Electronics One

A Brief Introduction to Electronics
for Programmers, Makers, and Students

PatternAgents 2016

Agenda

* Basic Electronics Introduction
* “It's the Law!”, Ohms, Watts, and Moore
* “On the Bus” Keseyian Signaling Methods
* UART, I2C, SPI, and other Acronyms
* Questions & Answers
* General Discussion

Source : PatternAgents.com

Basic Electronics Introduction

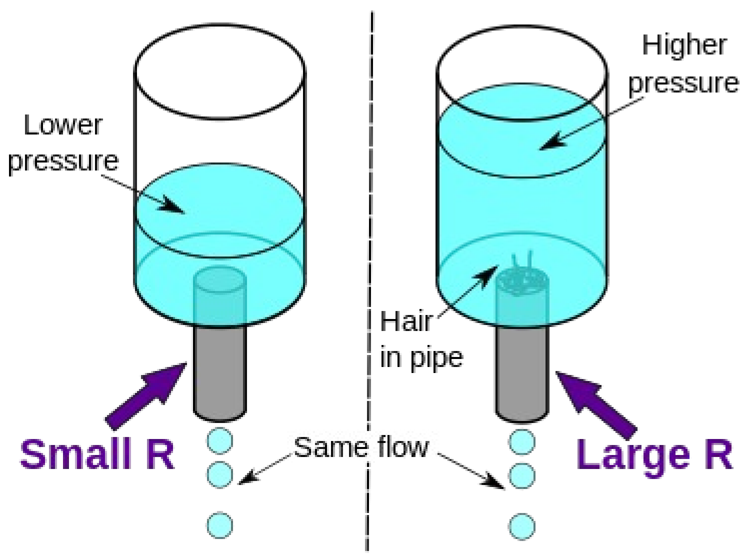
* In order to make sure everyone starts on the same page, we’ll briefly cover some basic concepts in physics, mathematics, and electronics

* Please be patient if you know this, we'll quickly get into new material for most people

* For many people, electronics are literally a “black box”, that they interact with daily, but don't really understand. Let's open the lid, void the warranty, and have a look inside...

Basic Electronics Concepts

- It is often easier for people to visualize the physics of electrons by comparing them to moving water in a hose/pipe as an analogy :



Source : Wikipedia

Basic Electronics Parameters

- So, the first electronics terms we will cover are the basic parameters of voltage, current, and resistance. By analogy to water they would be :

  Voltage - analogous to the water pressure
  Current - analogous to the volume of water
  Resistance - analogous to the diameter of the pipe

- See, you already have an intrinsic understanding of these physical concepts, now you just need to learn the terms and symbols to "speak" electronics properly

Source : PatternAgents.com

Representations of Electronics

- We use different representations of electronic systems for different purposes, and often to convey different types of information quickly and efficiently.

- A Schematic, or Schematic Diagram is a representation of the elements of an electronic system using abstract, graphic symbols rather than realistic pictures. A schematic usually omits all details that are not relevant to the information the schematic is intended to convey, and may add unrealistic elements that aid in comprehension or in conveying the essential “design intent”.

Source : PatternAgents.com

Schematic Subway Map

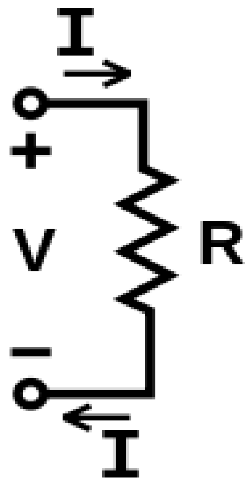
- Sometimes is it easier to think of an electronics schematic diagram as a subway map for the electrons, it describes where they can go, and the stops along the way

Source : PatternAgents.com

Basic Schematic Symbols

- We often read a schematic diagram like a Subway map, as the electrons must follow the wires, just like a train on the tracks

- The (most) basic schematic to the left, shows a Voltage (V) being applied across a Resistor (R), causing a current (I) to flow from the positive terminal through the Resistor(R) and to the negative terminal. This relationship is described by Ohm's Law



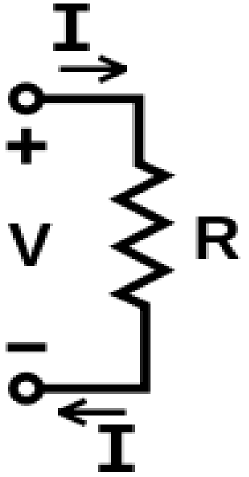
Source : PatternAgents.com

Ohm's Law

- Voltage (V) - electric potential (in Volts)
- Current (I) - electric charge (in Amperes)
- Resistance (R) - material opposition (in Ohms)

- Ohm's Law defines the relationship :

$$I = V / R \quad (\text{ 1 Ampere} = 1 \text{ Volt} / 1 \text{ Ohm})$$



Source : PatternAgents.com

Basic Ohm's Law Equations

P = Watts

$$\text{Watts} = \frac{\text{Volts}^2}{\text{Ohms}}$$

Watts = Amperes² x Ohms

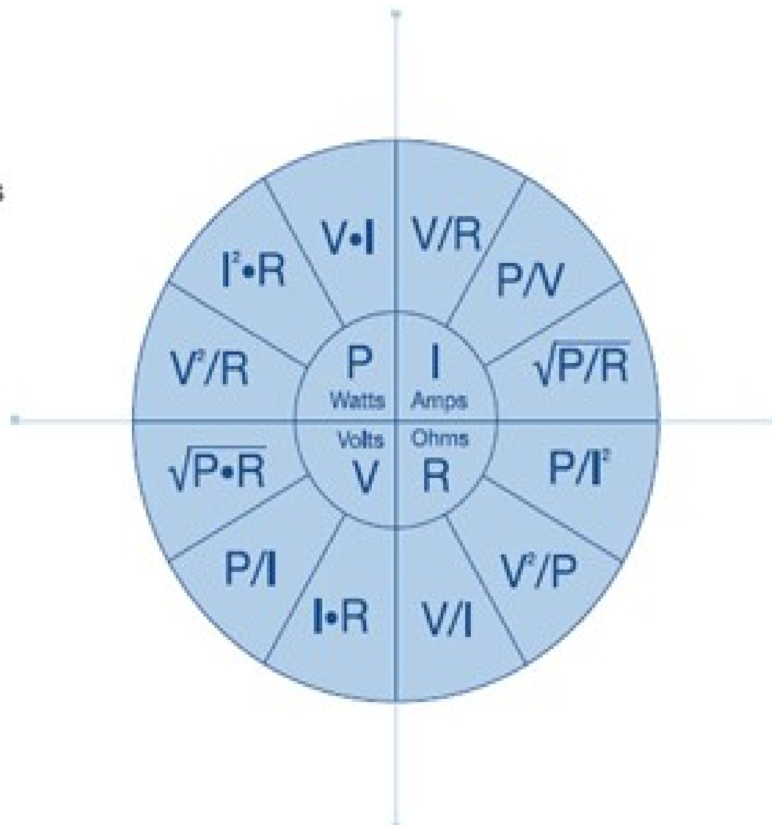
Watts = Volts x Amperes

V = Volts

$$\text{Volts} = \sqrt{\text{Watts x Ohms}}$$

$$\text{Volts} = \frac{\text{Watts}}{\text{Amperes}}$$

Volts = Amperes x Ohms



I = Amperes

$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$

$$\text{Amperes} = \frac{\text{Watts}}{\text{Volts}}$$

$$\text{Amperes} = \sqrt{\frac{\text{Watts}}{\text{Ohms}}}$$

R = Ohms

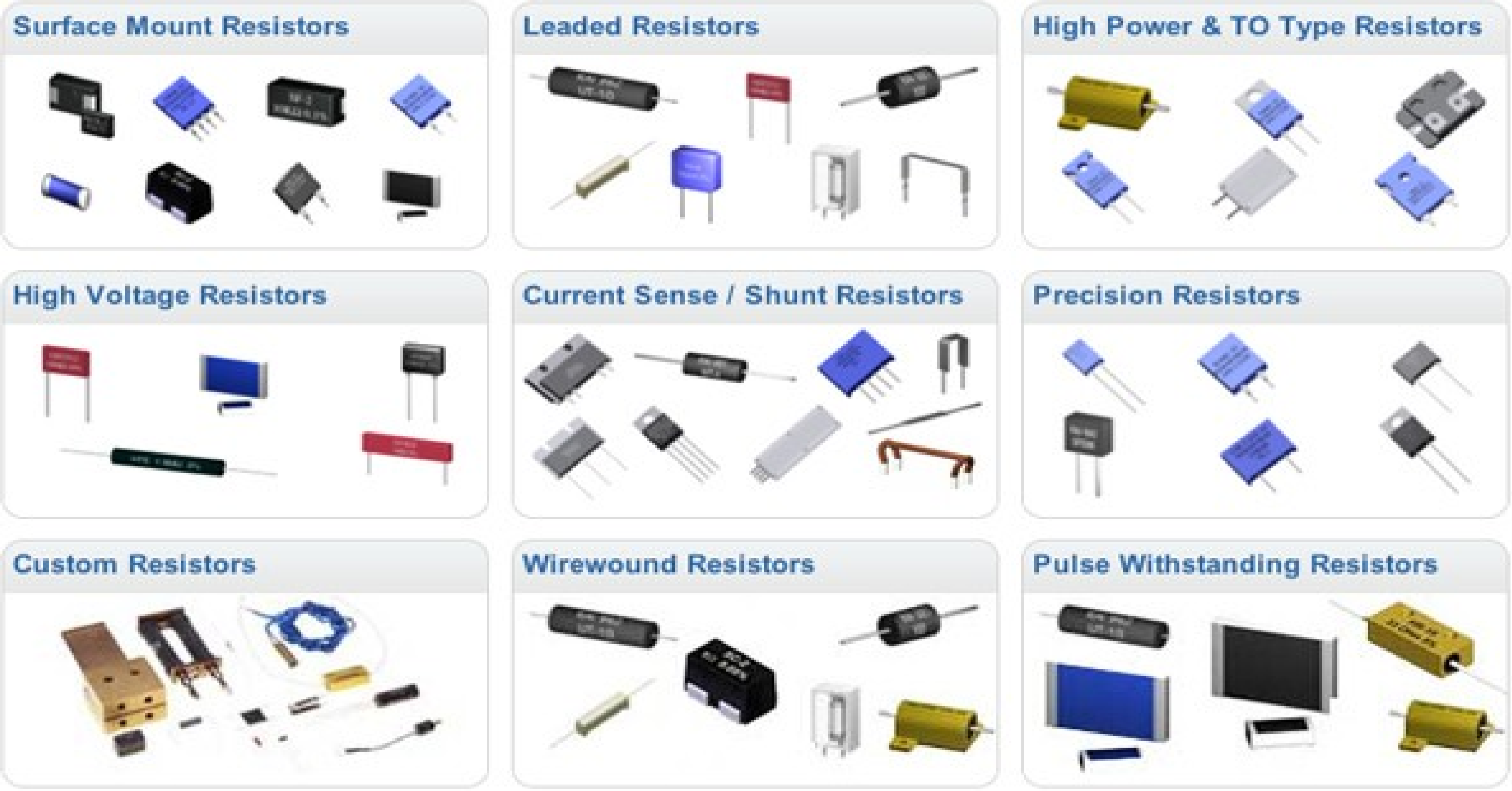
$$\text{Ohms} = \frac{\text{Volts}}{\text{Amperes}}$$

