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SOUND SYNTHESIS IN LOGIC II

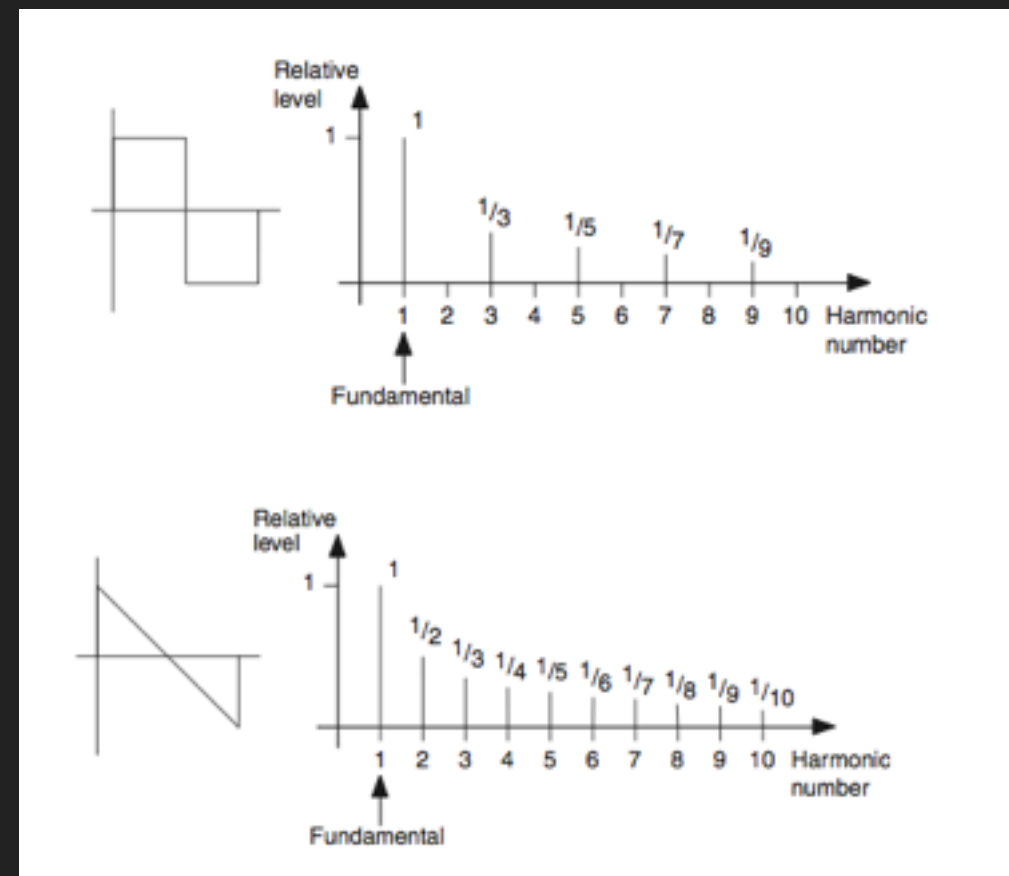
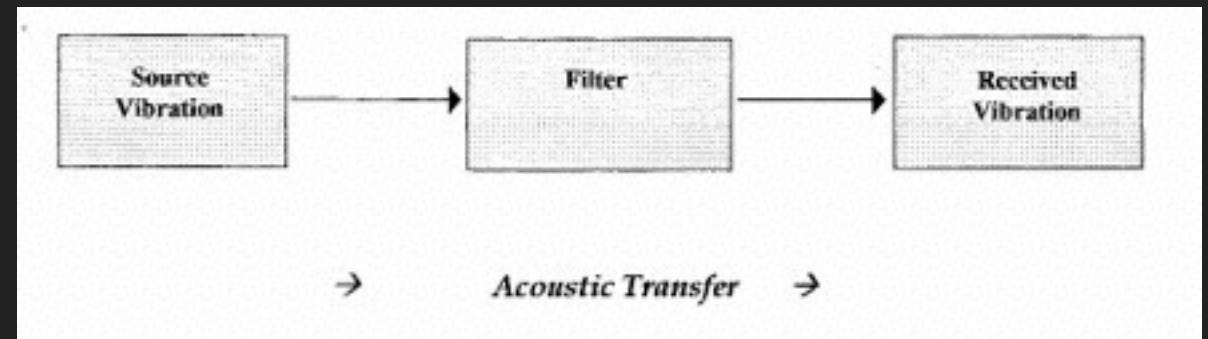
RECAP...

