SYNTHESIS AND SYNTHESISERS

AoS1: SYNTHESIS

Additive, Subtractive, FM Synthesis: https://www.youtube.com/watch?v=X4E-2qq5rE8

Granular Synthesis: https://youtu.be/F1RsE4J9k9w?t=844

What is a Synthesiser?

- An electronic sound generator capable of creating and manipulating synthetic sounds
- Come in both **software** and **hardware** forms
- **Analogue Synthesis**: A signal is generated using an **electrical voltage** and then shaped
- **Digital Synthesis**: **Computer technology** is used to model other synthesisers and generate sounds
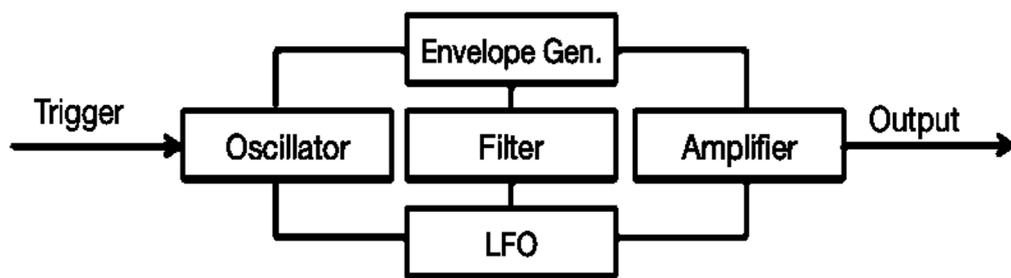

- They are commonly used today in the form of DAW plug-ins but vintage analogue hardware is highly regarded for its unique warmth and authenticity

- Pictures:
  - Korg MS-20
  - ES1 (Logic)

How Does it Work?

- Trigger eg. keyboard causes the oscillator(s) to start to generate sound based on the wave forms selected

Waveforms

- The oscillator will **generate** a sound at a given pitch; depending on the chosen waveform different **timbres** can be created
  - Sine = Pure tone
  - Triangle = Slightly harsher than sine
  - Sawtooth = Even and 'edgy' sound
  - Square = 'Hollow' and 'woody'
  - Pulse = 'Nasal' sounding

Sine

Triangle

Sawtooth
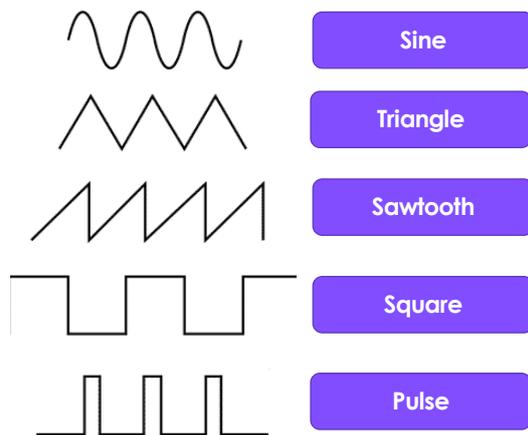
Square

Pulse

 - Sine = basic building block of sound (every sound can be broken down into a combination of sine waves)
 - Triangle = Flute-like sounds and pads
 - Sawtooth = Strings, basses, pads and brass/dance leads
 - Square = Clarinets, oboes and basses
 - Pulse = Can change the pulse width
                  - Reed instruments and basses

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Oscillator

- The oscillator allows for the **octave** to be selected as well as **coarse** and **fine-tuning**
  - Coarse tuning sets the pitch in semitones
  - Fine-tuning sets the pitch in cents

- Many synths feature multiple oscillators

- The options for octave are often 4', 8', 16' and 32' and come from the lengths of different pipes found on an organ

- 1 cent = 1/100 of a semitone or 100 cents = 1 semitone

- Fine-tuning can be used to slightly detune oscillators in order to create a 'chorus-like' effect

