Notes on Lookup Tables for Signal Generation

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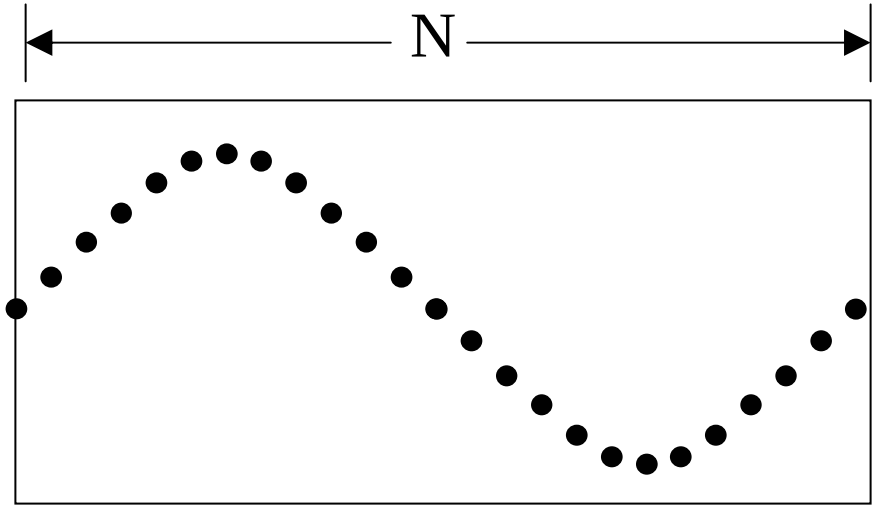
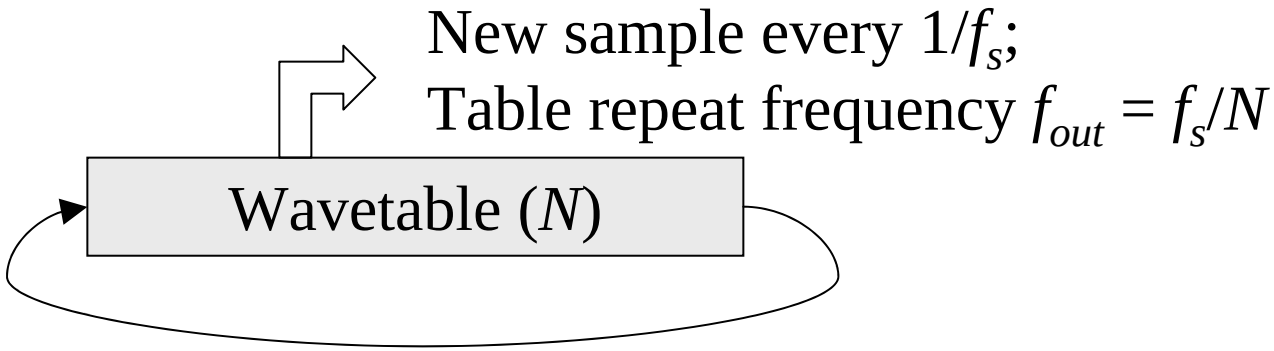
Stored Waveform Lookup

- Start with an array of N uniformly spaced signal samples covering one waveform period



“Wavetable” Frequency Control

- Assume table is length *N*, holds one period of the signal, and the sample rate is f_s samples per second (Hz)
- If every stored value in the table is used, the waveform repetition frequency, f_{out}, is f_s/N



Frequency Control (cont.)

- In order to have a waveform repetition frequency different than f_s/N, you need to *re-sample* the stored data.
- Typically use a *phase counter* or *look-up index* (LUI) to hold the current table location.
- The resampling "hop" through the table is the *sample increment* (SI), defined by:

$$SI = N \cdot \frac{f_{out}}{f_s}$$

Frequency Control (cont.)

- The current lookup index is calculated iteratively

$$LUI[n+1] = \{ LUI[n] + SI \} \text{ modulo } N$$

- LUI increments from zero up through N-1, then rolls over back to zero
- The *integer* part of LUI points to the fetch location in the table; the *fractional* part of LUI can be used for interpolation

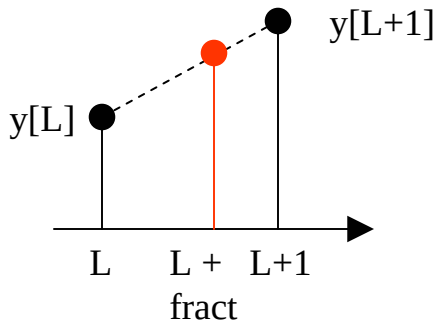
Wavetable Lookup Example

- f_s=48000 Hz, N=1024, desired f_{out}=440 Hz
- SI=1024×440 / 48000 = 9.386667

LUI	Truncated
0.000000	0
9.386667	9
18.773334	18
28.160001	28
37.546668	37
46.933335	46
56.320002	56
. . .	. . .
994.986702	994
1004.373369	1004
1013.760036	1013
1023.146703	1023
8.533370	8
17.920037	17

Linear Interpolation

- LUI fractional part is used to *interpolate* the table.
- Need to handle "end of table" issue: LUI may point to region between last stored sample and the start of the table
- There is *distortion* due to the difference between the "true" value and the linear interpolation



$$y[L + fract] = y[L] + fract \cdot (y[L+1] - y[L])$$

Aliasing due to resampling

- The discrete-time signal represented by the wavetable has a spectrum that may occupy the entire bandwidth from 0 - $f_s/2$
- Re-sampling the waveform to change its period can result in aliasing if the wavetable is not properly bandlimited