- ▶ Synthesis: artificial sound generation
- ▶ Variety of methods: additive, subtractive, modulation, physical modelling, wavetable
- ▶ Logic incorporates software synthesisers which deploy all of these techniques (singly or in combination), with the exception of additive synthesis
- ▶ These synthesisers are triggered and controlled via MIDI data

RECAP: SUBTRACTIVE SYNTHESIS

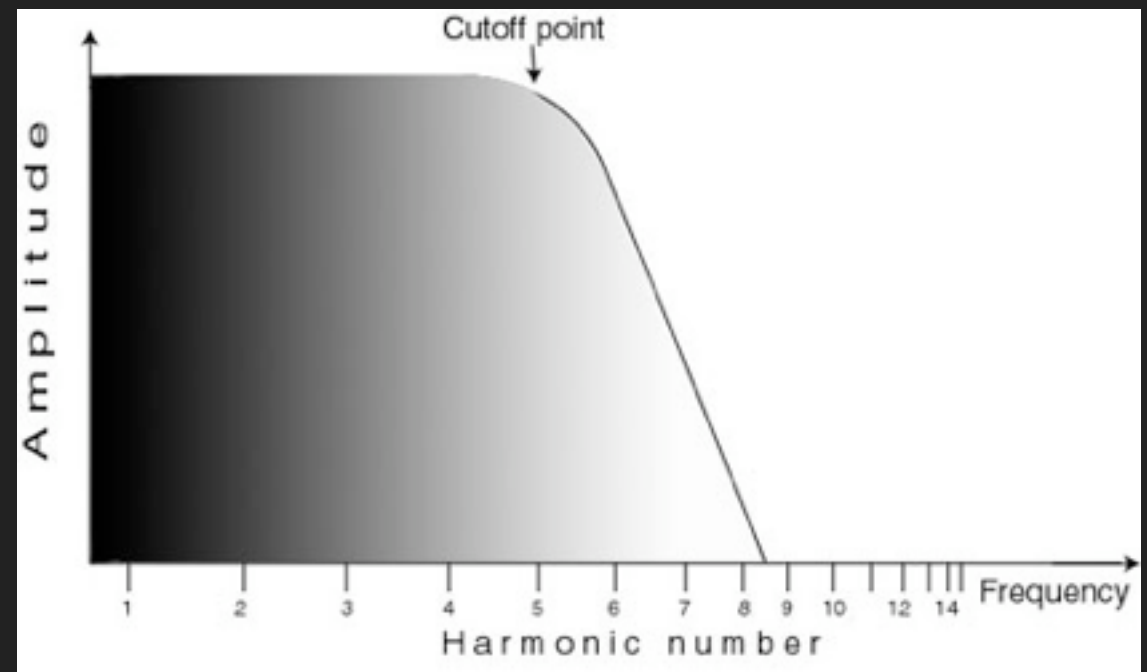
► Source-Filter

- Source: oscillator wave shape and timbre (wave shape means pattern of harmonics...means different texture/timbre)



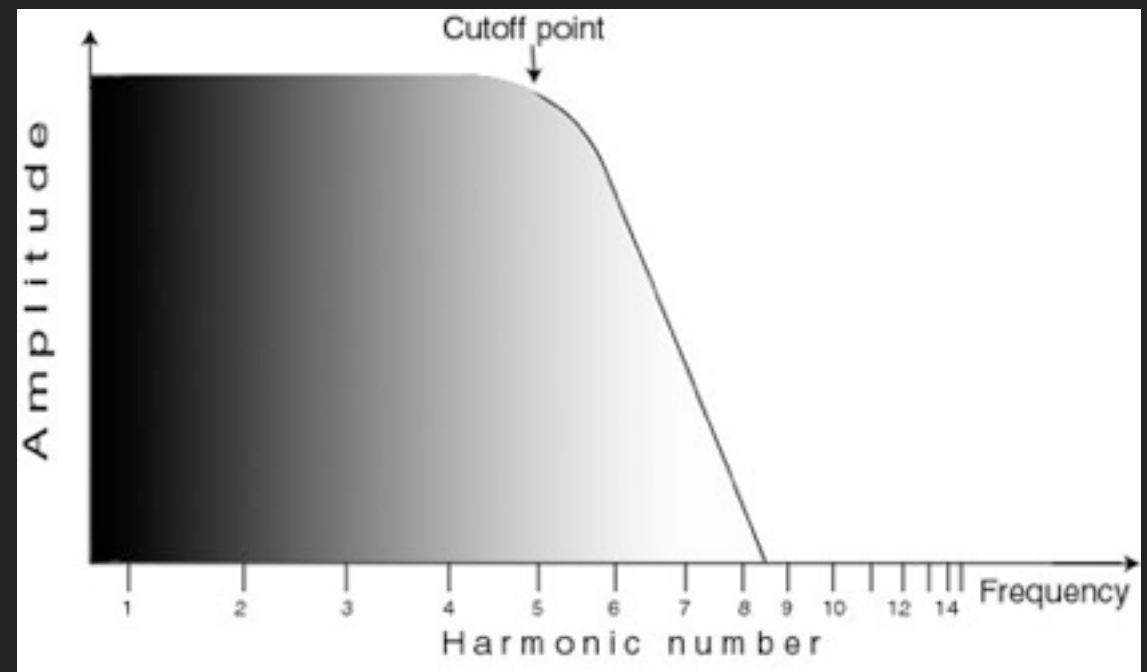
RECAP: LOW-PASS FILTERS

- ▶ Low-pass filters are the most commonly-used filters in subtractive synthesisers
- ▶ As we saw earlier, you can think of them as being based on the body of a musical instrument, which will tend to amplify the output of a vibrating string, reed etc., but will amplify different frequencies by different amounts
- ▶ To make a simple but effective synthesised sound, one of the most important things to do is to differentiate between **bright/harsh** and **muted/dull timbres** by applying low-pass filtering



