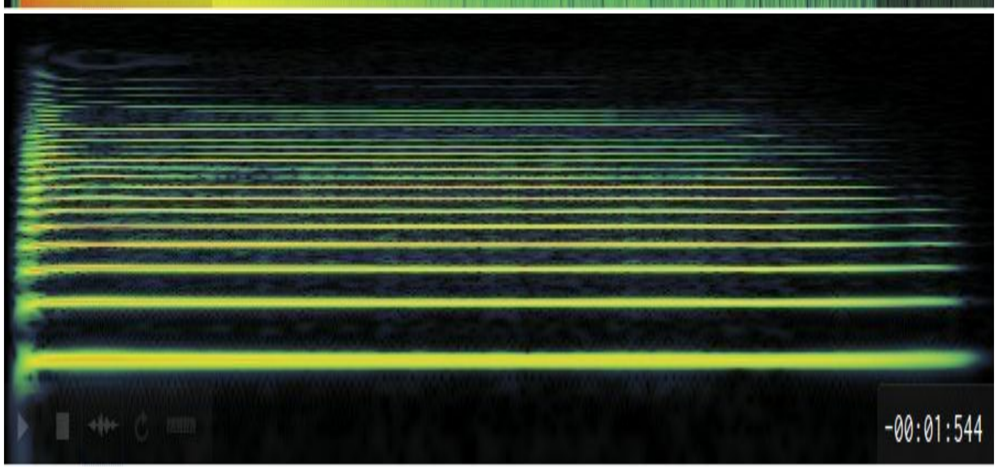


Timbre: changes in time: Spectral Envelope

Piano G2



Trumpet G2



Our perception of timbre is deeply related with how sinusoids change in the short time: in the millisecond range. Subtle changes in amplitude frequency and phase affect timbre sensation.