Monophony and Polyphony

- The polyphony on a synth tells you **how many notes** it can play at once

- A **monophonic** synth can only play **one note at a time**

Capable of creating and manipulating synthetic sounds

(Picture – Jupiter Prophet 5 Mono Synth)

Glide/Portamento

- Controls the amount of time it takes for a synth to **slide** between two **overlapping** notes

- Commonly found on **monophonic** synths

- The **range** of a synth's pitch bend can be changed

- MiniMoog was one of the first synths to feature a pitch wheel

- This determines how many semitones the note will bend up/down by

- (Picture – MiniMoog Vintage Synth)

White Noise

- A noise generator creates a **random signal**

- **White noise** is a signal that consists of **all frequencies** playing at an **equal amplitude**

- There are other types of noise such as **pink noise** that have **different frequency distributions**
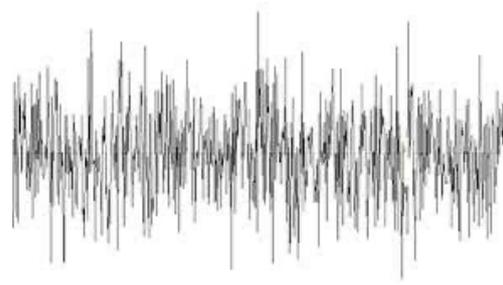
- White noise = simulates wind or percussive sounds
- Can be filtered to create a sweeping effect (i.e. risers)

Filters

- Filters **remove specified frequencies** from the initial signal in order to help shape the sound

- Most synths will incorporate at least a **low pass filter**
  - Removes all frequencies **above** a set cut-off

- Resonance can be added to filters to create a narrow boost near the cut-off frequency
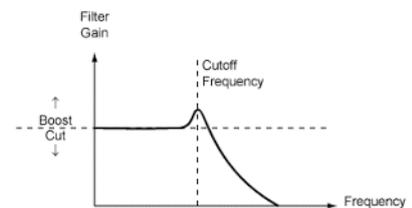
- The cut-off frequency is the point at which the filter begins to remove frequencies

- Some synths also include high pass and band pass filters

- Resonance creates a 'whistly' sound that makes frequencies near the cut-off sound brighter and harsher
    - High resonance settings can lead to self-oscillation, where the boost of a specific frequency is so loud that the filter appears to create a pitched note

Envelope Generators

- Envelopes are used to control various elements of a synth such as the oscillator, amplifier and filters

- Envelopes help to shape a sound's timbre along with the harmonic content provided by the oscillator
  - Helps to tell the difference between synthesised instrument
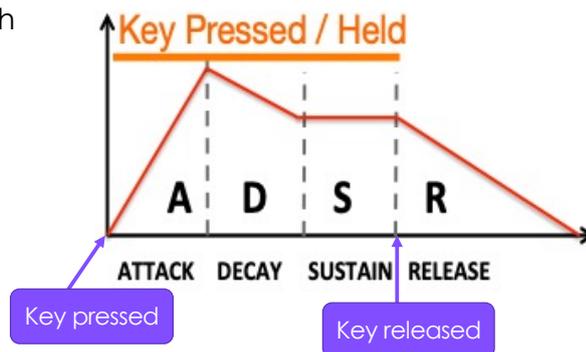
- They can be used specifically to control things like the cut-off frequency of a filter

- Attack = The time taken for the parameter to increase from 0 to the max level
- Decay = The time taken for the parameter to decrease from the max level to the sustain level
- Sustain = The level at which the parameter is held whilst the key is pressed down
- Release = The time taken for the parameter to decrease to 0 one the key is released

- Piano has fast attack whereas violin has slower attack

Low Frequency Oscillators (LFOs)

- Similarly to envelopes, LFOs are control signals used to change a parameter over time