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RECAP: MODULATION SOURCES

- ▶ Moog's key invention from 1964 was a system of remote control for synthesiser hardware which enabled control signals to automate processes such as filter sweeps (which we have just seen) and basic changes in level (for describing the changes in overall loudness over time which are common characteristics of musical instruments)
- ▶ Such control signals are commonly termed modulation sources
- ▶ Modulation sources can be anything which automate synthesis controls/parameters
- ▶ *Not to be confused with modulation synthesis (in this context, 'modulation' is relatively slow automation of synthesis controls/parameters)*

SUMMARY—KEY ES1 CONTROLS



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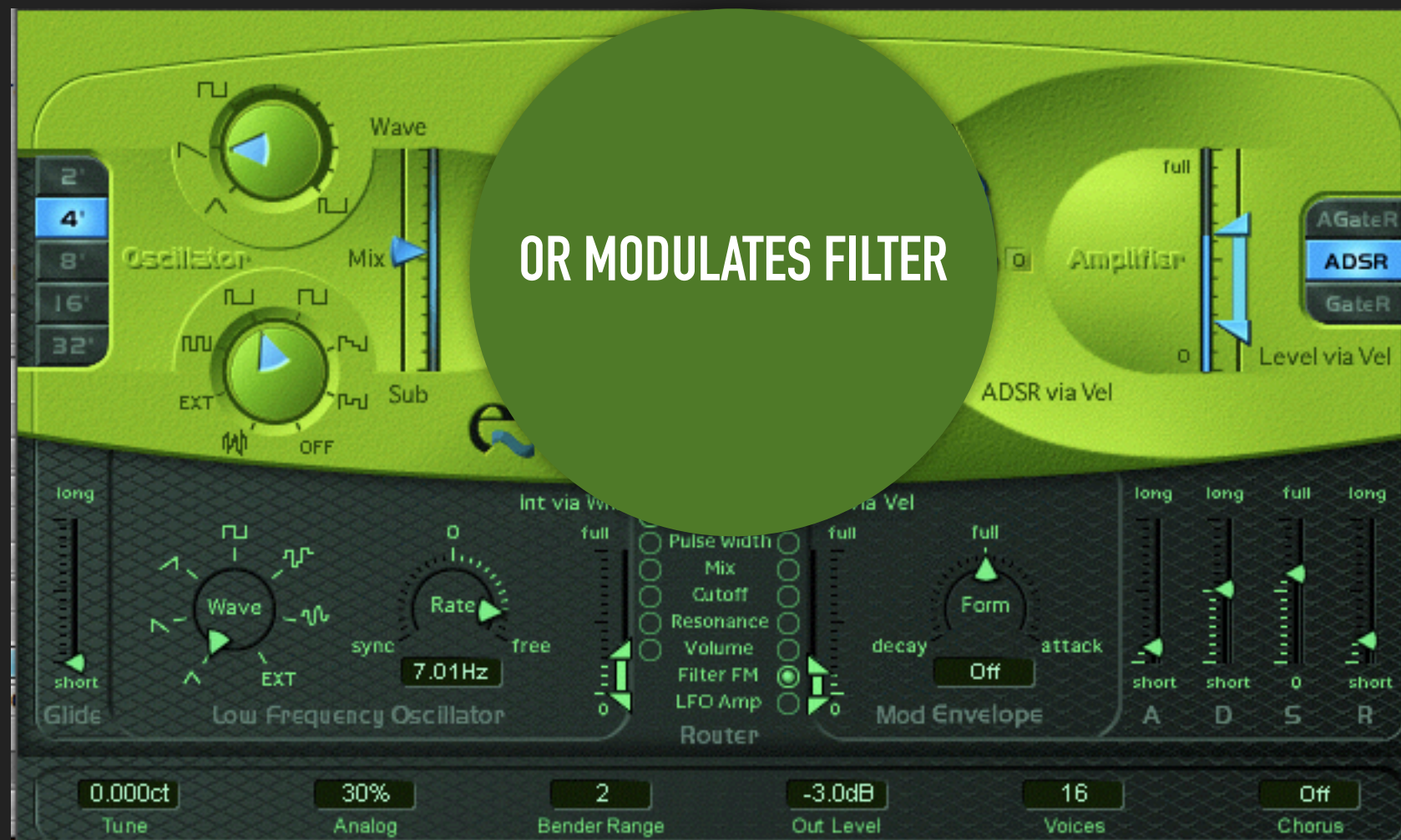
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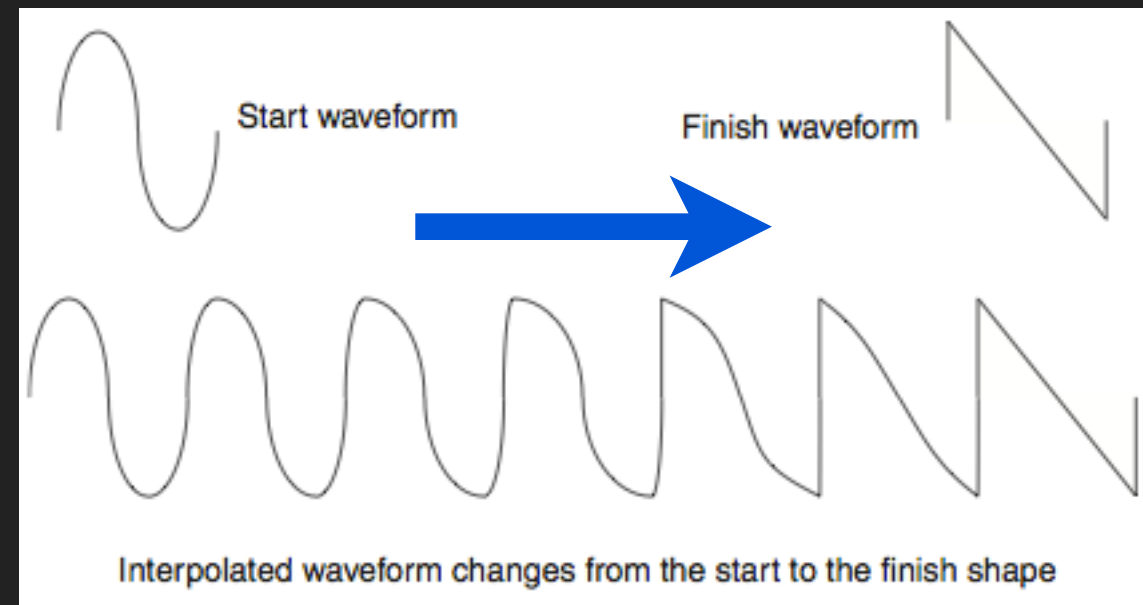