Subtractive Synthesis

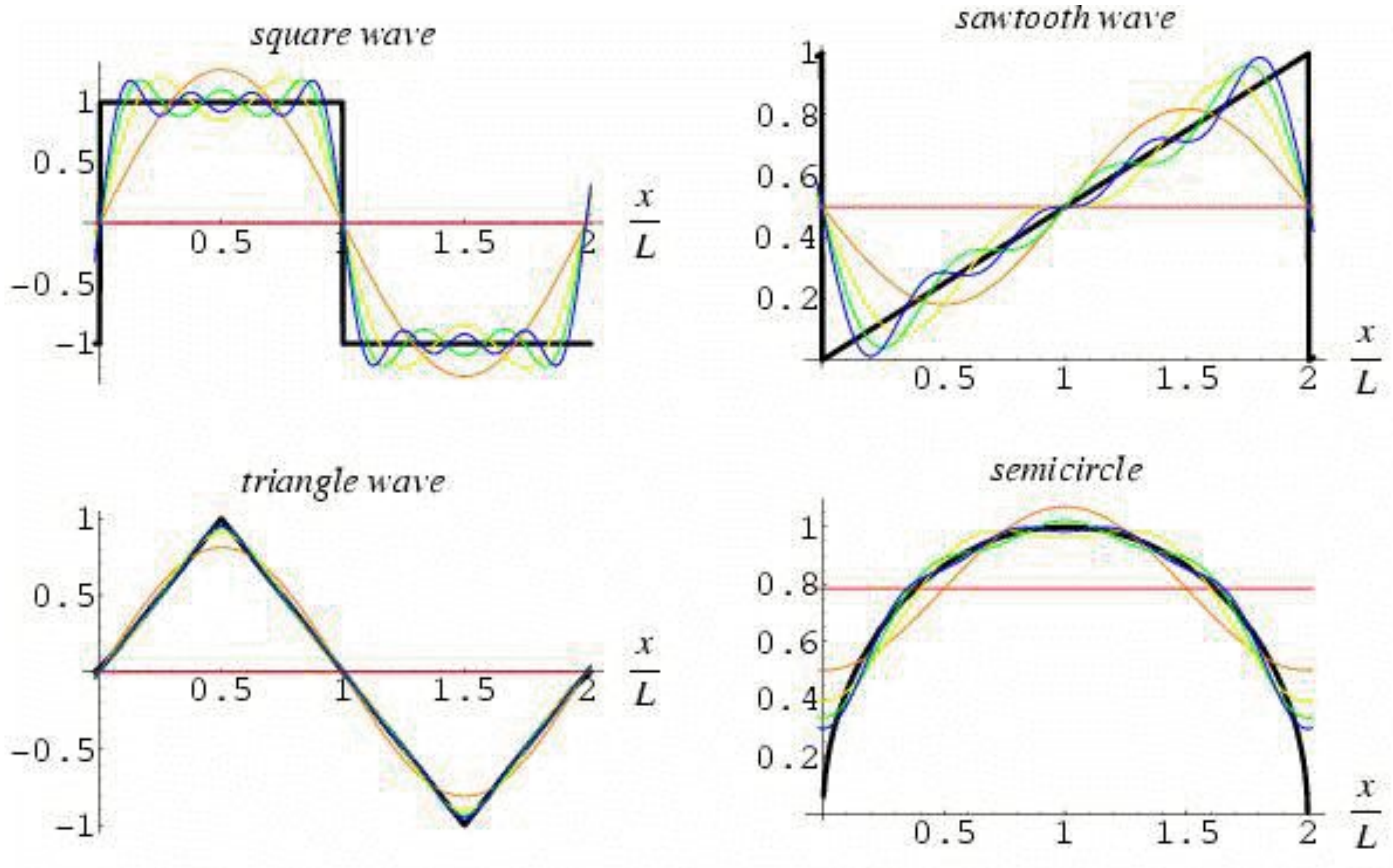
Subtractive synthesis

Source signals rich in harmonics

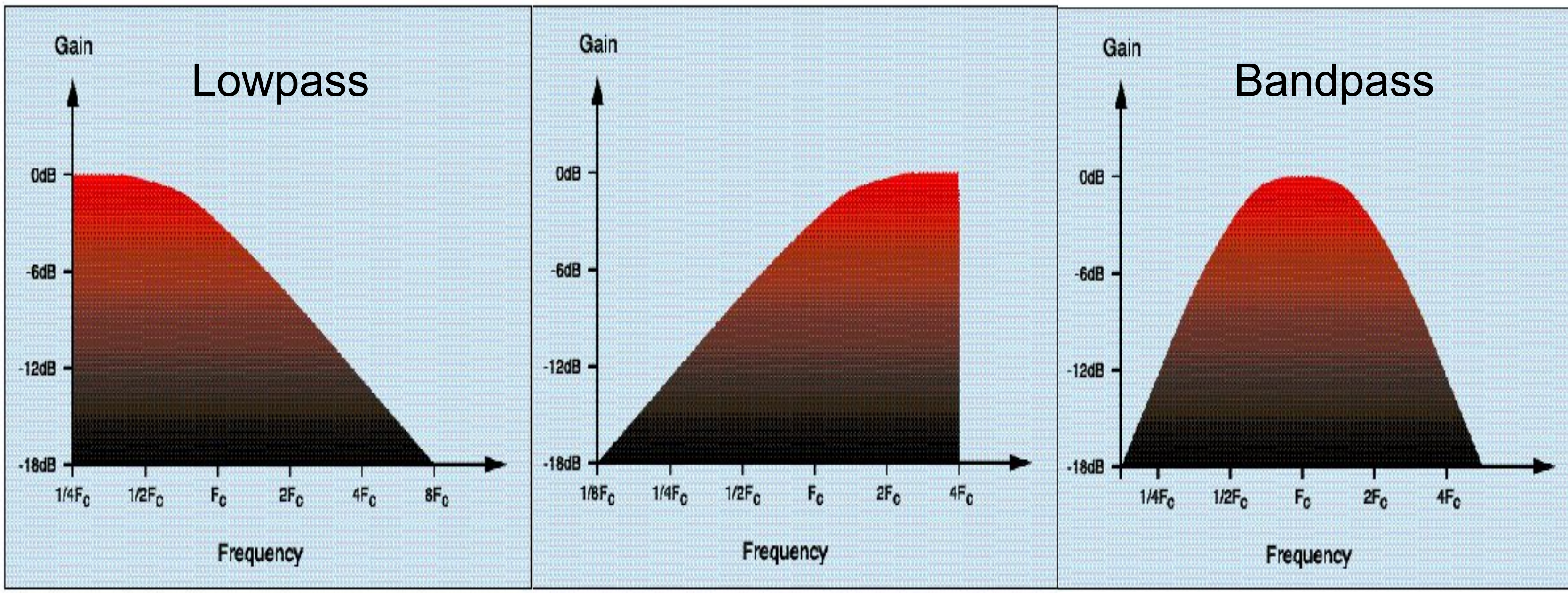
Filtered in various ways:

- Types of filters: lop, hip, bp, br
- Decay slope of the filter
- Cutoff frequency response
- Effect of resonance (if present).

