# Session 3
# Brief history bit, “East Coast” style approach

VA309 Modular Sound Synthesis @ EKA

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# Informational / Organisational

**Coursework 1 only sent out today. Oops!**

This means that the deadline is not next week, but in 2 weeks instead – as promised

# Recap of previous sessions

- What is a VCO? What does it produce?
- What is an octave?
- How are linear and exponential CV tracking related to it?
- What is PW/PWM?

# Recap of previous sessions

- How many signal layers are there in the more classic approach to a modular?
- Does every module belong to  just one set layer?
- Does the way we think of/treat a signal affect which layer it belongs to?

# Today

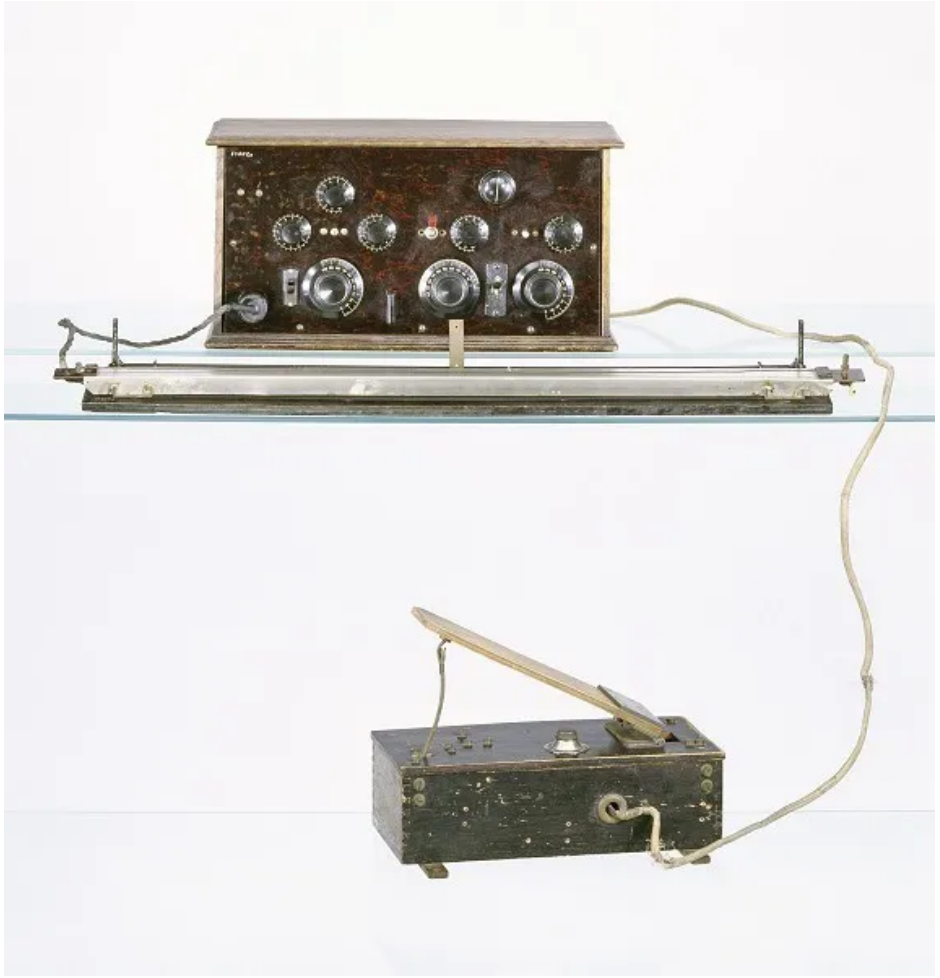
- First half: brief electronic synthesizer bit, east coast basics
- Second half: let’s make a basic east coast patch!