SUMMARY—KEY ES1 CONTROLS



(MULTI-CYCLE OR DYNAMIC) WAVETABLE SYNTHESIS

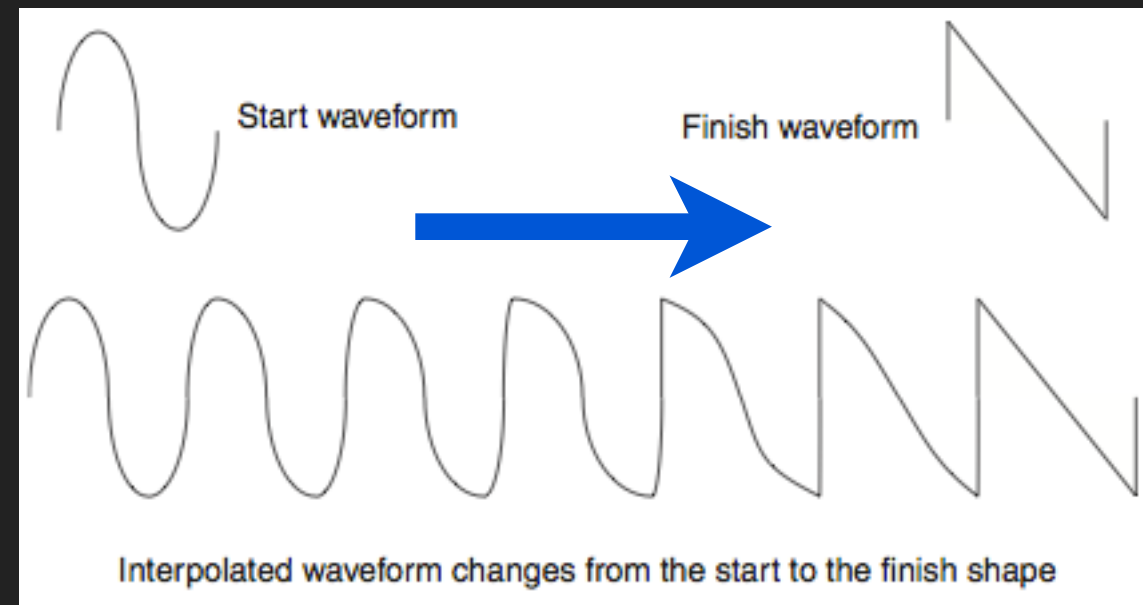
- ▶ Wavetable synthesis - a musical sound is generated through 'scrolling' (reading) through a 'table' of different soundwave shapes (think of them as like film/video frames), resulting in a sound whose timbre evolves as the wave shapes change
- ▶ *This is because (as mentioned previously) different wave shapes create different harmonic patterns (spectra)*