$$\text{Ohms} = \frac{\text{Volts}^2}{\text{Watts}}$$

$$\text{Ohms} = \frac{\text{Watts}}{\text{Amperes}^2}$$

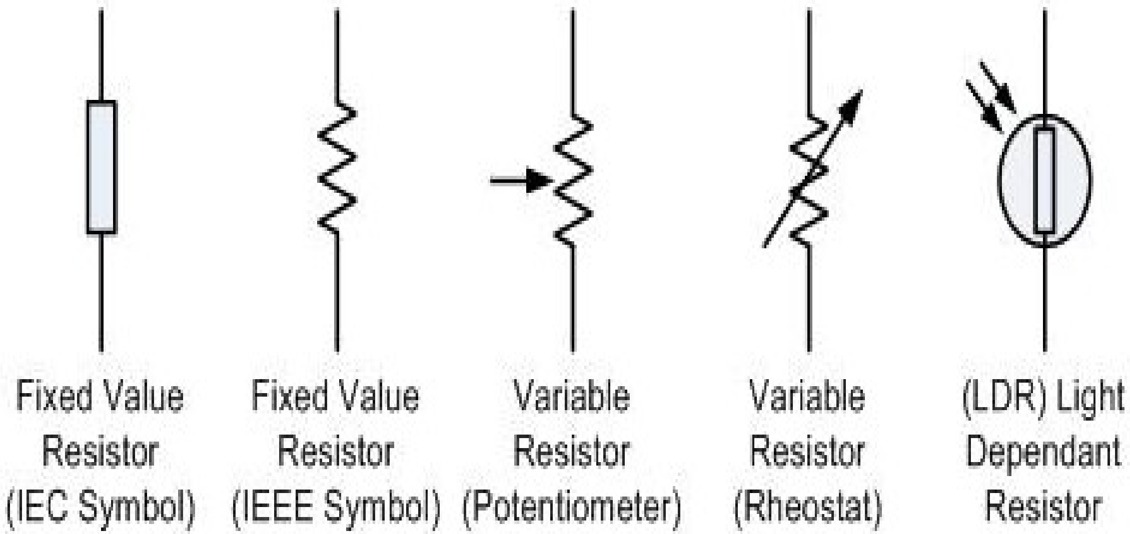
Source : PatternAgents.com

Resistor Physical Types



Source : Digikey

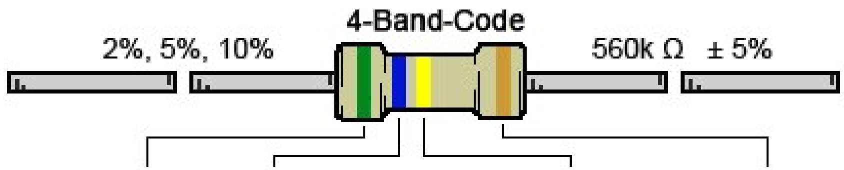
Resistor Schematic Types



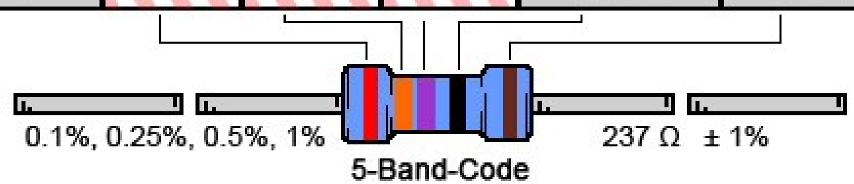
We use different schematic symbols to describe different physical resistor types, but they are all members of the same resistor “class” of components

Source : PatternAgents.com

Axial Resistor Color Code



COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8		± 0.05%
White	9	9	9		
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)



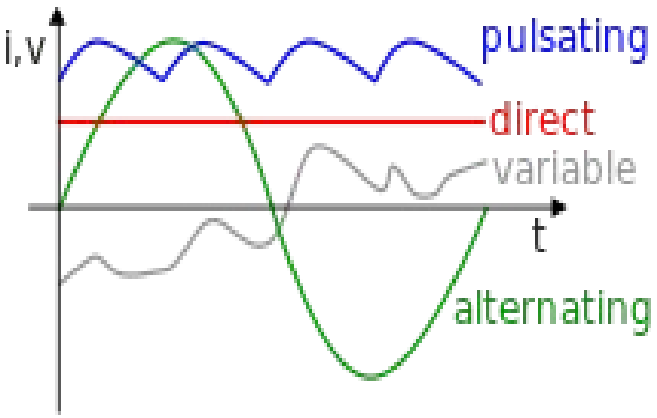
Source : Digikey

AC-DC

- We already talked a little about "Current", or the amount of electrons flowing in a circuit, which is measured in Amperes (or Amps for short)
- We break down current into two major classes, Alternating Current and Direct Current (AC~DC)

Alternating & Direct Current

- Direct Current, or D.C. as the name would suggest moves in only one direction in a wire, from positive to negative
- Alternating Current, or A.C. changes the direction of current flow in a wire from positive to negative, and then from negative to positive, as some frequency



Source : PatternAgents.com

Electronics for Audio

- There are a number of special electronics terms we use for working with Audio, such as loudness, sound pressure, harmonics, overtones, and more.
- The next section is a brief introduction to some Audio terminology

Loudness Measurement

- dB (Decibel) relative logarithmic scale for comparing the loudness of two sources

  dB = log (source1/source2)

- dBm (Decibel milliWatt) logarithmic scale referenced to one milliwatt of power

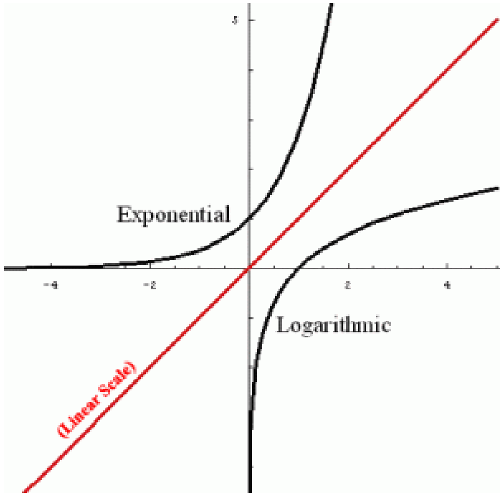
  dBm = 10 * log(source1/1mW)

Source : wikipedia.com

Sound Pressure Levels

- Reference level for air pressure chosen at 20 micropascals (20uPa), about the limit of sensitivity of the human ear

SPL = 20 log (Source1/Source2)



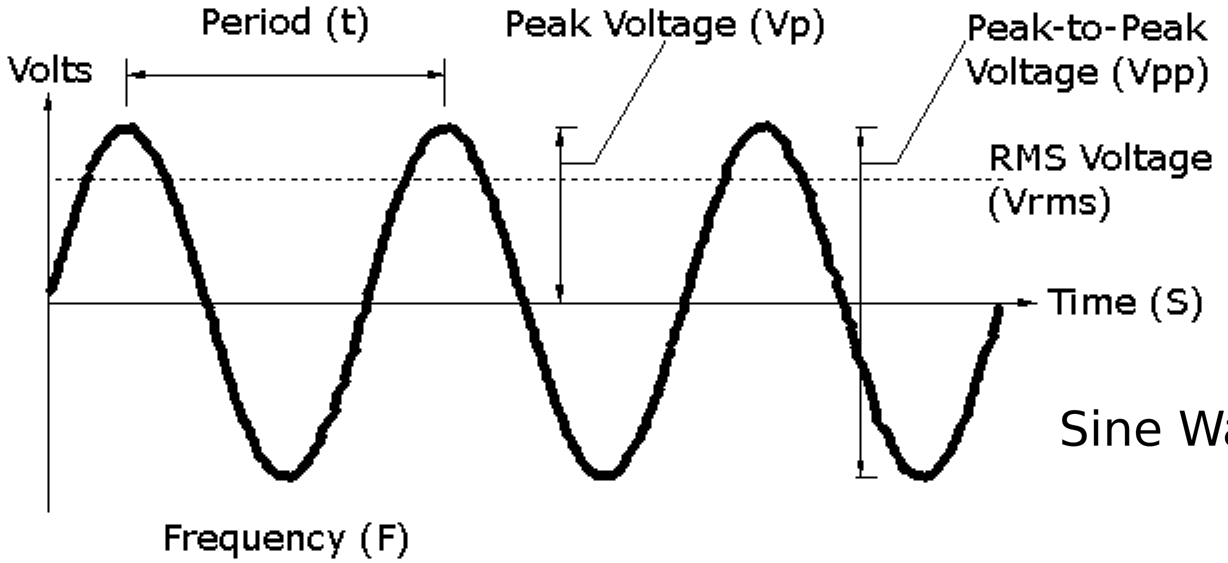
What does a one dB difference sound like?

