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On Minimizing the Look-up Table Size in Quasi Bandlimited Classical Waveform Oscillators

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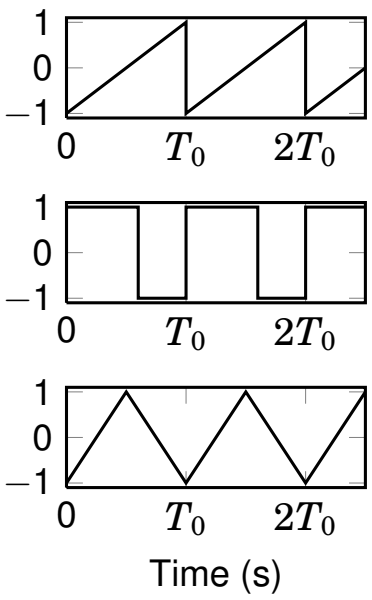
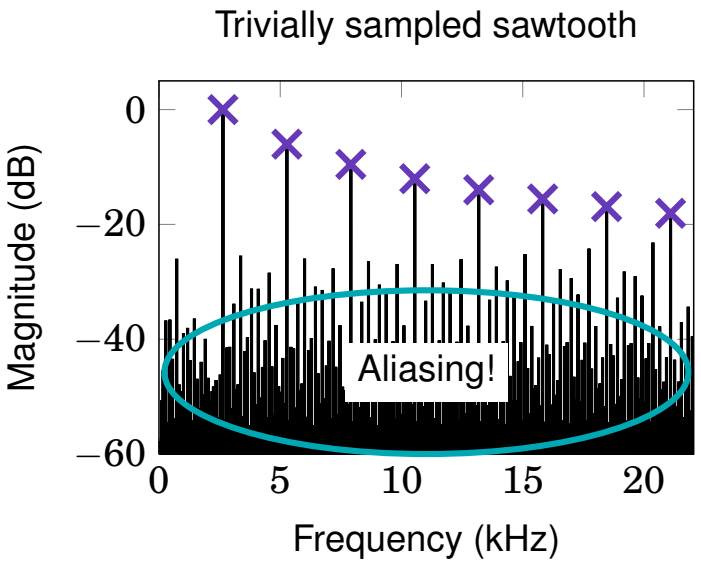
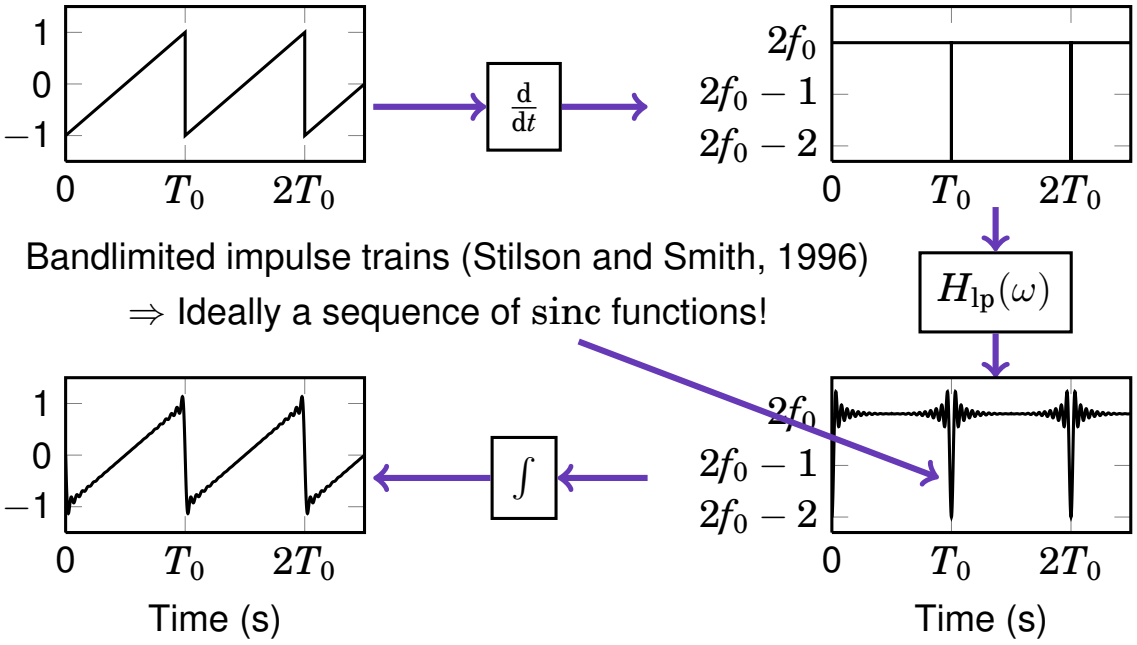
Oscillators in Subtractive Sound Synthesis