- ✦ This technique was pioneered in the PPG Wave synthesiser (1982), which combined dynamic digital wavetables with analogue filters (for a so-called hybrid approach)

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WAVETABLE SYNTHESIS: PPG WAVE 2.2 (1982) DEMO

<http://www.youtube.com/watch?v=zu0EsapgHfA>



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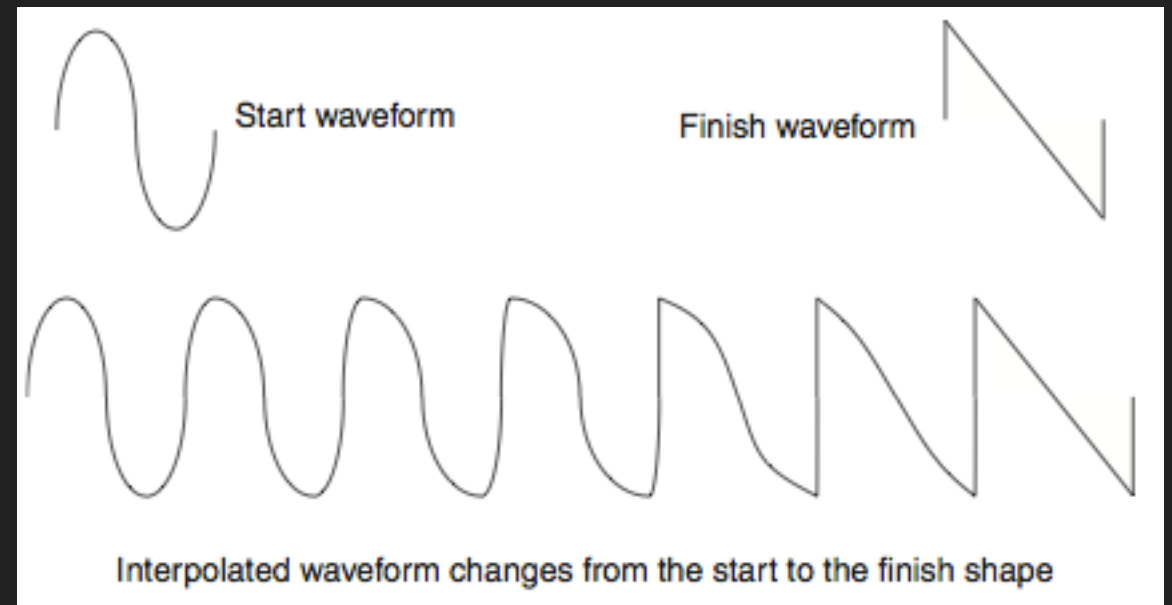


LOGIC'S RETROSYNTH WAVETABLE COMPONENT



RETROSYNTH WAVETABLE: SUMMARY

- ▶ Source-Filter (oscillator plus filter, with envelope shaping)
- ▶ But...oscillator is complex, morphing wavetable oscillator
- ▶ Therefore, two levels of shaping to the sound