# First synthesizers

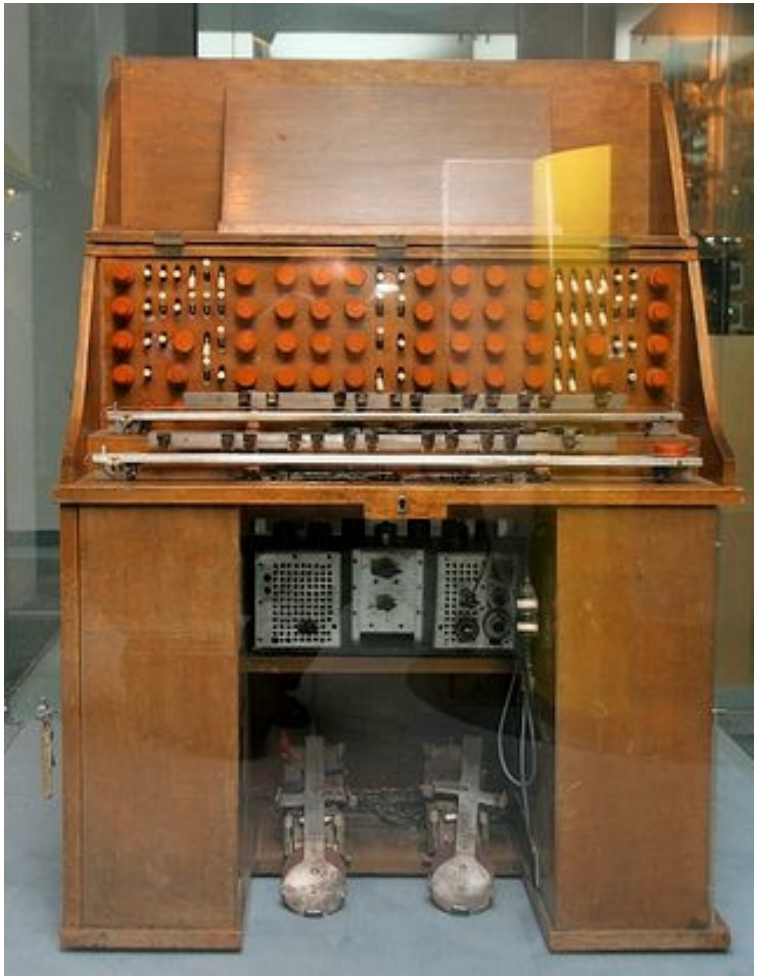
- Numerous experiments with sound+electricity since **at least** 19th century. All results were **electromechanic**, not purely electronic.
- 1922: Lev Teremen invents the famous **Thereminvox** (or simply Theremin) – the first **fully electronic** sound instrument known to us so far. It ran on vacuum tubes.
- In 1930, Friedrich Trautwein invents a (less famous, but arguably more important) **Trautonium:** direct ancestor of modern synthesizers. It pioneered the idea of **subtractive synthesis** – generating a harmonically rich wave and filter it, rather than layering a lot of harmonically simple ones.

[link]

# Trautonium



First version, 1930



Mixtur-Trautonium, 1952

# First (commercial modular) synthesizers

- 1960s: USA got two engineers develop the first commercial modular synthesizer, at the same time, at the opposite sides of the country – **Bob Moog** in New York and **Don Buchla** in California.
- Both were technical university students with musical background
- Both received grants from their schools, and support/help with development from friends or family
- Unknowingly, they created two opposite approaches to generating sound, nowadays known as "**east coast**" and "**west coast**" paradigms.

# East vs West

**East Coast:**

- Pioneered by Bob Moog
- Core concept: subtractive synthesis
- Is inspired by and aimed for tonal and traditional-leaning music. Trautonium is a major precursor.
- Main idea: generate a sound of a rich timbre, then subtract harmonics from it using filters to create a harmonically dynamic and controlled sound.
- Listen: Wendy Carlos – Switched-On Bach, 1968

# East vs West

**West Coast:**

- Pioneered by Don Buchla
- I wish its core was called “additive synthesis”, but it isn’t :c
- Inspired by test equipment musical (mis)usage and sound experimentation, aimed for whatever crazy noise fun
- Main idea: start with a sound with a simplest timbre (sinewave or triangle), then use distortions, waveshapers, wavefolders and feedback to make the sound harmonically rich, dynamic and controlled.
- Listen: Morton Subotnick – Silver Apples On The Moon, 1967