3.0 dB is twice as loud
-3.0 dB is half as loud

Source : UNSW, wikipedia.com

Electronic Waveforms

- Electronic waveforms can be shown graphically in a number of different ways
- Usually they are graphed against Time (S)



Sine Waveform

Source : PatternAgents.com

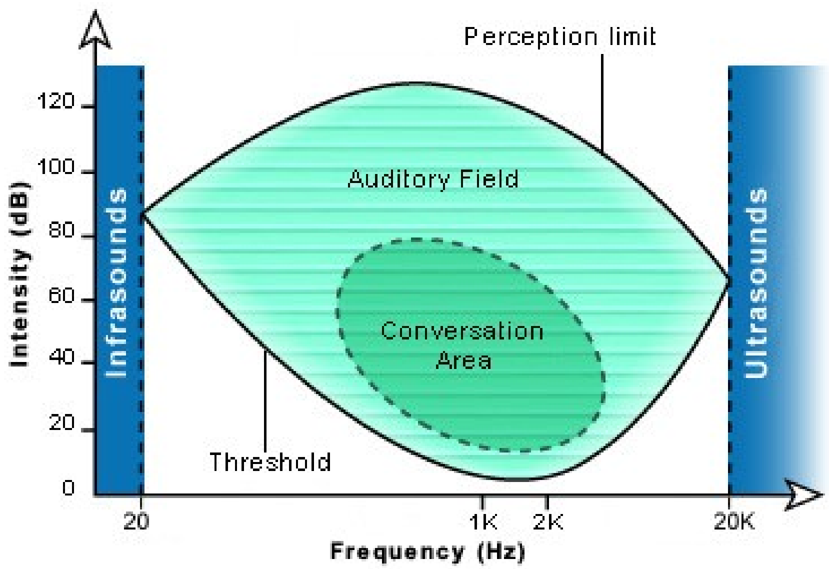
Waveform Parameters

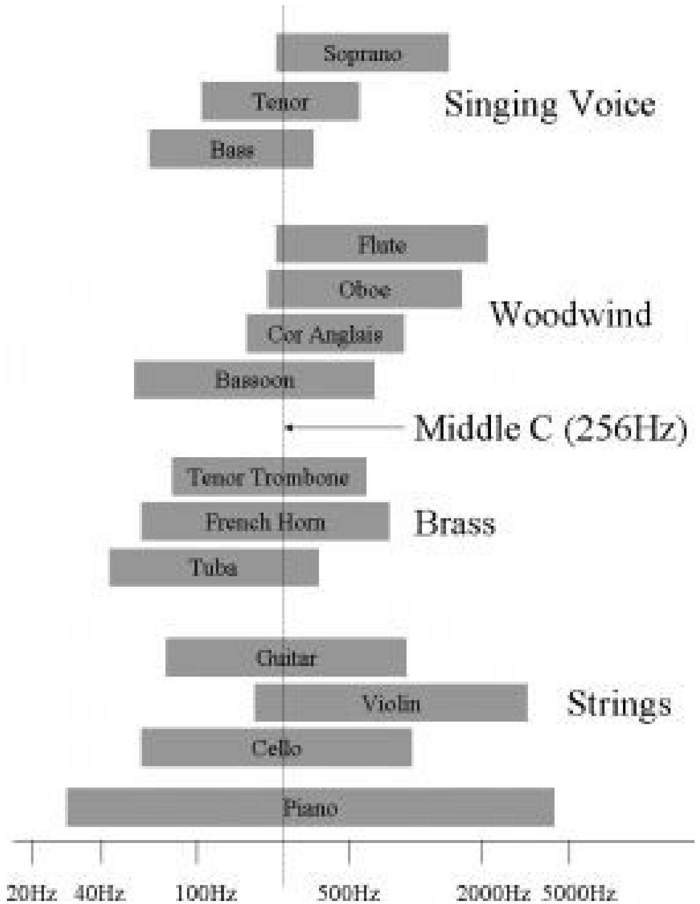
- In a sine wave it is easy to find the primary or fundamental frequency, by measuring the time between the peaks. Period and frequency are merely the inverse of each other

  Frequency (Hertz) = 1 / Period (Sec)

Audio Waveform Frequencies

- Human hearing is generally in the range of 20 hz to 22,000 hz

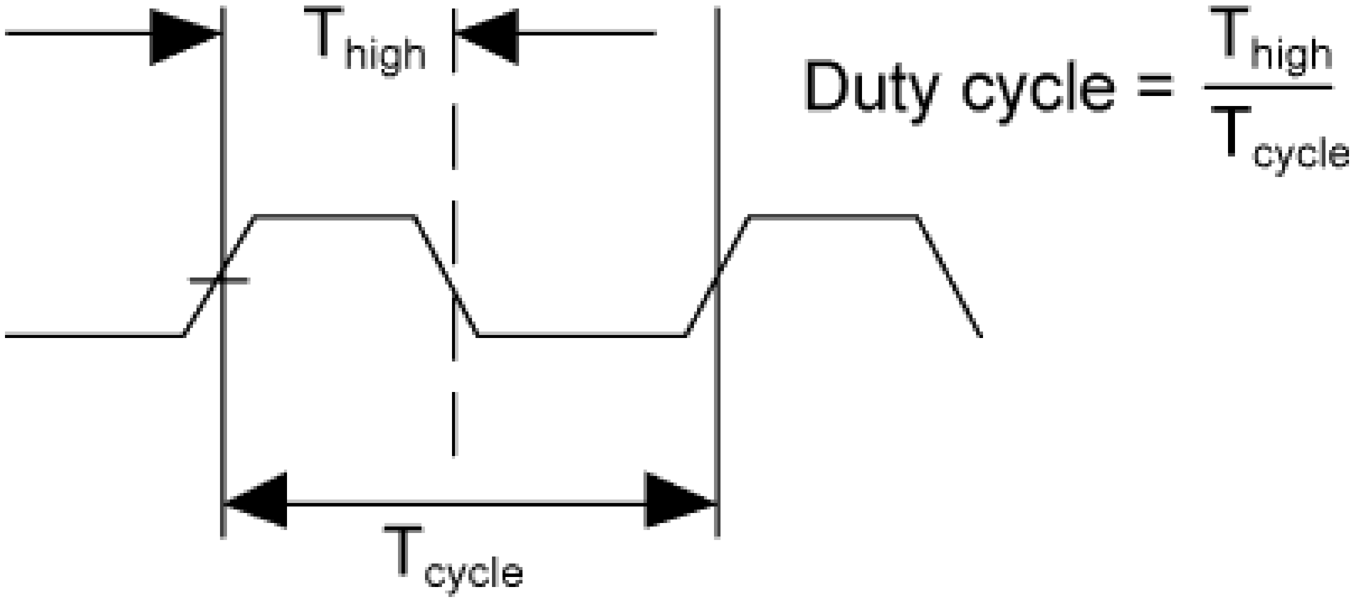




Source : wikipedia.com

Waveform Duty Cycle

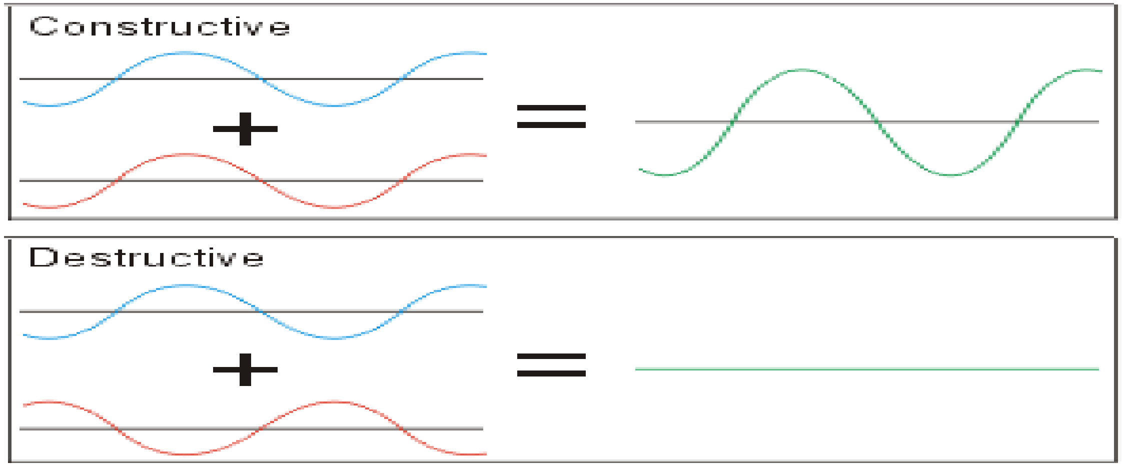
* The Duty Cycle is the percentage of “on” time to the total time of the wave period