MUS112 DESKTOP AUDIO PRODUCTION 2

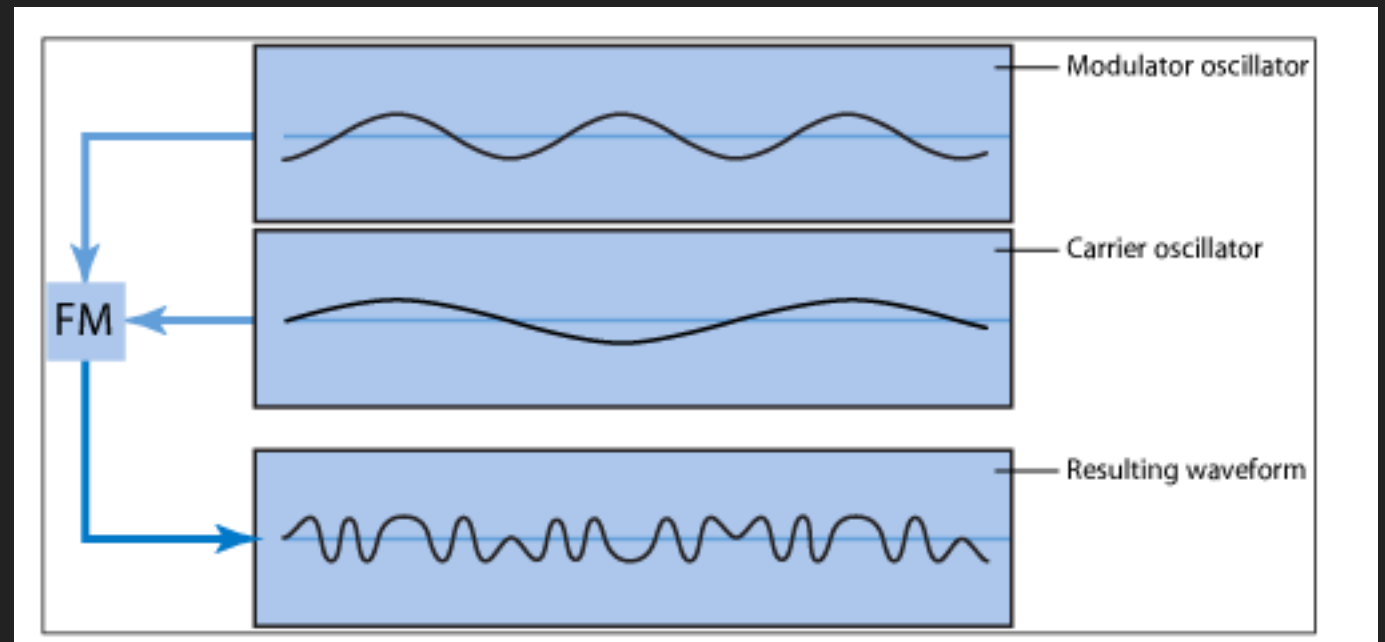
FM SYNTHESIS

MODULATION SYNTHESIS: EFM1

- ▶ Logic's EFM1 synthesiser is an example of modulation synthesis: it uses frequency modulation to generate its sounds (hence 'FM' in the name)
- ▶ We also find this method in the FM pane of Retrosynth
- ▶ In frequency modulation synthesis - one sound generator imposes its vibration on another one (in a similar manner to vibrato in an acoustic instrument) at a high frequency, causing the resulting vibration to become more complex (original sound wave is 'bent out of shape'), resulting in a richer sound (shape of sound wave dictates frequency content)
- ▶ This general synthesis method was popularised by Yamaha's bestselling DX7 (1983), as used on an extended basis by Brian Eno (e.g. Eno, 1992, *The Shutov Assembly* <http://www.youtube.com/watch?v=mcC-Epy-kBo>)

FM AND EFM1

- ▶ FM effectively 'bends' the wave out of shape=> a **modulator oscillator** bends the output of a **carrier oscillator**
- ▶ This changes the resulting harmonic pattern/frequency spectrum (and, hence, timbre)
- ▶ Thus, FM adds new components to a simple sound, rather than taking away components from a complex sound



EFM1 COMPONENTS



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CONTROLLED BY ENVELOPE

EFM1 COMPONENTS



EFM1 COMPONENTS



EFM1 COMPONENTS



EFM1 COMPONENTS

“FM is a bit like...

...SUBTRACTIVE SYNTHESIS...”



...IN THAT INCREASING FM DEPTH ADDS
EXTRA HARMONIC CONTENT (LIKE
'OPENING' A FILTER)

EFM1 COMPONENTS

“FM is a bit like...

...SUBTRACTIVE SYNTHESIS...”



EFM1 BASIC STRUCTURE (I)

- ✦ Carrier (source note)
- ✦ Harmonic (modulation frequency - rate) - **where to add harmonics**
- ✦ FM (modulation amplitude/ depth) - effect a little similar to low-pass filter - **higher settings add more harmonics, spread them out**



EFM1 BASIC STRUCTURE (II)

- ✦ Modulator wave - change modulator waveshape - **more harmonics in this wave produce more complex FM results - lots more harmonics in output**
- ✦ Sub oscillator
- ✦ Modulation envelope/depth (automate amplitude of modulating oscillator - like automated big FM knob)