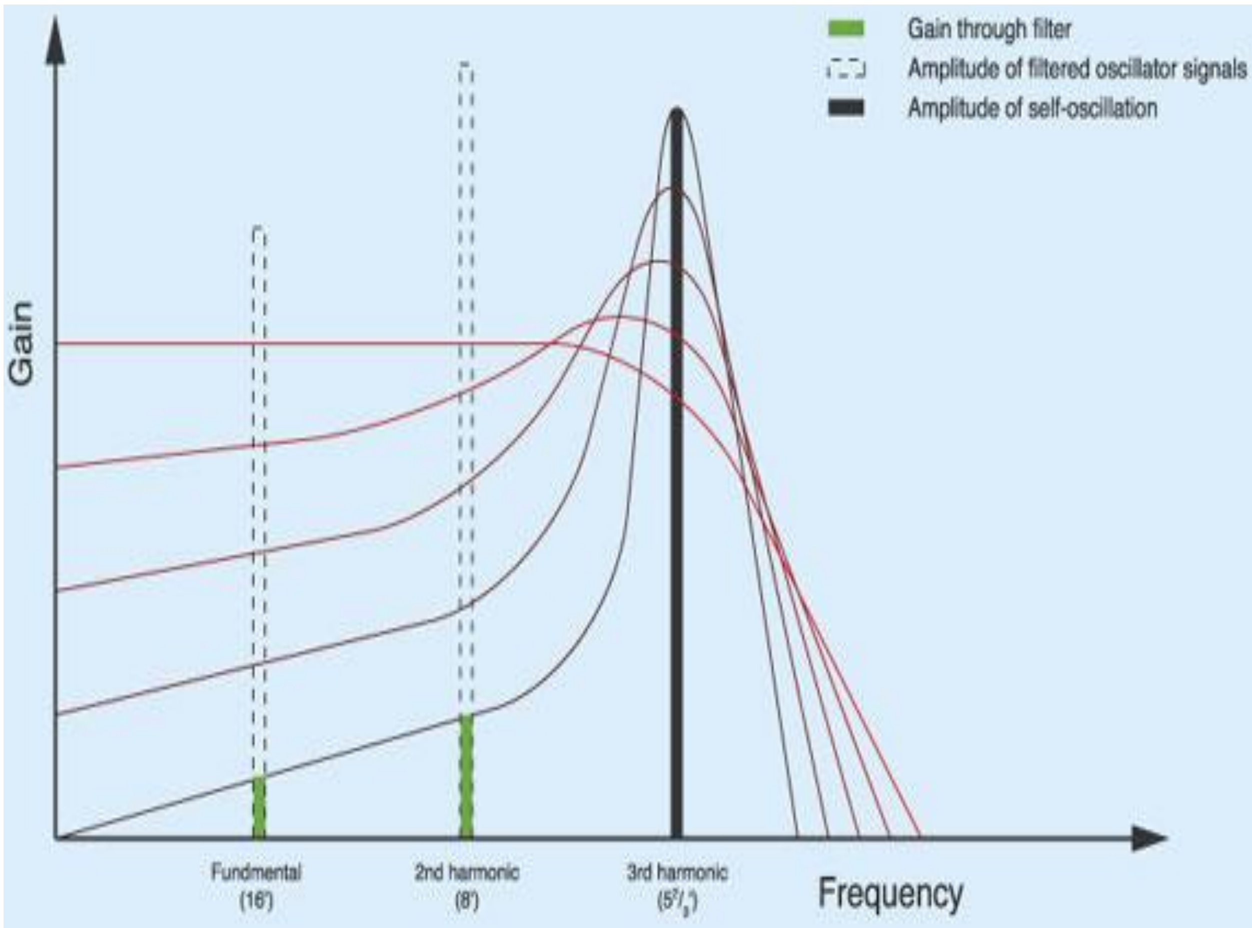
Subtractive Synthesis - Complex Waveforms



Subtractive Synthesis - Filters



Subtractive Synthesis - Resonant Filters



FM synthesis

Frequency Modulation

John Chowning (1973) “The synthesis of complex audio spectra by means of frequency modulation.”

Use just two sinusoids to generate many sinusoids!

Very cheap to programme and low consumption of processing power.

Properties of the FM Spectrum

- Tends to be symmetric around the Carrier fundamental
- Spectrum is harmonic if the ratio is an integer, inharmonic when decimal.
- The amplitudes of the spectral components change unevenly with the Index factor.
- At some Index values, the spectral symmetry ends.