Source : wikipedia.com

Waveform Interference

* When multiple waveforms meet (in the air or on a wire…) there can be interference between them, yielding a new waveform

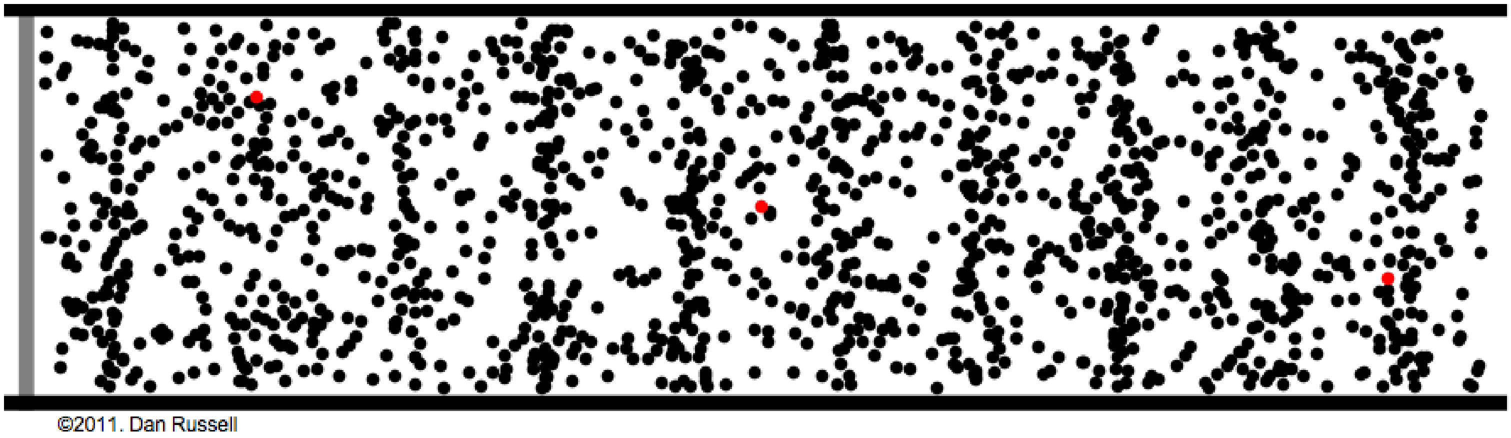


* Destructive Interference is how noise canceling headphones work….

Source : wikipedia.com

Longitudinal Waves

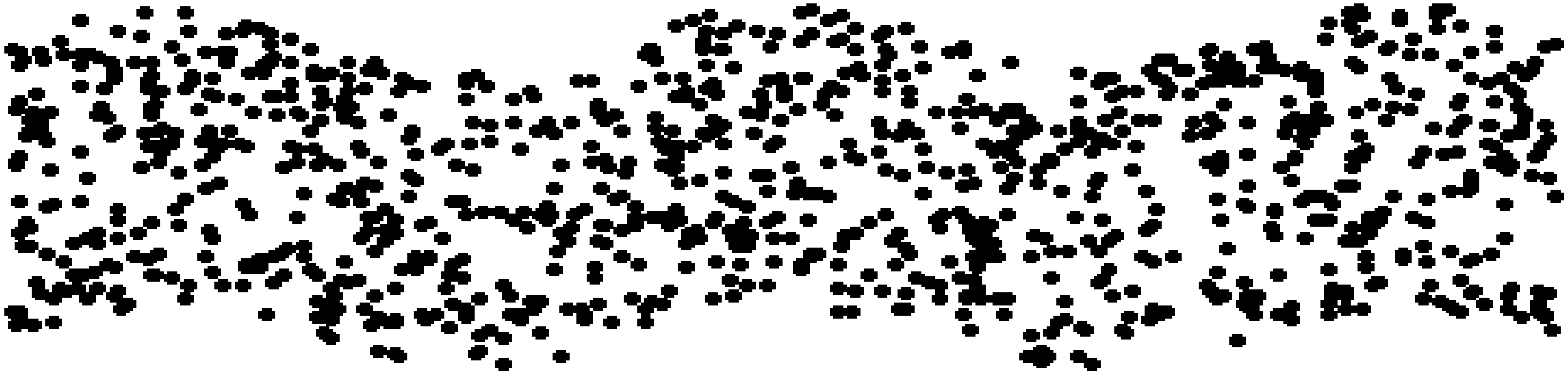
* In a longitudinal wave the energy (or the particle displacement) is parallel to the direction of the wave propagation



Source : wikipedia.com

Transverse Waves

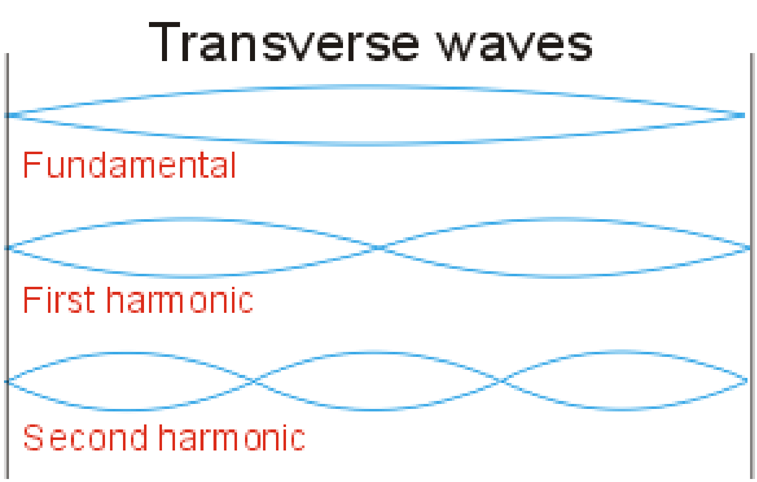
- In a transverse wave the energy (or the particle displacement) is perpendicular to the direction of the wave propagation



Source : wikipedia.com

Harmonics

- Transverse waves can produce harmonics such as when a string that is fixed on both ends is plucked or bowed. Because both ends are fixed, a standing wave pattern with center antinodes can be produced



Source : wikipedia.com

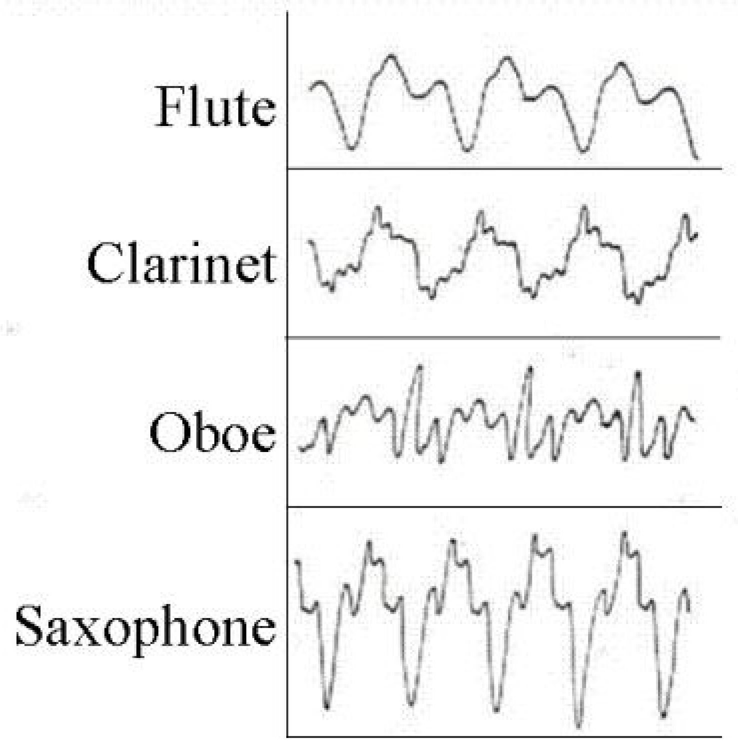
Overtones

- An overtone is any frequency higher than the fundamental frequency of a sound
- Together the fundamental and the overtones are called partials
- Harmonics are partials whose frequencies are integer multiples of the fundamental
- Inharmonics are partials whose frequencies are not integer multiples of the fundamental