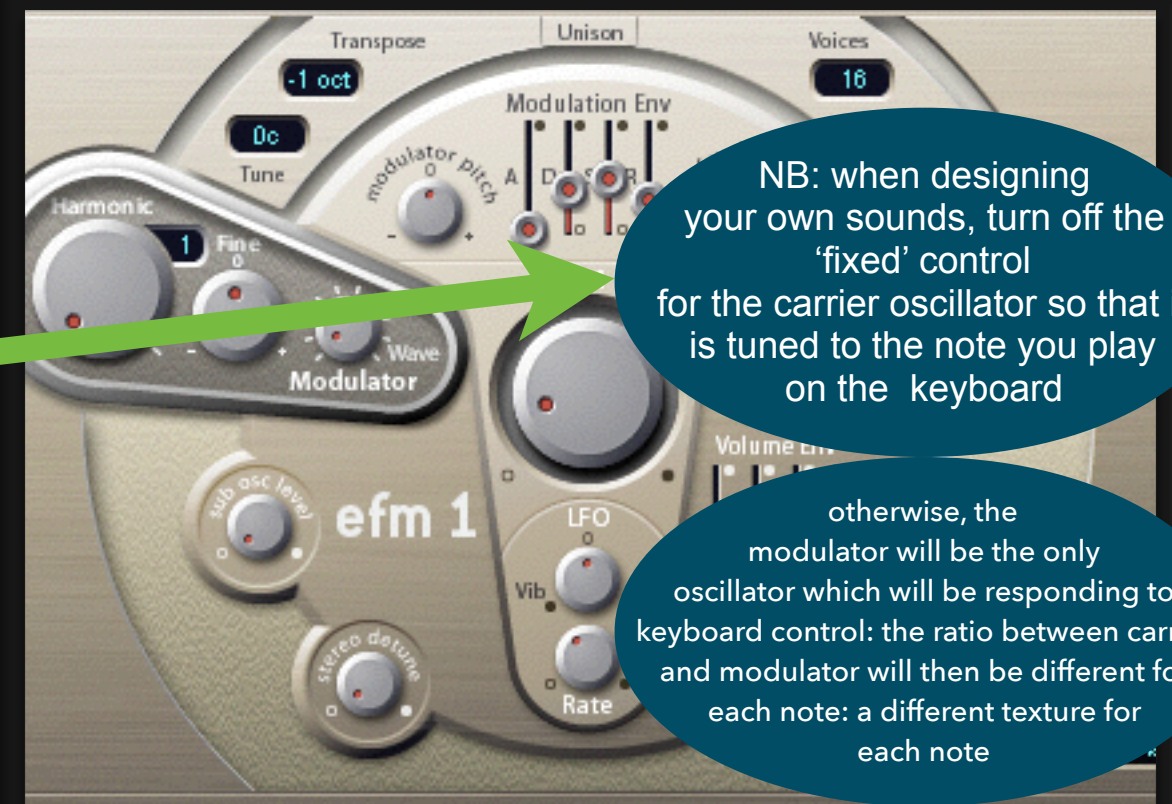


EFM1 – RULES OF THUMB FOR MAKING SOUNDS – MODULATOR

- ✦ Modulator - different ratios between carrier and modulator makes different types of sound
- ✦ Carrier 1, Modulator 2 - like square wave
- ✦ Carrer 1, Modulator 1 - like sawtooth wave
- ✦ *NB: remember to switch off 'fixed' control on carrier (see right)*
- ✦ Other than this, even tuning ratios tend to sound more 'harmonic'/'musical', odd (higher numbers) tend to sound harsher/more metallic
- ✦ High modulator, low carrier - 'broader' harmonic spectrum (low to high)
- ✦ High carrier, low modulator - 'narrower' harmonic spectrum (high only), high peak determined by carrier

note - the comparative unpredictability of FM results is what makes it fun!

EXPERIMENT!