# OK, but then what is Eurorack?

**Brief timeline:**

- 1970s: modular synths become more commonplace and popular, studios get them and bands use them
- Bob Moog hard-wires a few Moog modules, slaps on a 12tet keyboard, sells it as “Minimoog”, thus (re)inventing hard-wired synthesizers
- A basic keyboard-n-knobs synth is now small and affordable

# OK, but then what is Eurorack?

**Brief timeline:**

- 1980s: electronic music becomes commonplace
- Tons of hard-wired analog synthesizers designed, most following Moog's east coast paradigm
- Digital drum machines (Linn Electronics LinnDrum, 1982) and synthesizers (Yamaha DX7, 1983) push analog gear out of studios and band vans


# OK, but then what is Eurorack?

**Brief timeline:**

- 1990s: analog is completely out of fashion. **MIDI** and computer made music become more and more usual.
- FastTracker is made for Commodore Amiga, giving way to **tracker music** and **studio-free musicians**.
- **Moog**, **Buchla** and others try keeping up and generally **fail**, releasing weird stuff that ends up being obscure collector pieces now
- People running modular systems are considered **weirdos**, and module formats vary widely. Some people develop their own in-house format.

# OK, but then what is Eurorack?

**Brief timeline:**

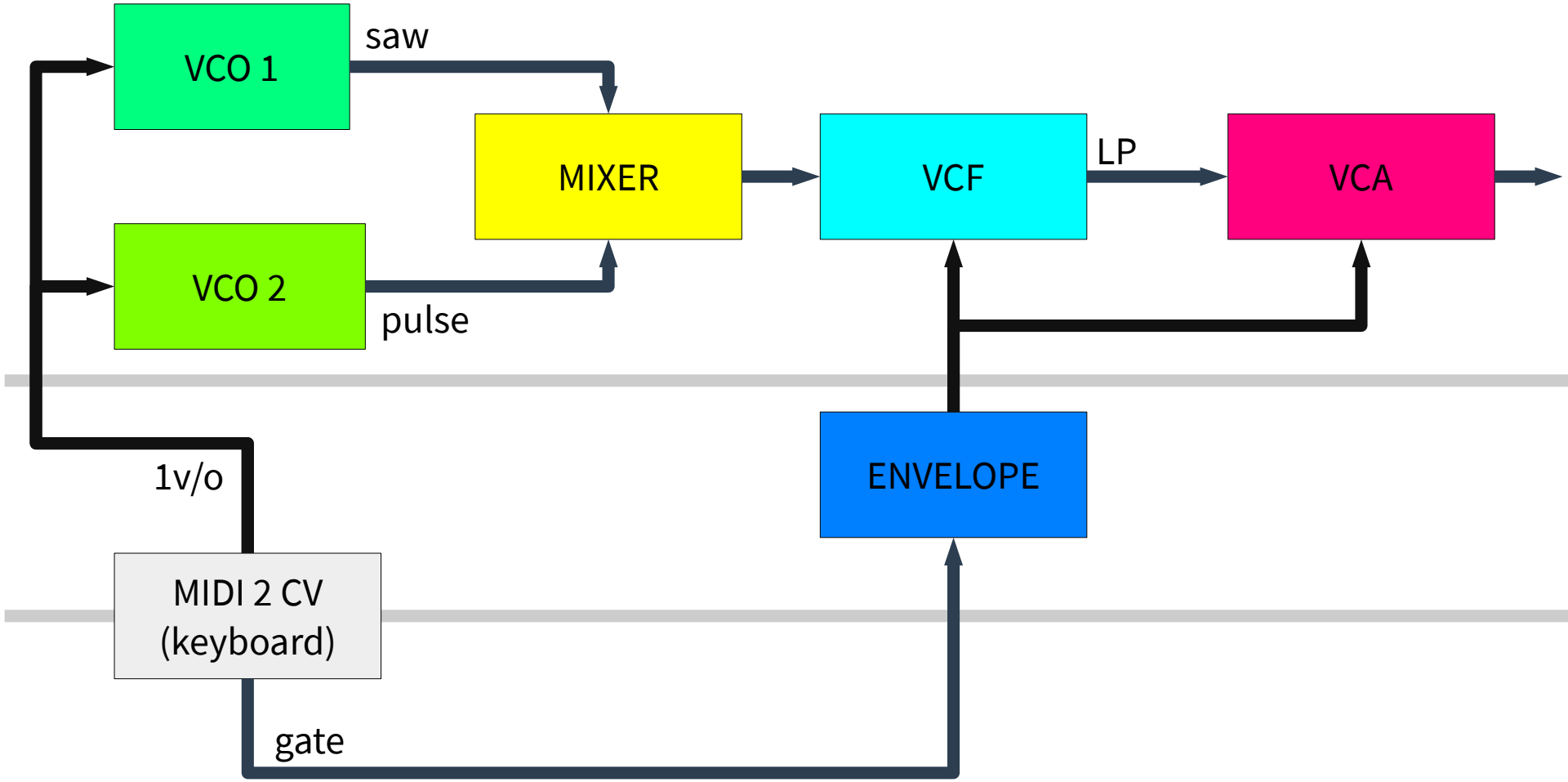
- 1995: one **Dieter Döpfer** from Germany and his company decide they want to make a modular system and start developing modules for it, mostly following East Coast ways.
- They made a bunch of “classic” oscillators, a whole plethora of filters, standard envelopes and LFOs, and all that.
- They even made a set of modules that, combined, produce a modular copy of the Mixtur-Trautonium! (Yes, even the ribbon)
- They decided to call their format “**Eurorack**”, probably because they are European