Bandlimited Impulse Train (BLIT) Algorithm

Continuous-Time Derivation



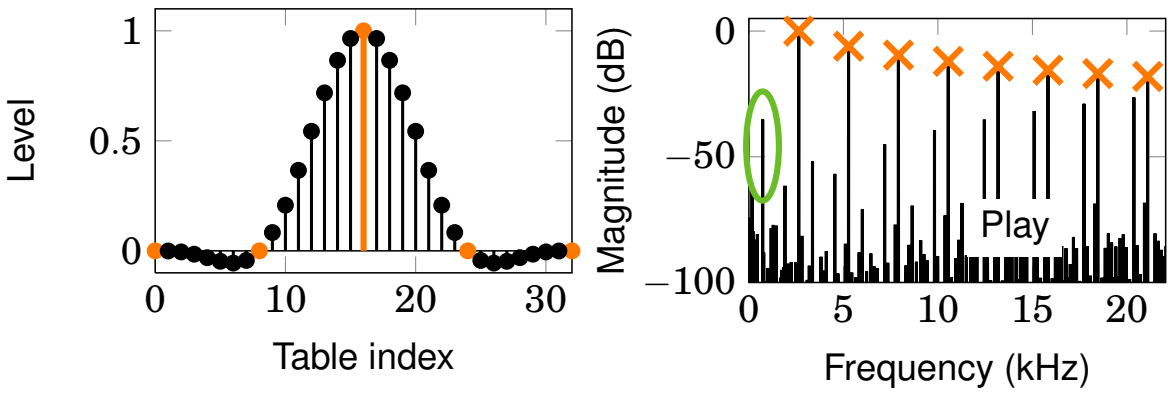
Bandlimited impulse trains (Stilson and Smith, 1996)

$\Rightarrow$ Ideally a sequence of sinc functions!

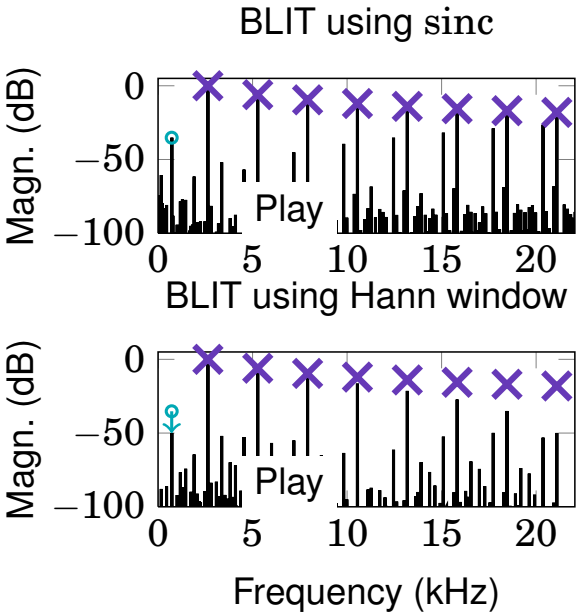
Problems in the BLIT Algorithm

- sinc function infinitely long! $\Rightarrow$ Truncation, windowing & tabulation
- High oversampling required in order to get proper positioning
- For good quality, long tables are required

Short Table Example (Hann-Windowed sinc Function)

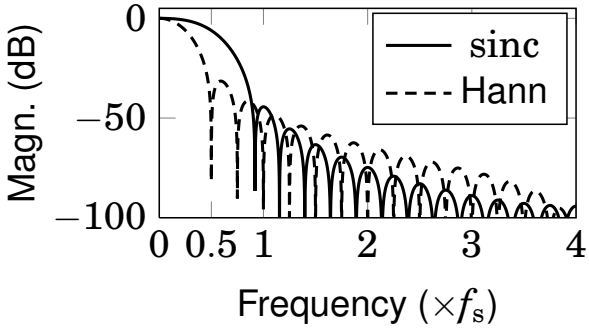


Means to Improve the Performance?



Replace the windowed sinc function with the plain window function?