Source : wikipedia.com

Complex Waveforms

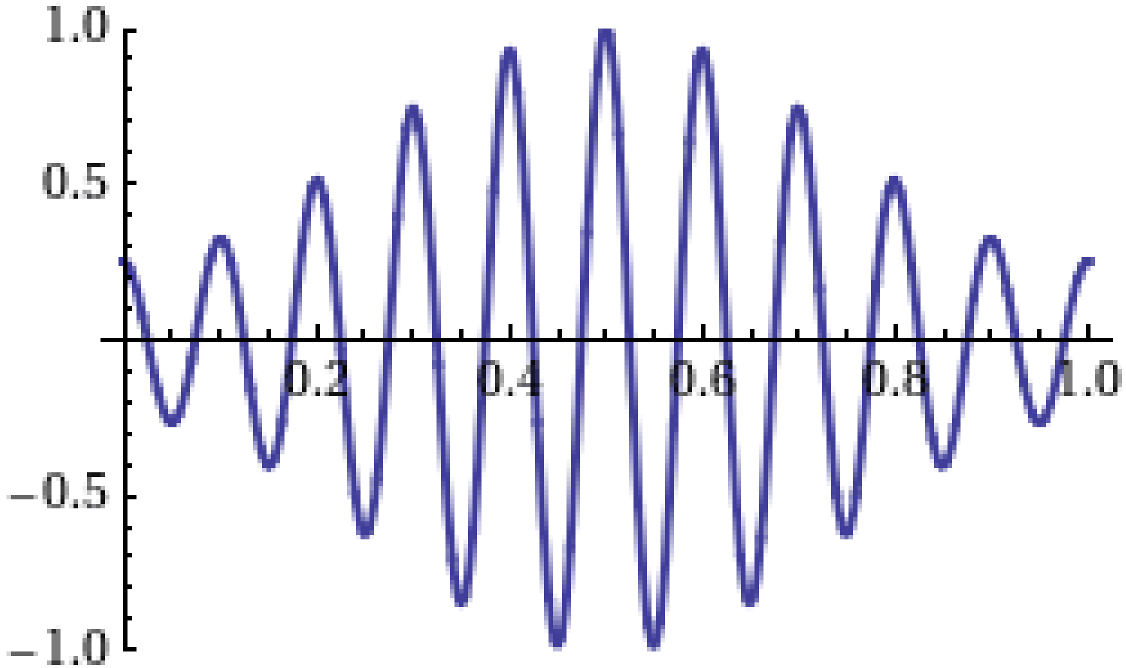
* Most sounds you hear are complex waveforms, they have many overtones



Source : wikipedia.com

Modulating Waveforms

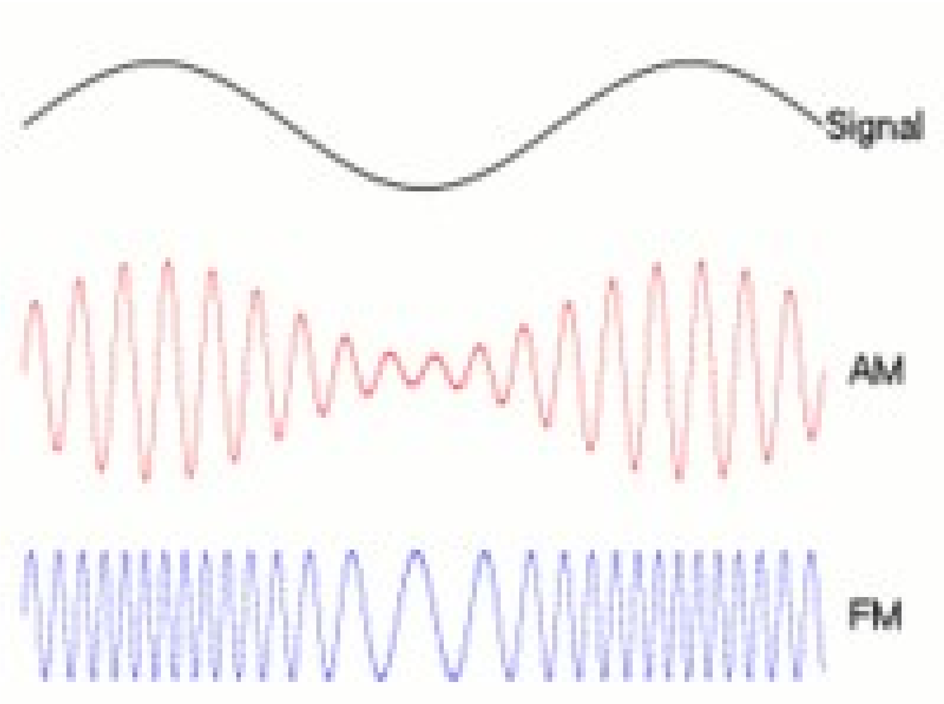
- A basic waveform (carrier wave) can have its parameters modified by another waveform using a process known as modulation



Source : wikipedia.com

Amplitude Modulation

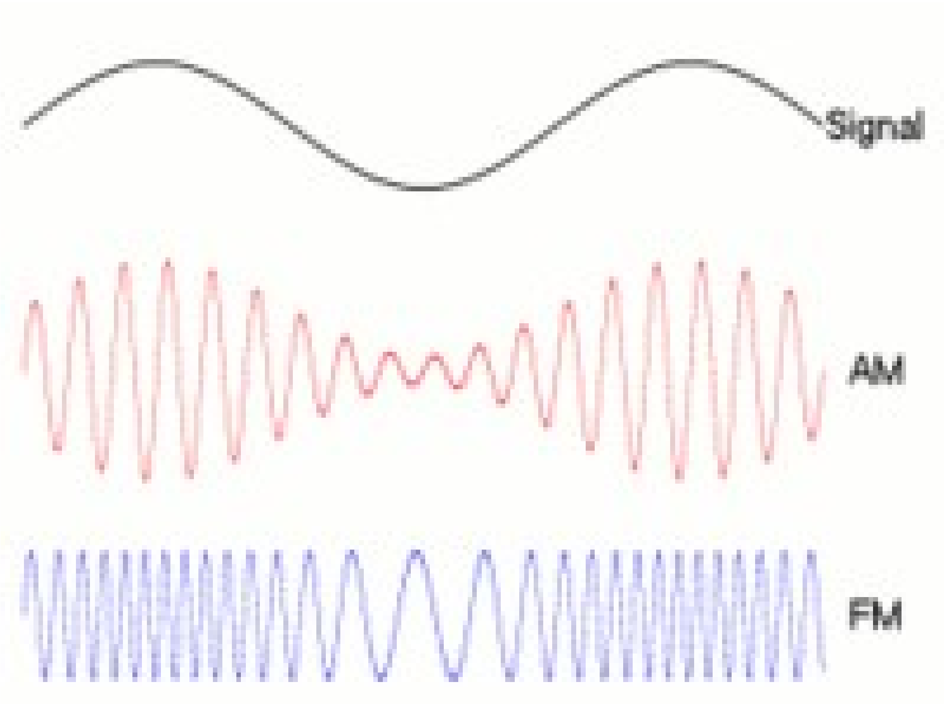
- If the Amplitude of the carrier waveform is changed by another signal it is called Amplitude Modulation



Source : wikipedia.com

Frequency Modulation

- If the Frequency of the carrier waveform is changed by another waveform it is called Frequency Modulation