# OK, but then what is Eurorack?

**Brief timeline:**

- **Mid 00’s**: Eurorack explodes in popularity. Makers switch to it to be compatible with one another
- Many makers work in the format → many views on synthesis → many different modules
- Eurorack quickly loses its distinct East-Coast flavour that Doepfer and other early makers gave it, and becomes paradigm-agnostic
- Users start being able to assemble systems tailored to their particular needs and tastes.

# Let’s build a basic East Coast patch!



# Filter: heart of an East Coast patch

The main part of classic East Coast style (or subtractive) patch is the **filter**: a device that subtracts harmonics from the sound.

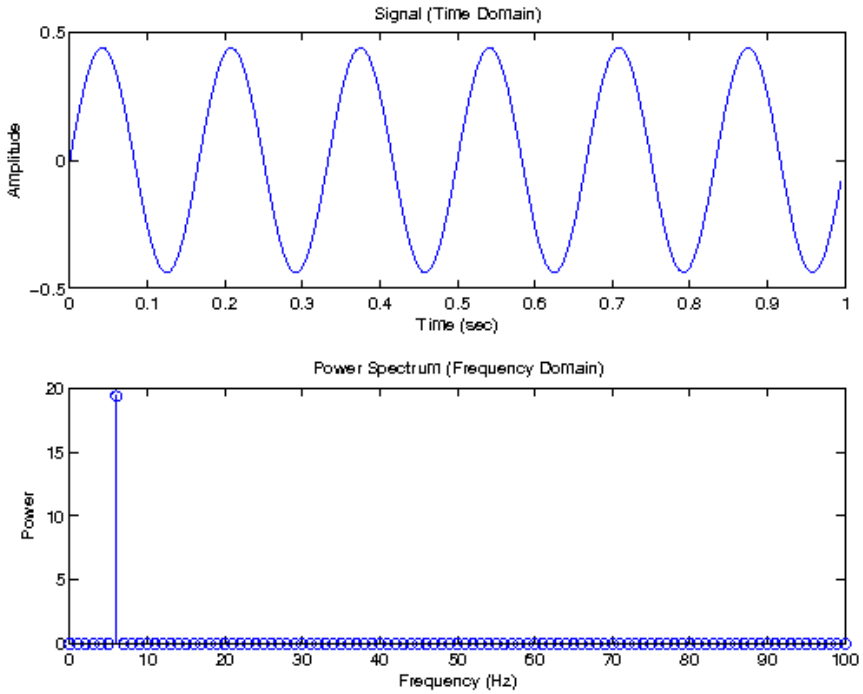
# What are harmonics?