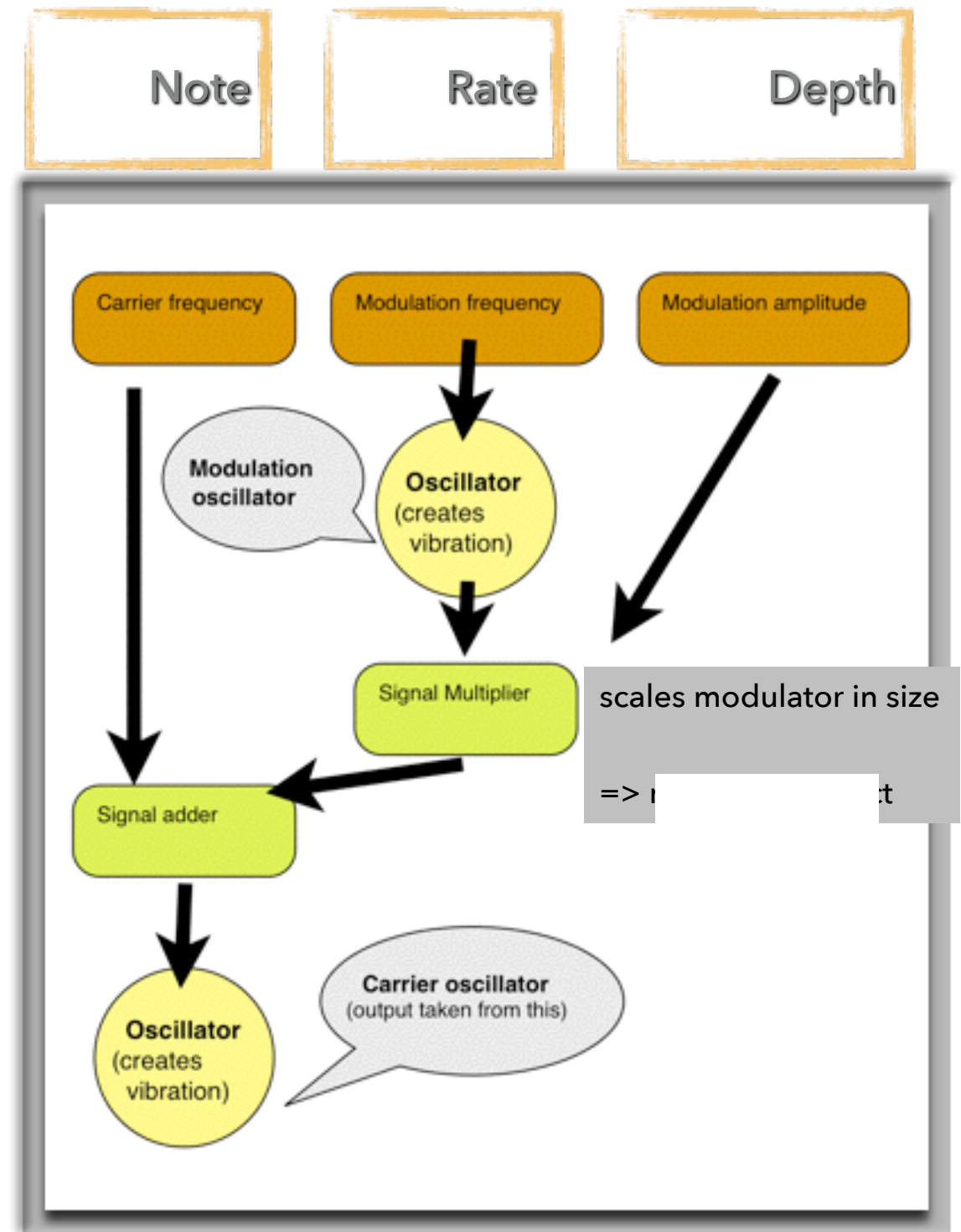
EFM1 – RULES OF THUMB FOR MAKING SOUNDS – MODULATOR

- ✦ Experiment with different settings whilst looking at analyser on EQ
- ✦ Fix carrier or modulator frequency (harmonic) and experiment with opposite control
- ✦ For bell-like sounds which change texture with every key, select 'fixed carrier'

note - experimenting by ear and looking at the result on the EQ is the best way to get a sense for what's going on with this type of synthesis



- EFM1
- Simple approach to FM
- FM - two oscillators
- Think of it as vibrato
- When vibrato gets fast enough, timbre (sound texture) is changed



FM IN RETROSYNTH



- ▶ The FM implementation in Retrosynth provides an easy access point to a rich array of sounds.
- ▶ FM: modulation amount
- ▶ Harmonic: tuning of modulator by harmonic number ('plays' up and down the harmonic series)
- ▶ Inharmonic: tuning of modulator by fractions of harmonic number (i.e. make more inharmonic)
- ▶ Shape: morph wave shape from sine (simple FM effect) to square (more complex, richer sounds)
- ▶ Mix: change audible proportions of modulator or carrier signal
- ▶ Has the benefit of a filter (something EFM1 and the original DX synths lackeded)!

FURTHER READING

d'Esquivan, J. 2012. *Cambridge Introduction to Music Technology*. Cambridge: Cambridge UP. [in library as e-book - log in via portal to view/download temporary copy]

<http://www.soundonsound.com/techniques/totally-retro>

<https://9to5mac.com/2015/07/05/logic-pros-how-to-retro-synth/>

For an overview of all of Logic's synths: <http://logicstudiotraining.com/members/synth-cheat-sheet/>

FURTHER READING AND LISTENING

- ▶ d'Esquivan (2012, chapter 3) provides a readable (and very short!) contextualisation along with ideas about how to think of (and engage with) the different synthesiser models (including more advanced physical modelling types such as Logic's *Sculpture* synth; we may look at this at a later point)
- ▶ (*ibid.*, pp.77-8) gives a useful run-down of key synthesis types and their potential applications...you don't need to be familiar with all of them, but it would be useful to have a quick read so that you know how to engage with them if you continue with this! Note that we will discuss digital sampling and recording later
- ▶ <http://www.musicradar.com/news/tech/10-synths-that-defined-the-80s-213447>
- ▶ <http://www.thevinylfactory.com/vinyl-factory-releases/the-14-synthesizers-that-shaped-modern-music/>
- ▶ For further listening, check out this Youtube library of vintage synthesis techniques (and how they're used in various vintage, mostly 80s tracks)! <https://www.youtube.com/user/retrosound72/videos>

EXAMPLES ON RECORDINGS (BY SYNTHESIS TYPE)

- ▶ FM (in the shape of Yamaha's DX7)
- ▶ http://bobbyblues.recup.ch/yamaha_dx7/dx7_examples.html
- ▶ Wavetable (in the shape of the PPG Wave)
- ▶ <https://www.gearslutz.com/board/electronic-music-instruments-electronic-music-production/881206-official-ppg-waveterm-thread.html>
- ▶ **Physical modelling:** many contemporary recordings with Rhodes Piano/other electric piano sounds! And Clavinets!