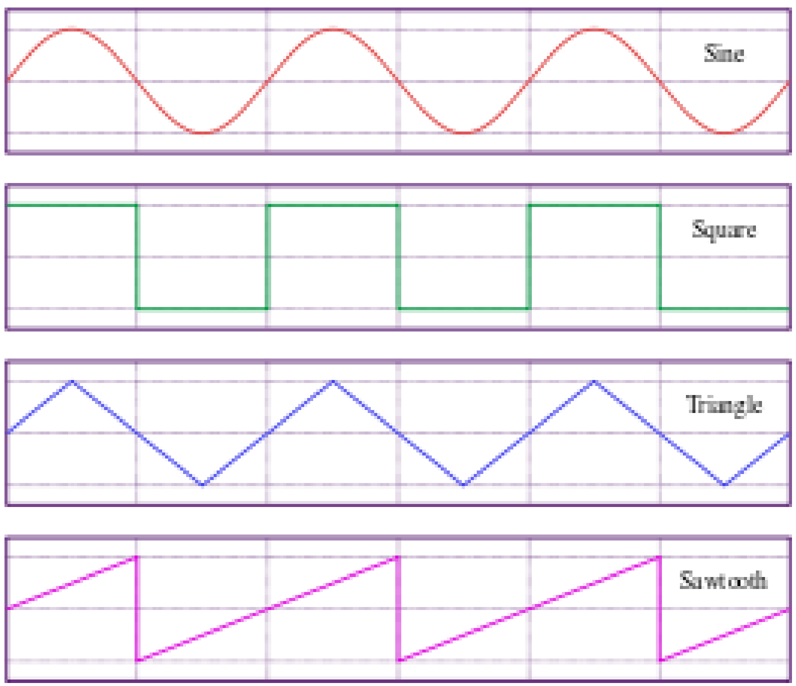


Source : wikipedia.com

Creating Basic Waveforms

* A electrical circuit known as an oscillator is used to create basic waveforms

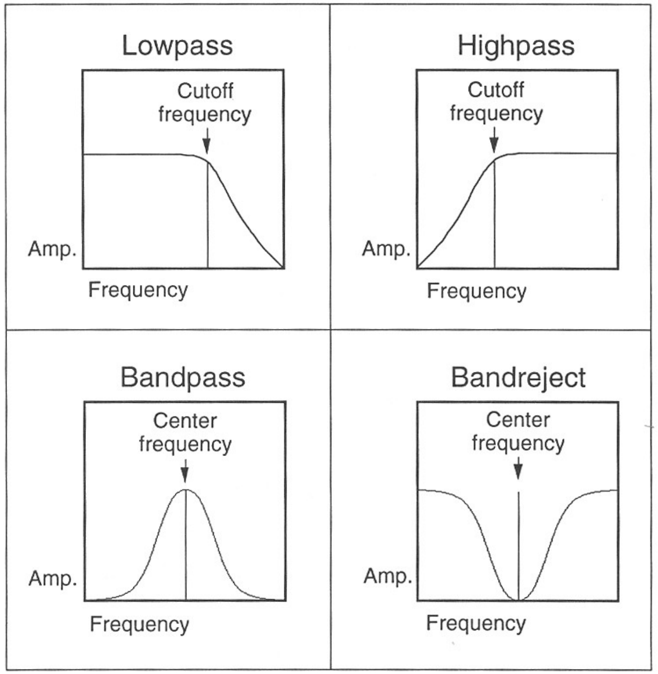
1 Khz 256 Khz



Source : wikipedia.com

Audio Filters

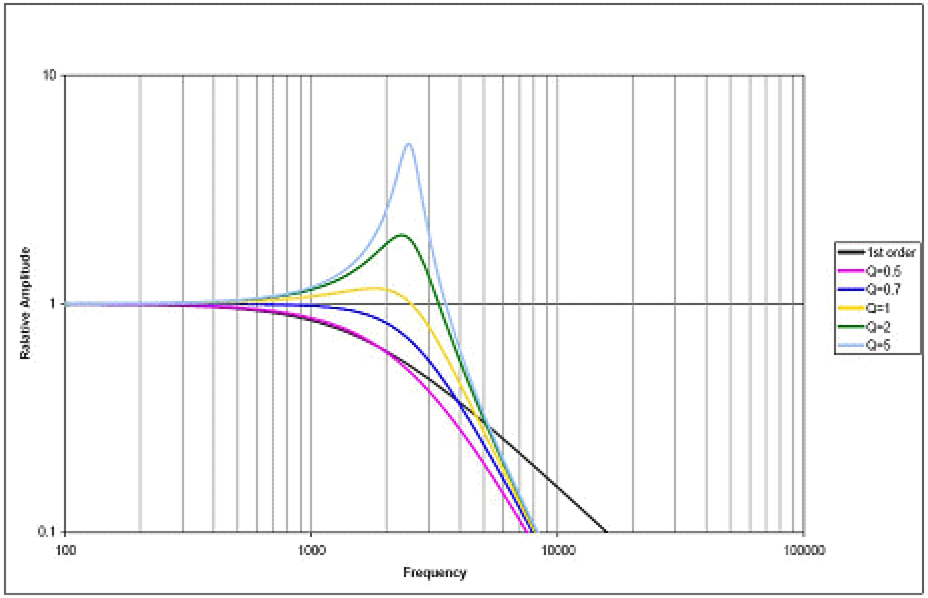
- This is a topic would could spend days on
- An Audio Filter is a frequency dependent amplifier circuit, with several variations



Source : wikipedia.com

Filter Parameters

- Cutoff Frequency : Fc (in Hertz)
- Resonance : Q , Quality Factor (no units)
  a measure of bandwidth relative to frequency
- Several others : Order (2nd/3rd), Type (Elliptical)



Source : Graphic- Beb Hennick/TI

Audio Filter Sounds

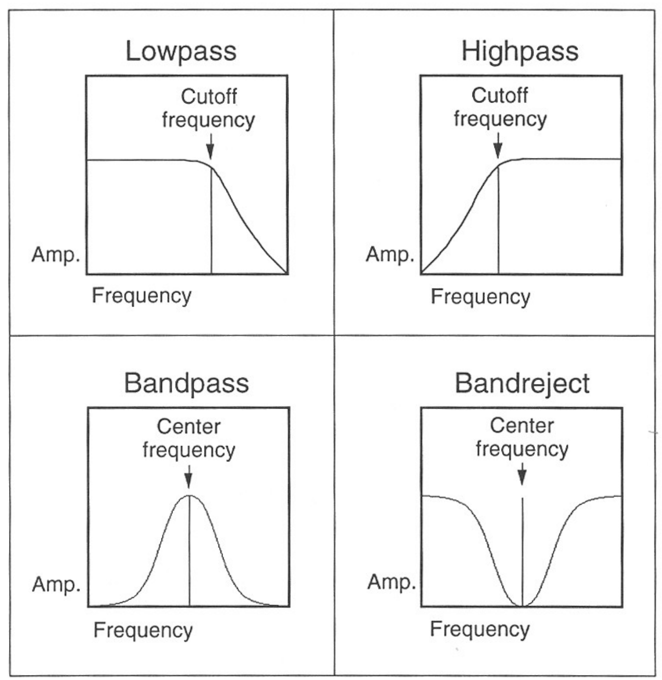
- Okay, so what do they sound like?

LPF – High Q

LPF – Low Q

HPF – High Q

HPF – Low Q



BPF – High Q

BPF – Low Q

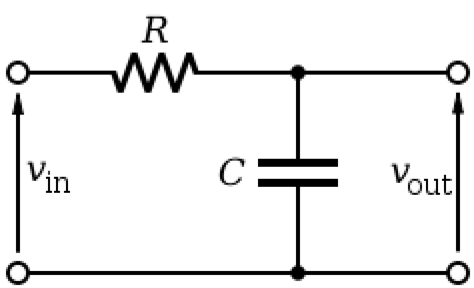
BRF – High Q

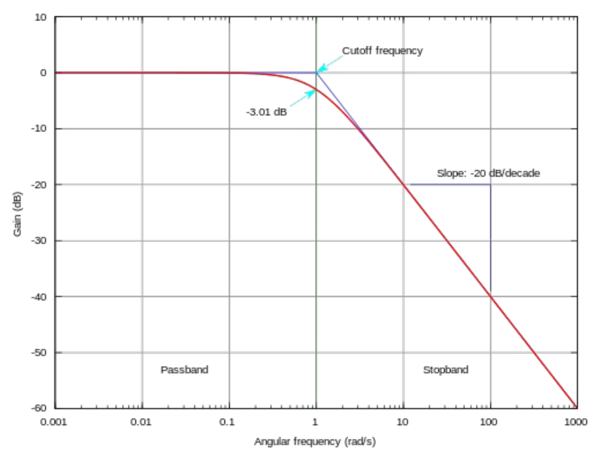
BRF – Low Q

Source : wikipedia.com, Ableton

Low Pass Filter (Passive)

* As the name suggests, only lower frequencies can "pass" thru the filter



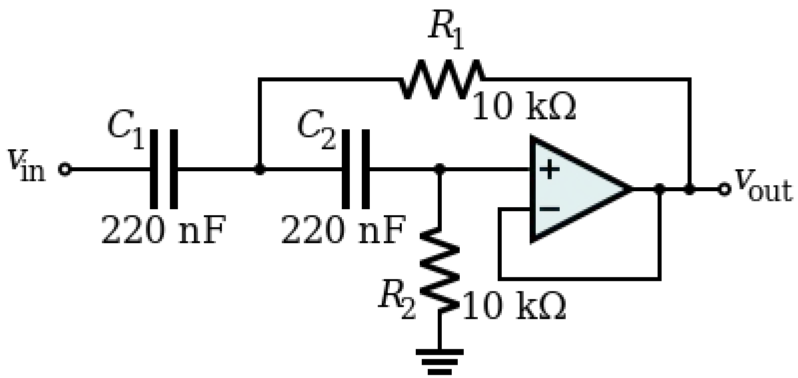


$$f_c = \frac{1}{2\pi R_2 C}$$

Source : wikipedia.com

Sallen-Key Filter (Active)

- Sallen Key is a popular example of an active filter, and uses an operational amplifier (OpAmp) as the active element

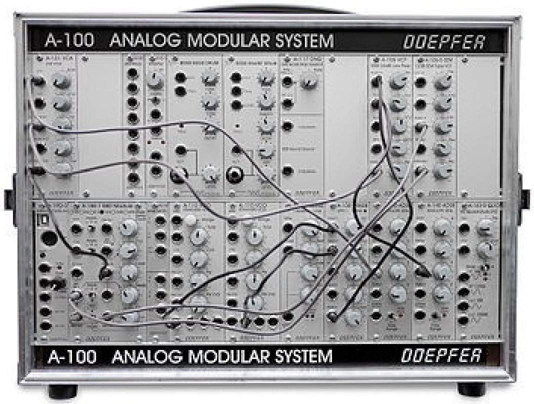


- This LPF has Fc = 15.9Khz and Q = 0.5

Source : wikipedia.com

Voltage Controlled Analog

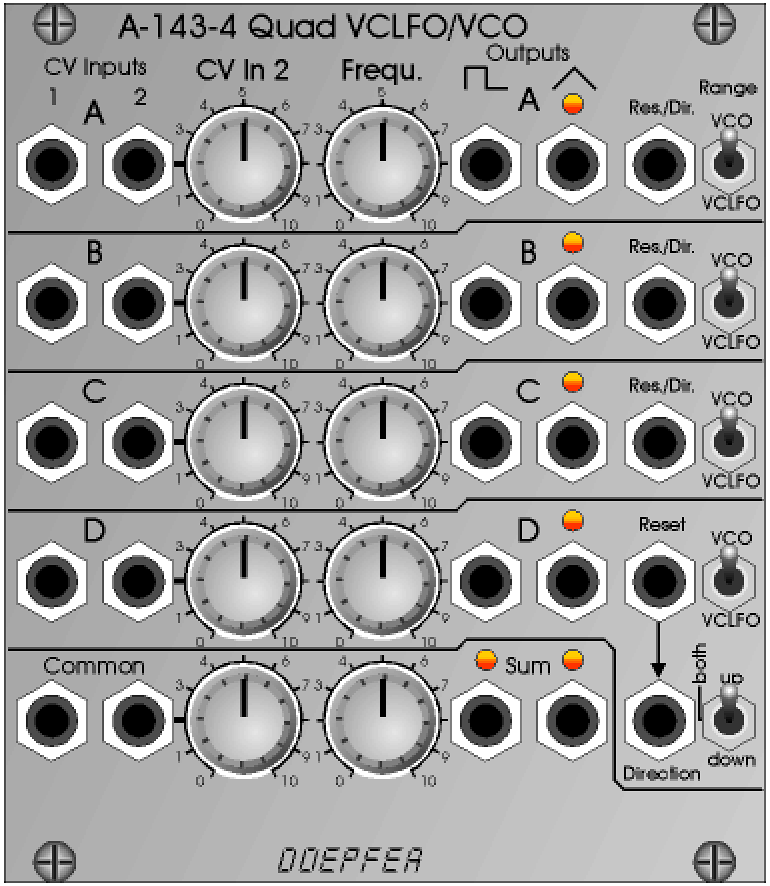
- In the 1960's voltage control of audio functions became popular with the analog synthesizers designed by Dieter Doepfer, Bob Moog, Don Buchla, and many others