Optimize: minimize table size while keeping aliasing inaudible and amplitude drop acceptable

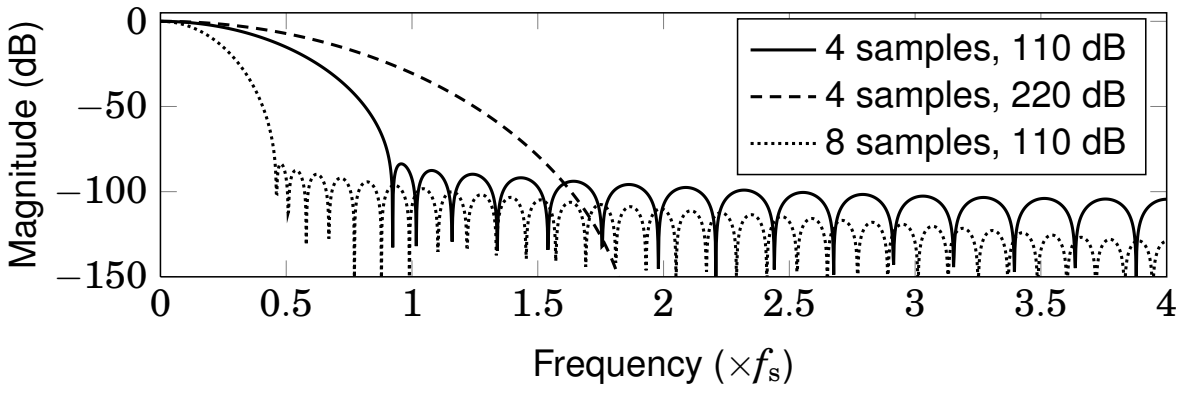


Parametric Window Functions

Approach 1: Kaiser & Dolph-Chebyshev Windows

- Allow control over the minimum stopband attenuation!
- Gain depends on the table parameters
- First-order IIR post-EQ filter to compensate the amplitude drop

Example: Kaiser Window



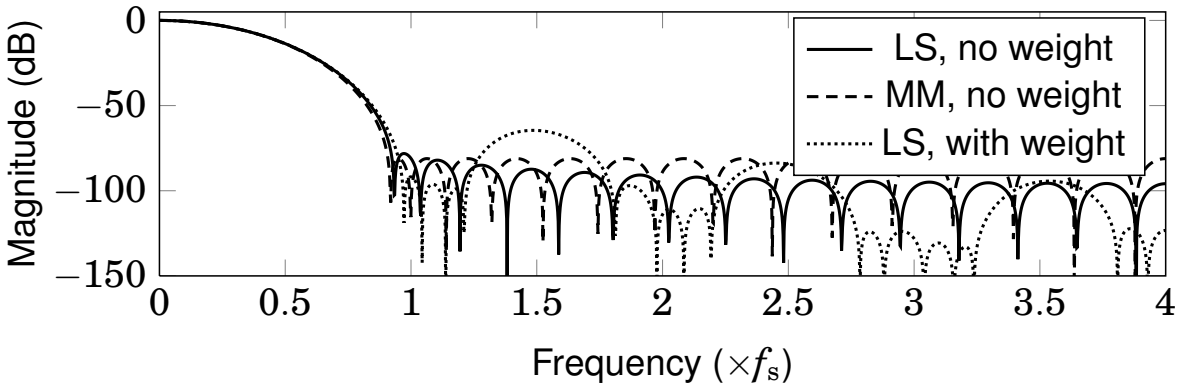
Direct Optimization Strategies

Approach 2: Minimax & Least-Squared Minimized Stopband Gain

Objective Minimize the stopband gain using an error measure
Subject to Passband gain constraints

Design Issues

- Error measure: minimax, least-squares, other?
- Weighted error: how to choose the frequency dependency?



Conclusions

- Aliasing in BLIT algorithm investigated using short look-up tables
- The ideal windowed sinc function **is not the optimal look-up table!**
- Better alias reduction performance with alternative approaches
  - Like fractional delay filters (Nam et al., 2010)

In this paper

1. Parametric window functions
   - Gain depends on parameters
   - Amplitude compensation using post-EQ
2. Direct optimization approaches
   - Minimize a weighted error measure in stopband
   - Independent control over the amplitude drop

Further Pointers

Aside This Paper...

J. Nam, V. Välimäki, J. S. Abel, and J. O. Smith. Efficient antialiasing oscillator algorithms using low-order fractional delay filters. *IEEE Transactions on Audio, Speech, and Language Processing*, 18(4): 773–785, May 2010.

T. S. Stilson and J. O. Smith. Alias-free digital synthesis of classic analog waveforms. In *Proceedings of the International Computer Music Conference*, pages 332–335, Hong Kong, China, August 1996.

Additional Material @ Companion Page

- Look-up tables presented in the paper
- Sound examples

URL: `http://www.acoustics.hut.fi/go/dafx10-optosctables/`