

MTE 1001

Fundamentals of Sound Synthesis

Topic Area:

Unit Generators

Readings:

(Previously, Chapt. 1, pp. 32-41)

New:
Chapt. 3, pp. 90-98

Review

Max Mathews
Bell Labs

Music III (1960) introduces the concept of
Unit Generators

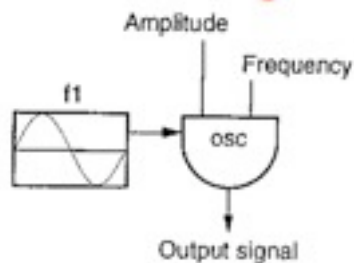


Oscillators

Our Most Important Algorithm:

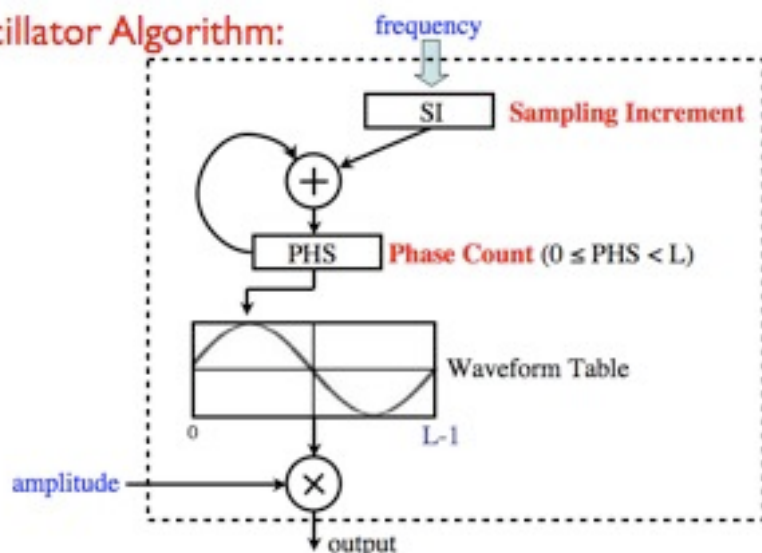
algorithm - "a process or set of rules to be followed
in calculations or other problem-solving operations"

The Oscillator Algorithm



Oscillators

Oscillator Algorithm:

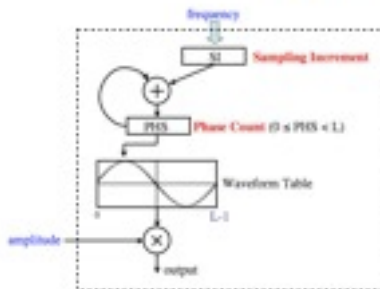


Oscillators

Computing the Sampling Increment

$$\text{If } SI = 1.0, \text{ then } \text{FundFreq} = \frac{SR}{L}$$

$$\text{For example, } \text{FundFreq} = \frac{44100}{1024} = 43 \text{ Hz}$$



Oscillators

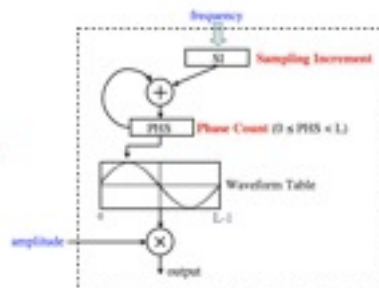
Computing the Sampling Increment

To create a specific target frequency:

$$SI = \frac{\text{target freq}}{\text{Fund Freq}} \quad \text{For example, } SI = \frac{440}{43} = 10.23$$

Or,

$$SI = \frac{L * \text{targetFreq}}{SR}$$



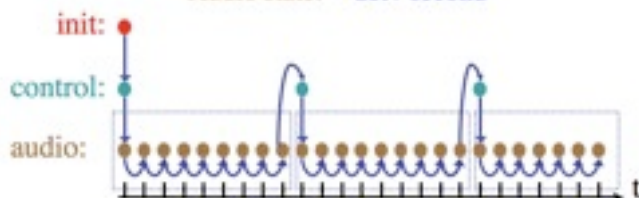
Oscillators

Internal Order of Digital Audio Software

Initialization: once

Control rate: every n samples

Audio Rate: SR / second

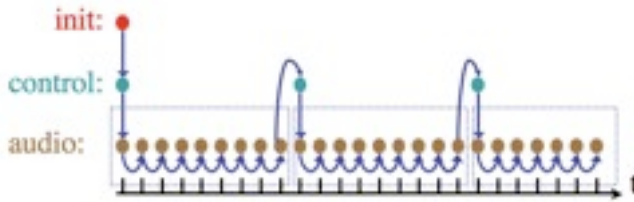


Audio rate operations are typically performed in blocks.