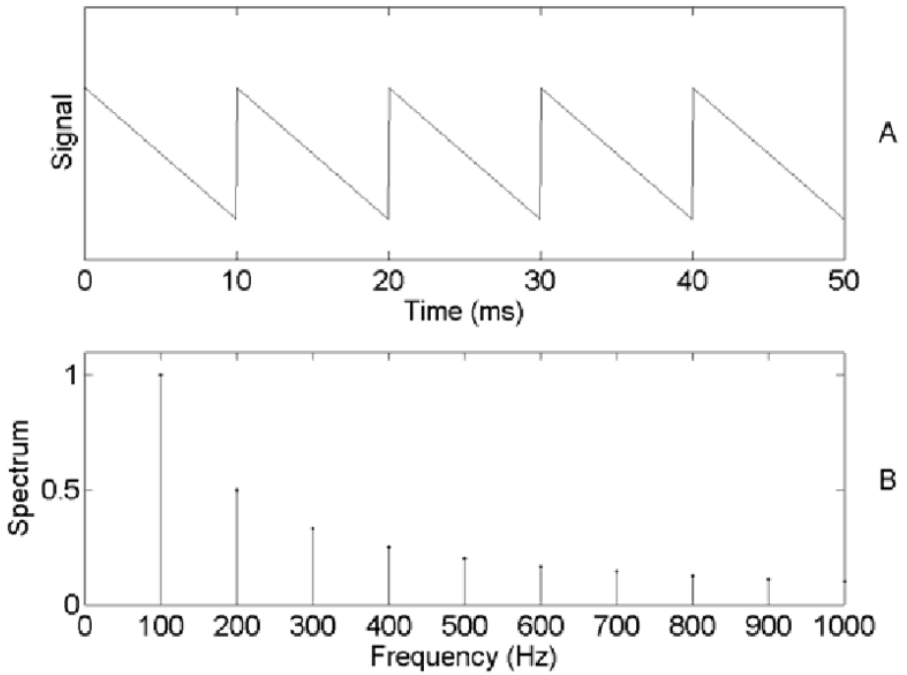
- Any sound’s timbre can be represented by its **harmonics**
- Think studio meter that shows bass, mid, and treble – 3 bands. Put a song to it – they will represent how much bass, mid and treble there are at the moment.
- Now, what if we had 5 bands instead of 3? 10? 20?
- How about an **infinite number** of bands?

# What are harmonics?

- A single **sinewave** represents **one single** harmonic – its fundamental. It is the most **harmonically simple** wave.
- For example, a 440Hz sine will only display a peak at exactly 440Hz on our “infinite bands meter” (also known as a spectrograph).
- However, anything more complex than a sinewave (like a sawtooth) displays many peaks...
- Which means it has to be constructed out of many sinewaves!

# What are harmonics?



# What are harmonics?

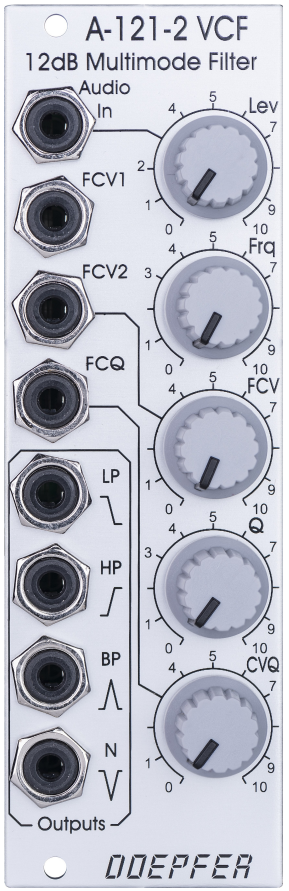
- Cyclic sound waves more complex than a sinewave are built out of **harmonics**: mathematically – a bunch of sinewaves, mixed together at correct volumes
- Which harmonics are at which volume = sound's perceived timbre, **and** the shape of the wave
- Changing the wave's harmonic content ↔ changing **both** the way it sounds **and** the way its waveshape looks like.