- LFOs have three main parameters
  - **Rate** – the speed at which the modulation takes place
  - **Depth** – how much the modulation affects the assigned parameter
  - **Shape** – the type of wave form used to modulate the signal
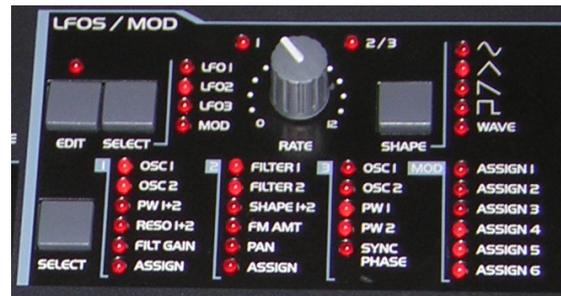
- Most synths can use LFOs to control different modules
  - If controlling the oscillator, it can change the the pitch being generated, resulting in vibrato
  - If controlling the cut-off frequency of a filter, the cut-off will change periodically depending on the wave shape the LFO is using

- Rate can either be synced to a note value in your DAW (e.g. 1/8 / quaver) or an absolute value in Hz (often between 0.05Hz and 15Hz)
  - The LFOs' ability to sync with the main tempo of a project is useful when trying to create effects thatare in time with your track

Arpeggiators

- An arpeggiator is a type of **sequencer** that repeats notes in a specified pattern
  - They were included in some analogue synths

- Like LFOs, arpeggiators can be synced with the tempo of a project by selecting a note value

- The Roland Jupiter-8 had an arpeggiator incorporated into it

Subtractive Synthesis

- Start off with a harmonically rich waveform generated by two or more oscillators and then use filters to remove specific frequencies

- Sound is then shaped with envelopes

Additive Synthesis

- Jean Baptiste Fourier theorised that more complex sounds are able to be split up into several more simple components

- Multiple simple waveforms are combined to create a more complex waveform
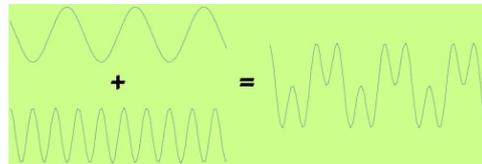
(Picture – Kawai K5)

Fourier also believed that even the most complex sounds could be created by combining the simplest of sounds, which are sine waves.

Sine waves are most commonly used (due to them being the simplest) but theoretically any waveform could be used (Some systems even use short segments of recorded sound)

Hammond organs/Church organs can be said to utilise additive synthesis due to their method of creating sounds by combining several sets of tone wheels/organ stops

FM Synthesis

• Uses one oscillator to modulate the frequency of another oscillator

• Artists began to move away from analogue subtractive synths for new digital technology that utilised early MIDI technology

• Was an extremely popular mode of synthesis during the 80s
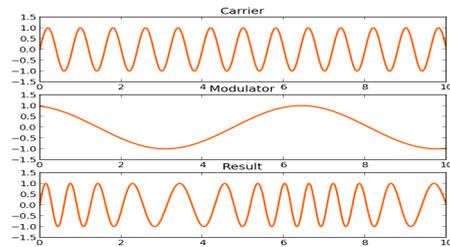
(Picture: Yamaha DX7)
FM = Frequency Modulation

Operator 1 = Modulator (The waveform that is performing the modulation)
Operator 2 = Carrier (The waveform being modulated)

Ratio = By how much is the modulator affecting the waveform of the carrier?

Granular Synthesis

- Doesn't exclusively use oscillators to generate sound
- Granulation is when a sample is split up into small segments known as 'grains'
- Cross-fades are then applied to the grains in order to blend their gain levels
- The shape and length of the cross-fades help to determine the tone of the final sound


(Picture: Collidoscope, Granulator II)

Grains can be played back in different orders and individual grains can be looped, skipped and manipulated in various other ways