Source : wikipedia

Voltage Controlled Oscillators

- In a Analog Voltage Controlled Oscillator (VCO), the frequency of the oscillator output is controlled by an input "Control Voltage"



Source : doepfer.de

Low Frequency Oscillator

- A Low Frequency Oscillator, or LFO is an oscillator that produces a waveform below the human hearing range (< 20Hz).
- LFO’s can be used in several ways, either to frequency modulate a carrier signal
(Vibrato effect), to amplitude modulate a carrier signal (Tremolo effect) or to control another function, such as a filter center (Wah-Wah effect)

Source : wikipedia.com

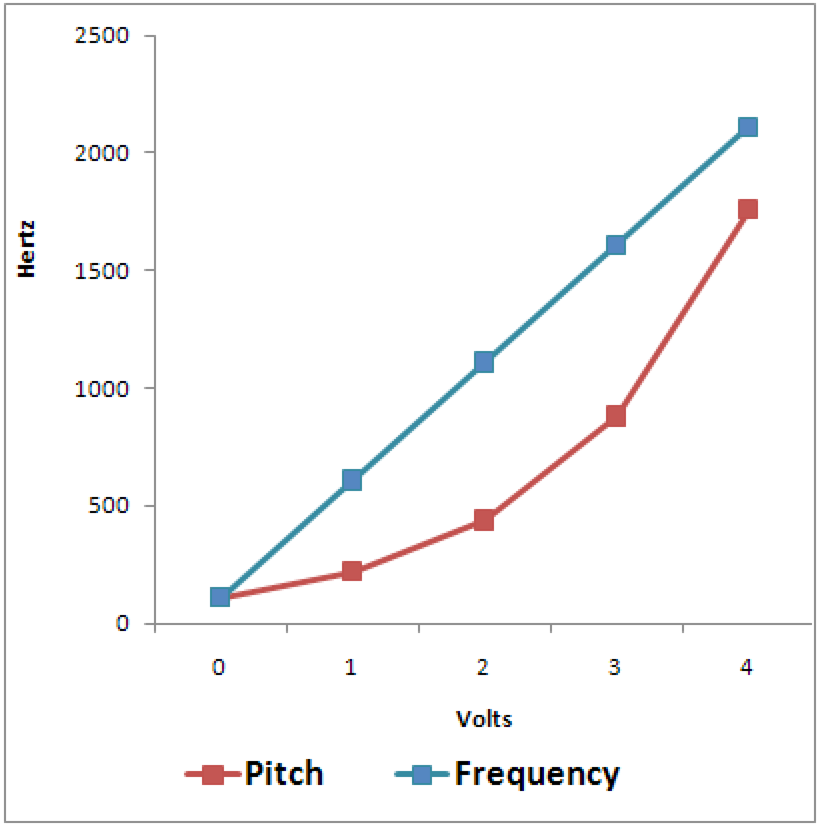
LFO Examples

- Tremolo Effect (Amplitude Modulation)
- Wobble Effect (Frequency Modulation)
- Ripple Effect (Filter Modulation)

Source : wikipedia.com

Volt per Octave Frequency

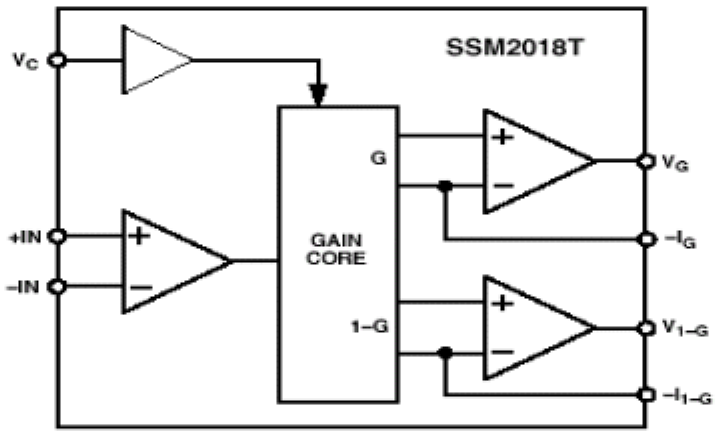
- Voltage Control, or "CV" was often used with Volt per Octave Frequency control.
- "Subjective Pitch" can be nonlinear, and is measured in Mels.



Source : emusician.com

Voltage Controlled Amplifier

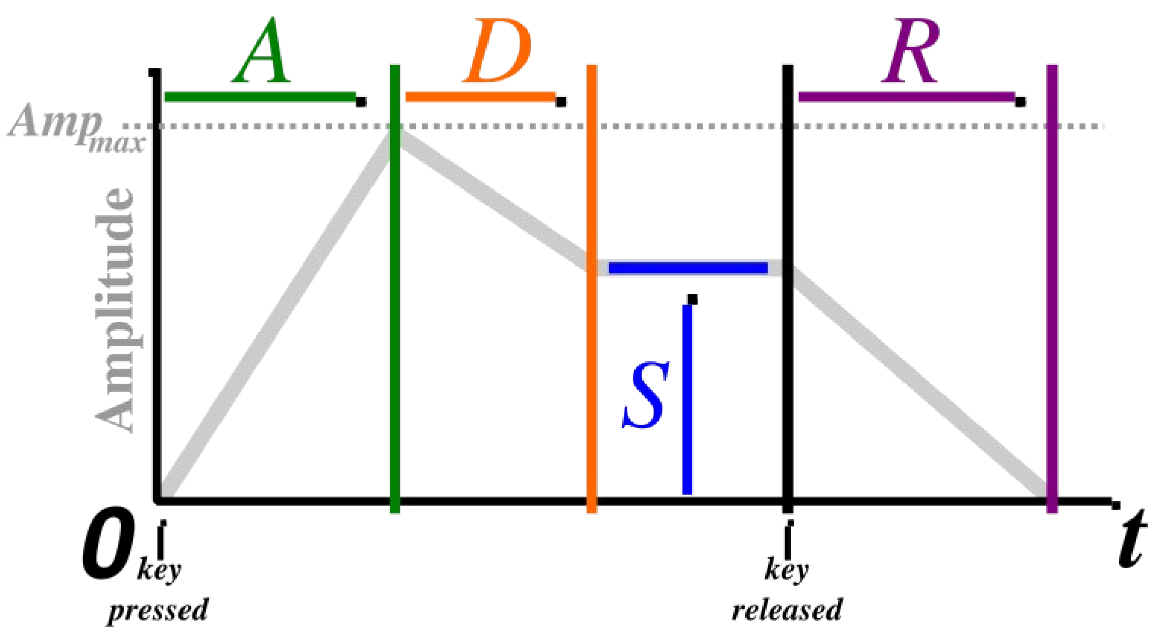
- The Voltage Controlled Amplifier (VCA) is used to vary the volume of the sound based on a control voltage input. The Solid State Music (SSM20xx) parts were widely used for this by Sequential, Oberheim, etc.



Source : analog devices inc.

Waveform Shaping (ADSR)

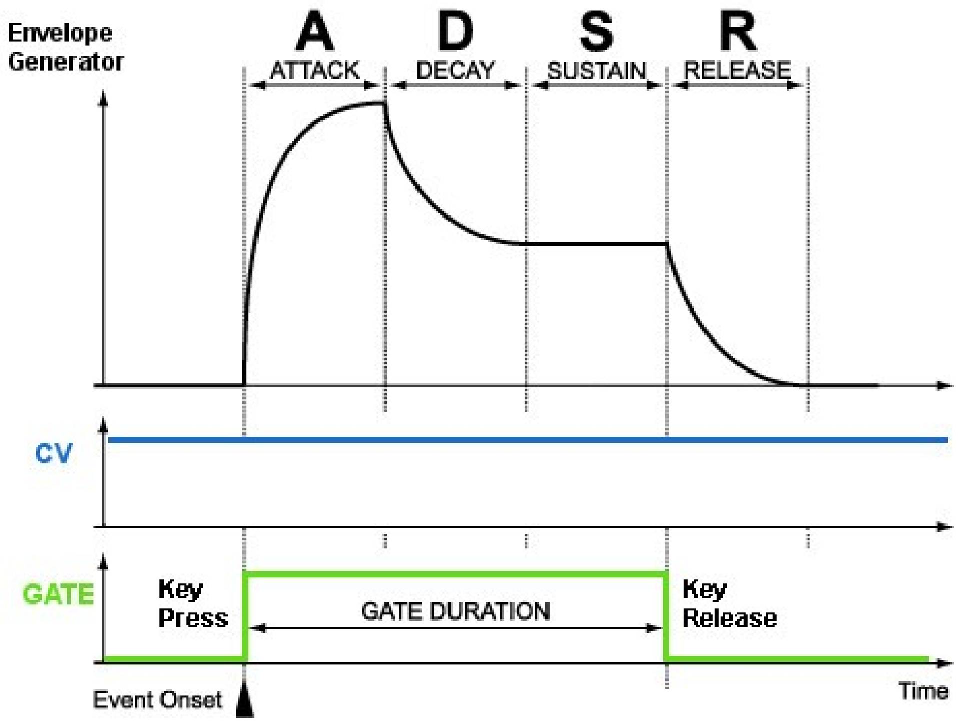
- Several ways to “shape” waveform envelopes to synthesize different sounds, one method is ADSR, which stands for : Attack, Decay, Sustain, Release