# What can you do with harmonics?

- Two most common things are to **add** and **subtract** harmonics from the sound.
- **Adding:** harmonics (literal sinewaves, spikes on the spectrograph) that weren't here before, appear. Done with **wavefolders** and distortions. ← *west coast*
- **Subtracting:** lowering the volume of some existing harmonics, up to silencing – done with **filters**. ← *east coast*

# Filters

- **Filters** are devices that subtract harmonics
- In simplest form, a filter has an **audio input** and an **audio output**. Output audio = input audio – some harmonics.
- Musical filters have more controls, such as: **cutoff frequency**, **resonance**, input volume…
- A VCF usually have **voltage control** over some of its parameters → cutoff or resonance can be dynamically altered
- Animating the filter's parameter is the core idea of west coast synthesis



# Filter outputs

Most filters have one or more of the following outputs:

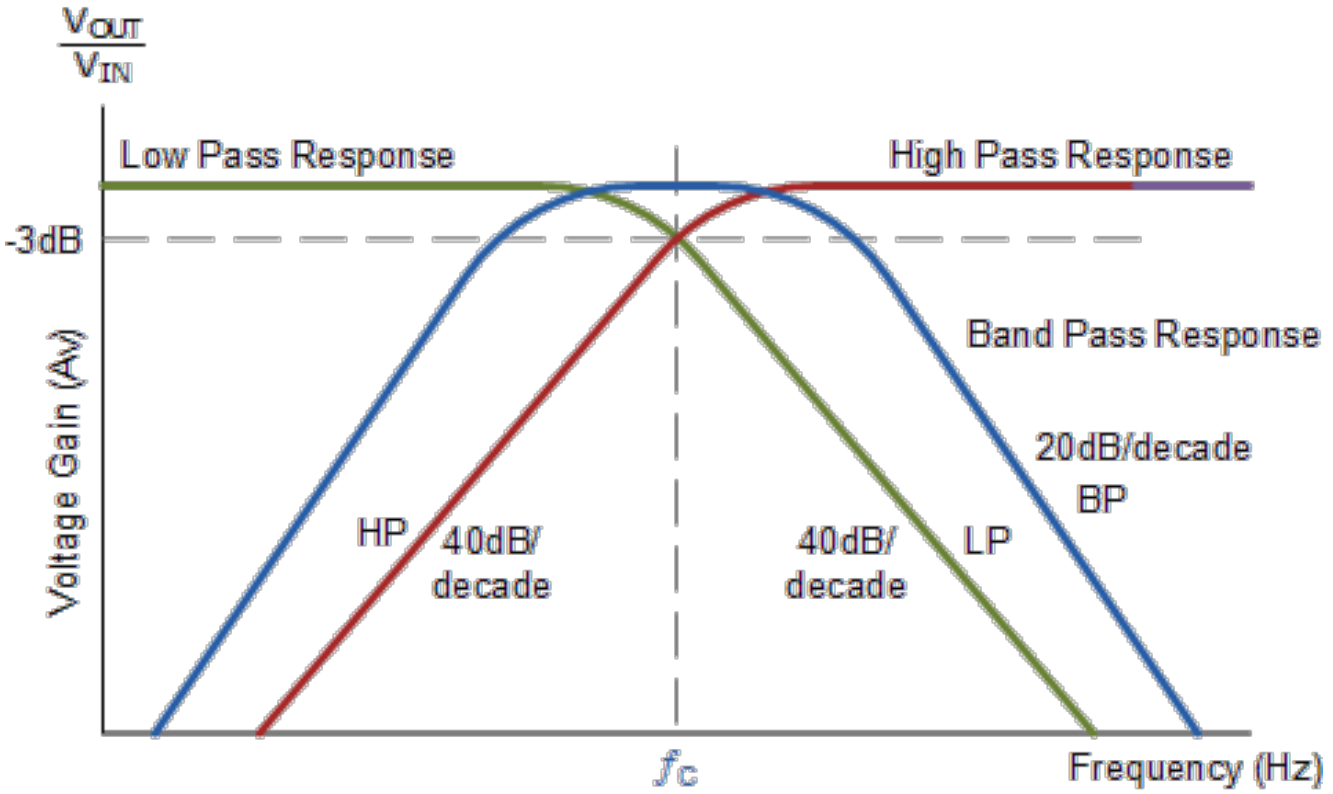
- **Low Pass (LP)** – lets low frequencies/harmonics below the cutoff frequency pass, blocks the ones above. The popular one.
- **High Pass (HP)** – lets high frequencies/harmonics above cutoff frequency pass, blocks the ones below
- **Band pass (BP)** – lets a narrow band of harmonics close to the cutoff frequencies pass, blocks the ones below and above
- **Notch (N) or Band Reject (BR)** – rejects a narrow band of harmonics close to the cutoff frequencies, lets the ones below and above through

