Oscillator Algorithm

- SI: Sampling Increment (determines frequency)
- PHS: Phase Count (0 ≤ PHS < L)
- Waveform Table
- Output
Sampling Increment

If SI = 1.0:

\[ \text{freqF} = \frac{\text{SR}}{L} \]

exp.: 43 Hz = 44100 / 1024

To create a specific target frequency:

\[ \text{SI} = \frac{\text{freqT}}{\text{freqF}} \]

exp.: 10.23 = 440.0 / 43

Or:

\[ \text{SI} = \frac{L \times \text{freq.}}{\text{SR}} \]

Oscillator Stages

Initialization:

\[ \text{SI} = \frac{L \times \text{frequency}}{\text{SR}} \]

PHS = 0 or other initial value

Sample Rate:

PHS = (PHS + SI)%L

IPHS = int(PHS)

OUT = WAVE(IPHS)

etc.
General Stages

Initialization: once

Control rate: every n samples

Sample Rate: SR / second

Program Flow
Oscillator Detail

\[
\begin{array}{c|c|c}
\text{SI} & \text{int} & \text{fract} \\
+ & & \\
\text{PHS} & \text{int} & \text{fract} \\
\downarrow & & \\
\text{result} & \text{int} & \text{fract} \\
\end{array}
\]

\[\text{index} = (\text{int})\text{PHS}\]

\[\begin{array}{c|c|c|c|c|c|c|c}
\text{Waveform Table} & \hline
0 & 1 & 2 & 3 & 4 & 5 & \ldots & L-1 \\
\end{array}\]

\[2^N = L\]
\[(2^{10} = 1024)\]

\[n\] determines the frequency accuracy

\[\begin{array}{c|c}
n & \Delta f \\
0 & 43.066 \\
4 & 2.692 \\
8 & 0.168 \\
12 & 0.0105 \\
16 & 0.000657 \\
\end{array}\]

How much accuracy is necessary?
**Signal to Noise**

Depends on L & method

<table>
<thead>
<tr>
<th>L</th>
<th>oscillator</th>
<th>interpolated</th>
</tr>
</thead>
<tbody>
<tr>
<td>256</td>
<td>36 dB</td>
<td>84 dB</td>
</tr>
<tr>
<td>512</td>
<td>42</td>
<td>96</td>
</tr>
<tr>
<td>1024</td>
<td>48</td>
<td>108</td>
</tr>
<tr>
<td>2048</td>
<td>54</td>
<td>120</td>
</tr>
</tbody>
</table>

Trade-off

**Interpolating Oscillator**

Output:

\[
\text{output} = \text{wavetable}(M) + \text{fract} \times (\text{wavetable}(M+1) - \text{wavetable}(M))
\]
Envelope Generator

Specification → Env.type → EnvGen → Osc

LevelScale  TimeScale → Frequency → Mul: Amp → signal

Envelope Multiplication

Osc → EnvGen → * → II → result
Env: Changing Amplitude

Type: ADSR

Specification:

- $t_{attack}$
- $t_{decay}$
- $t_{sustain}$
- $t_{release}$

- $0$ peakLevel
- sustainLevel
- sustainLevel
- $0$

Envelope Scaling

- peak amplitude
- duration

- peak amplitude
- duration
**Real Instruments**

- **Effort**
  - **high**
  - **med.**
  - **low**

**Interpolation by Sample**

\[
\text{amp} = \text{amp}(L) + \frac{n}{N} (\text{amp}(L+1) - \text{amp}(L))
\]

Operations count: \( + = \frac{1 \times 1}{1} / 1 \)
Interpolation by Successive Addition

\[ \text{amp}(L) \quad \quad \text{amp}(L+1) \]

initialization: \( \text{amp} = \text{amp}(L) \)

\[ \Delta \text{amp} = \frac{(\text{amp}(L+1)-\text{amp}(L))}{N} \]

loop: \( \text{amp} = \text{amp} + \Delta \text{amp} \) (N times!)

operations count: 1 0 0 0

Interpolation by Successive Multiplication

\[ \text{amp}(L) \quad \quad \text{amp}(L+1) \]

initialization: \( \text{amp} = \text{amp}(L) \)

\[ \Delta \text{amp} = 10 \text{ pow} \left( \log \left( \frac{\text{Amp}(L+1)}{N} \right) - \log \left( \text{Amp}(L) \right) \right) \]

loop: \( \text{amp} = \text{amp} \times \Delta \text{amp} \) (N times!)

operations count: 0 0 1 0
Problems

Changing Amplitude at low Control Rate

Very Audible!

sample interpolation
frame interpolation

Discontinuity!
Discontinuities in Samples

Sample hold for 2 sampling instances!
Audible Click

Discontinuities in Phase/Frequency

Very Audible
SuperCollider

control rate

\[ kr = \frac{44100}{64} = 689 \text{ Hz} \]

block rates?

\[ \frac{44100}{1024} = 43 \text{ Hz} \]
\[ \frac{44100}{512} = 86 \text{ Hz} \]
\[ \frac{44100}{128} = 344 \text{ Hz} \]