Oscillators

Internal Order of Digital Audio Software

Control Rates:
 Max/Msp: 1000 Hz
 SuperCollider: 689 Hz



Audio rate operations are typically performed in blocks.

Oscillators

Internal Order of Digital Audio Software

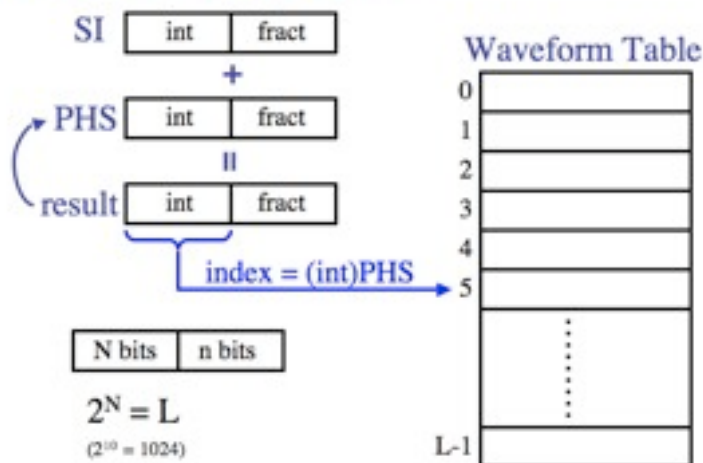
Oscillator Algorithm Order

Initialization: $SI = \frac{L * frequency}{SR}$
 PHS = 0 or other initial value

Sample Rate: $PHS = (PHS + SI) \% L$
 $IPHS = \text{int}(PHS)$
 $OUT = \text{WAVE}(IPHS)$
 ...
 etc.

Oscillators

Sampling Increment Detail:



Oscillators

Sampling Increment Detail:

N bits	n bits
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n determines the frequency accuracy

n	Δf	
0	43.066	
4	2.692	
8	0.168	
12	0.0105	SR = 44100
16	0.000657	L = 1024

How much accuracy is enough?

Oscillators

Signal-to-Noise Ratio:

Depends on L & method

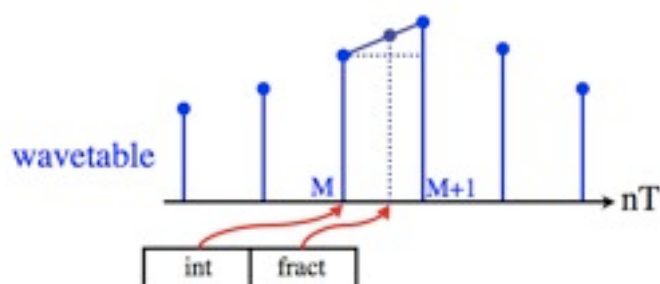
L	oscillator	interpolated
256	36 dB	84 dB
512	42	96
1024	48	108
2048	54	120

Trade-off

How much fidelity is enough?

Oscillators

Interpolating Oscillator

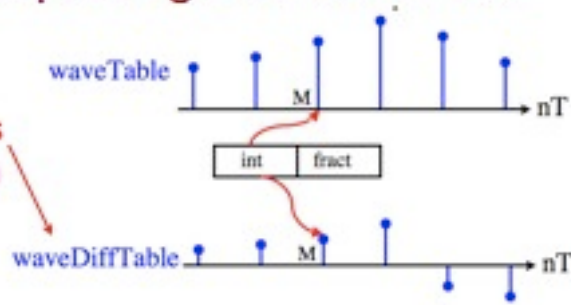


$$\text{output} = \text{wavetable}(M) + \text{fract} * (\text{wavetable}(M+1) - \text{wavetable}(M))$$

Oscillators

Interpolating Oscillator Trick!

A table of differences is computed in advance!



$$\text{output} = \text{waveTable}(M) + \text{fract} * \text{waveDiffTable}(M)$$

The amount of arithmetic is greatly reduced!

Oscillators

What have we learned?

Algorithm
Sampling Increment
Control Rate

For best fidelity:

Highly Accurate Sampling Increment
Table Size of 512 or higher
Interpolating Oscillator
Reduced computation trick

**Next Topic:
More on Unit Generators**