# Filter outputs

The graph shows the LP, HP and BP curves.

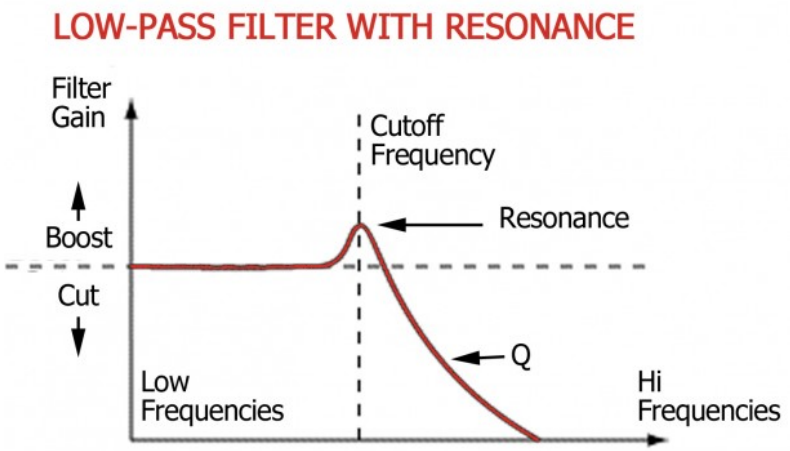
The higher the curve is, the louder this frequency/harmonic will be at the output mix.

E.G. low pass response lets all low harmonics pass, but gradually mutes higher ones. The filter's cutoff frequency will define starting at which frequency the mute-down starts.



# Filter resonance (Q)

- Filters may sometimes sound dull or too mellow at low resonance. Bringing up resonance adds a meowy emphasis!
- Resonance in a sound filter means that harmonics that exactly match the cutoff frequency receive a considerable volume boost



# Filter resonance (Q)

- The filter resonance is an effective tool of creating **emphasis**
- Since the resonance effect **amplifies the already existing harmonics** at the cutoff frequency, it will not have any effect if at its cutoff frequency no harmonics are present in the processed sound signal
- Thus, sounds of **rich harmonic content** will have a lot of harmonics across the entire spectrum for the VCF to resonate on

# Filters in an East Coast style patch

- **Filters play a center role in subtractive synthesis** (aka East coast style)
- VCFs have **voltage-controlled cutoff frequency**, that allows modulating it with envelopes, LFOs, and such
- VCFs also sometimes have **voltage-controlled resonance**, allowing to kick the emphasis in and out as needed
- VCF animates the otherwise continuous and harmonically permanent VCO wave

**Typical subtractive sound path**:
VCO → VCF → VCA → output