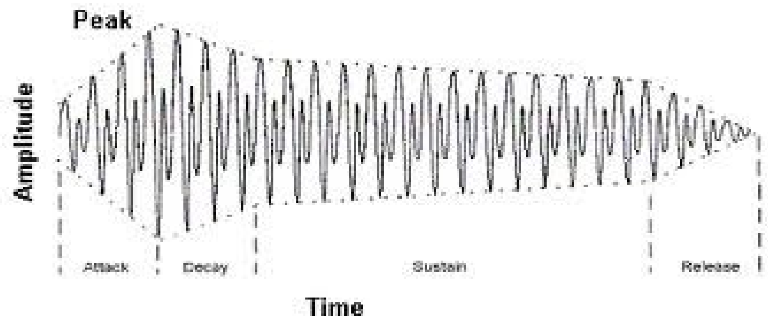


Source : wikipedia.com

ADSR Envelope Generator

- An example of a ADSR Envelope



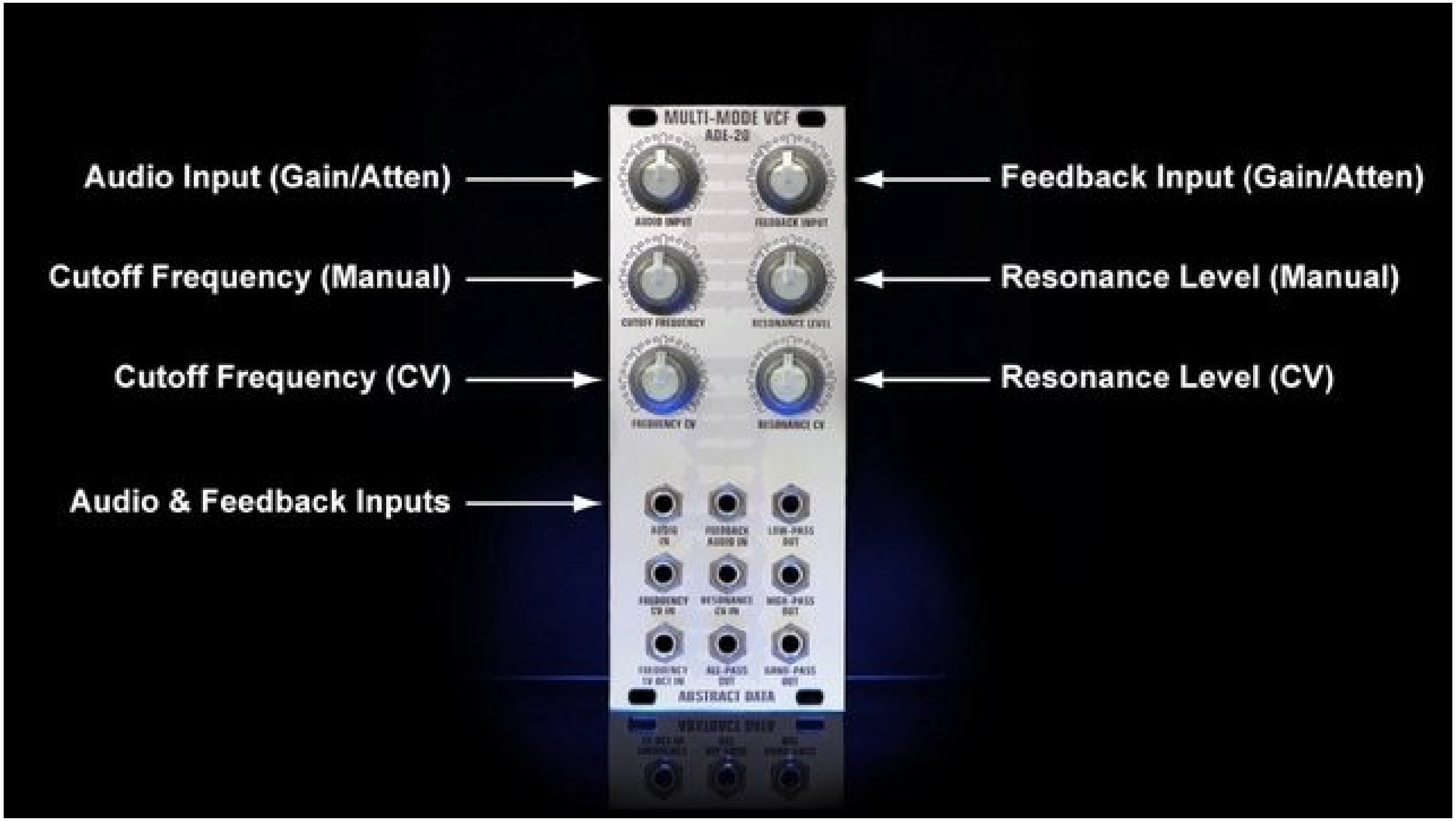


(Keyboard "Gate" Signal)

Source : PatternAgents.com

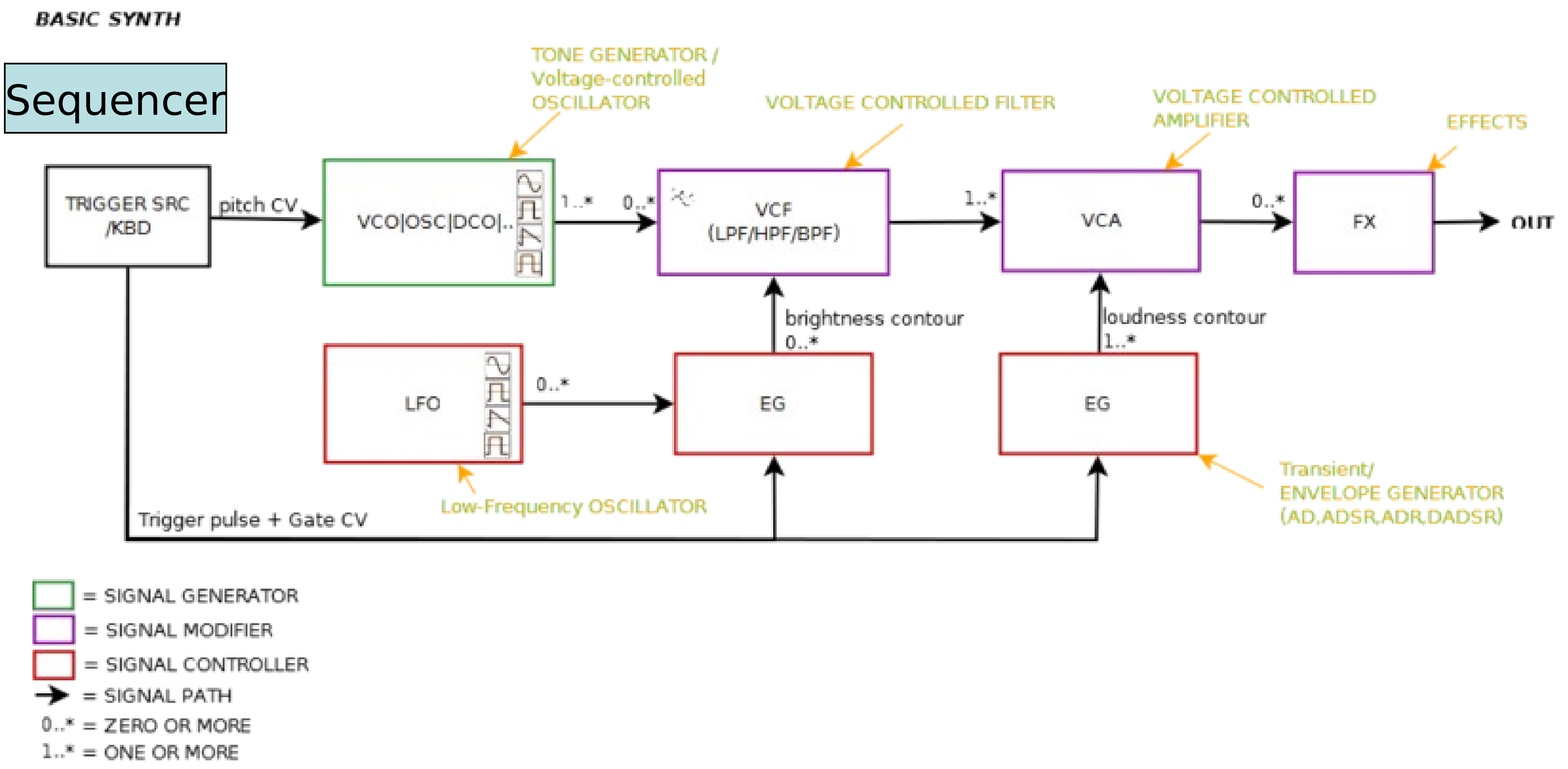
Voltage Controlled Filter (VCF)

* An example VCF, the ADE-20



Source : Abstract Data Effects

Putting It All Together



Source : wikipedia

Summary

Source : PatternAgents.com

Thank You !

Questions?

Sources and References :

- Wikipedia : en.wikipedia.org/wiki/
-

Notes :