Cross-fades are also known as smoothing

Usually come in software form but some hard ware versions exist

Modular Synthesis

- A module is an electronic circuit that is designed to complete a specific, music-related task
- Non-modular synths would have limited routing options
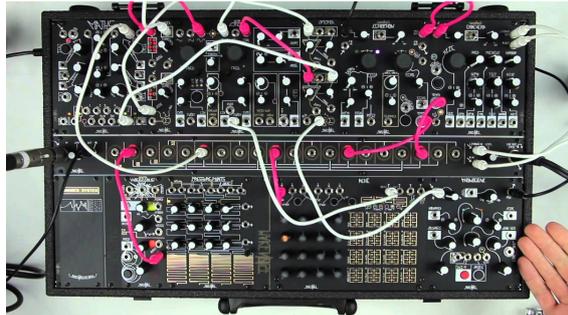
(Picture: Make Noize modular system)
Patch cables connect the modules together
What goes through the cables? – **Electricity**
- Low-voltage electrical signals - no different to any other cables
- Two types of signals can be sent:

1) Audio signals ("musical" signals that you can listen to if you connect them to a powered speaker)
2) Control voltage ("non-musical" (and often inaudible) electrical signals that are used to trigger and automate various parameters of modules.)

For example, there are modules that make sounds ("oscillators"), modules that filter sounds (LPF), modules that mix sounds together, and many, many other kinds of modules.
- Oscillators
- Filters
- Amplifiers
- LFOs

- Envelope generators
- Effects
- General utility

- Traditional, non-modular synthesizers usually have one (or a small number of) predetermined routing options.
- A modular synth lets you connect your modules *any way you like*.
- Meaning you can create a crazy, complex signal flow that has never existed before

The History & Development of the Synthesiser

The birth of synthetic sounds
- Theremin (1922)
- Ondes Martenot (1928)
- Trautonium (1930)

Moog Modular
- Wendy Carlos - *Switched-On Bach*

Rhodes Piano
- Ray Charles - *Shake Your Tailfeather*

Minimoog
- Tubeway Army - *Are Friends' Electric?*

Roland Jupiter-8
- Queen - *Radio Ga Ga*

Korg M1
- Des'ree - *You Gotta Be*

1954   **1968**   **1977**   **1983**

1920s-1930s   **1965**   **1969**   **1981**   **1988**

Hammond B3 Organ
- Booker T. and The M.G.'s - *Green Onions*

Hohner Clavinet
- Stevie Wonder - *Superstition*

Sequential Circuits Prohet-5
- A-ha - *Take On Me*

Yamaha DX-7
- Brian Eno - *Apollo: Atmospheres and Soundtracks*

1920s-30s: Manufacturers used electricity for making string instruments as a means of control and direction

1965: RCA = Radio Corporation of America

Software vs. Analogue Synthesisers

Benefits of Software Synthesisers	Benefits of Analogue Synthesisers
Can be automated, MIDI controlled and easily sequenced	Analogue sounds 'warmer' due to the imperfection associated with it
DAWs with global tempo allow for the synchronisation of LFOs and arpeggiators	It is possible to sync analogue equipment through the use of CV/gate systems
Better signal-to-noise ratio	Less reliant on pre-sets and sounds more unique
Wide variety of pre-sets available	'Hands-on' interface making it simple to adjust settings 'on-the-fly'
Can create multiple instances of a pre-set	
Stays in tune (analogue synth can go out of tune when they heat up)	
Has access to more envelope stages, waveform and filter types	

- As computers became more and more capable, more powerful software synths were being developed and gaining popularity
- You could have multiple different hardware synth equivalents without having to buy multiple synths

- Popular vintage synths also became harder to come across in working condition
- Working vintage analogue equipment today can sell for thousands of pounds

- Imperfections such as noise, distortion and subtle random variations in wave amplitude and frequency

Oscillator

Generates various types of waveform

Amplifier

Controls the output level of the synthesiser

Portamento/Glide

Controls the length of the slides between notes

Envelope

Shapes the sound by altering the attack, decay, sustain and release values for specified parameters

Polyphony

Controls how many notes can be played at once