The FM Synthesisers

volka FM

The DX7 sounds

crumar Synergy

"VIRTUAL" INSTRUMENTS

Virtual Instruments

- Typically software “emulations” of their hardware counterparts:
  - Virtual modular systems (VCV)
  - Additive and subtractive reconstructions
  - Specific hardware simulations (DX7)
  - Sampler instruments, etc.
  - but also original “non-imitative VI’s
- Normally distributed as **Plugins**
- Played via **MIDI** and **controllers**

Virtual Instrument Simulation Examples

FM Synthesis -- DX7

Subtractive - OB-X

Oberheim OB-X

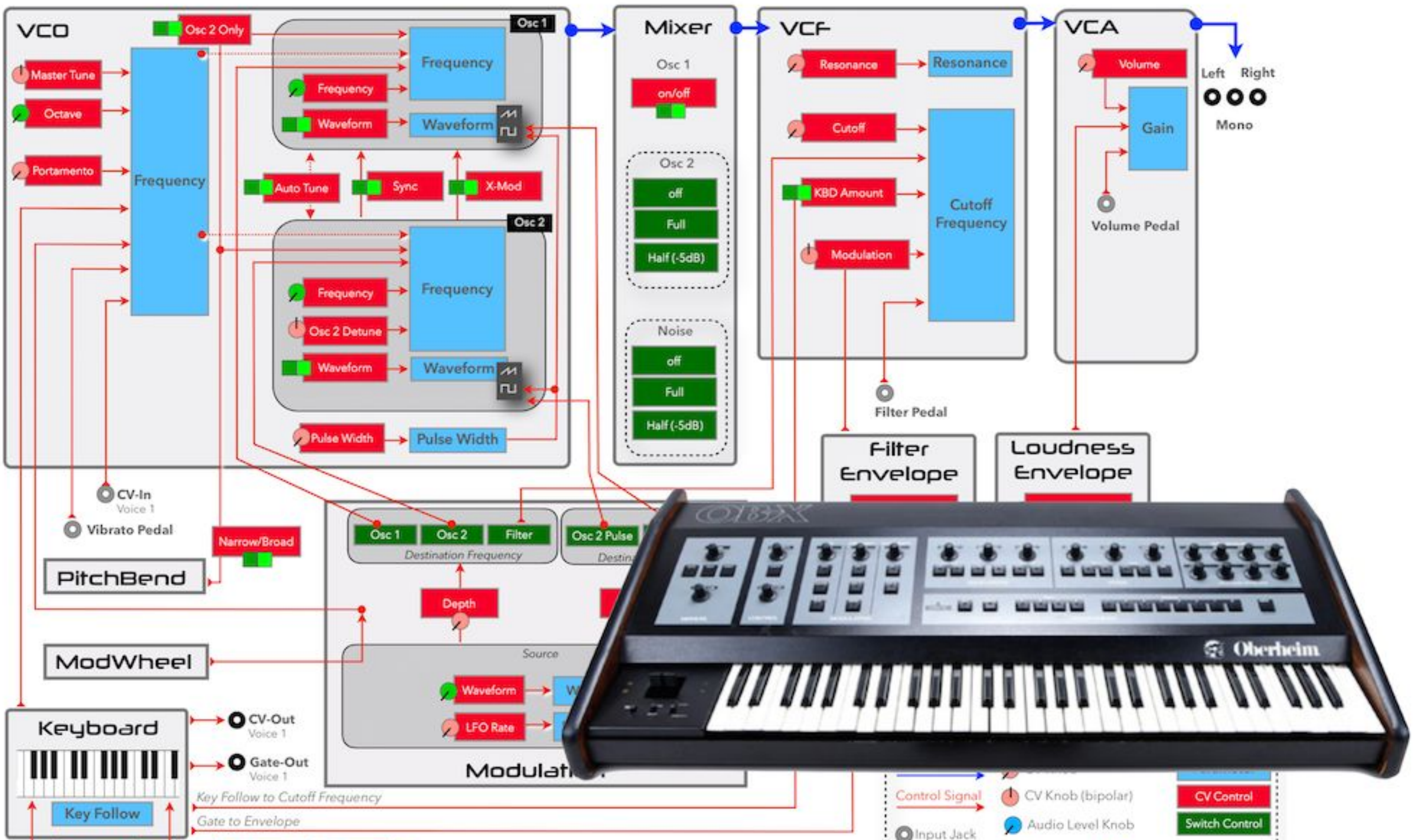


Diagram by Edgar Rothermich
www.DingDingMusic.com/Tech

To be able to play and interconnect most software and hardware synthesisers, we need...

MIDI