

Antialiasing in BBD Chips using BLEP

Leonardo Gabrielli¹, Stefano D'Angelo², Stefano Squartini¹

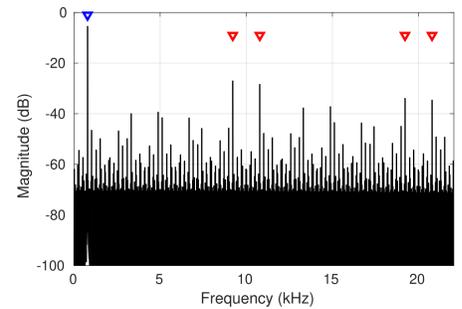
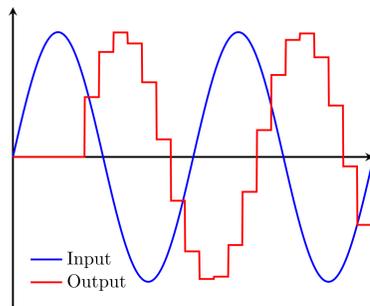
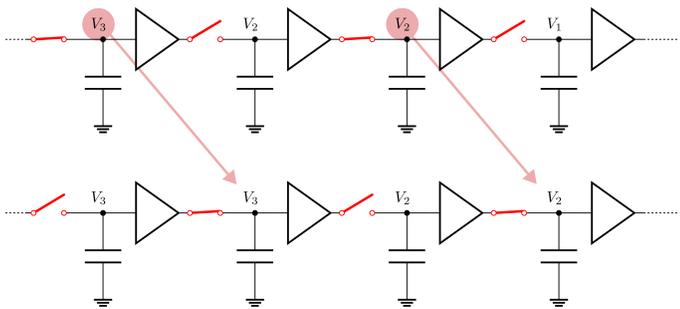
1



2



Background

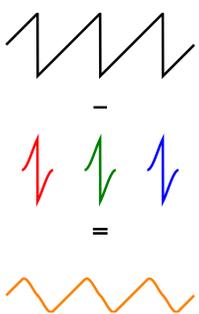


A *Bucket-Brigade Device* (BBD) is an analog delay line implemented as a chain of buffered and alternately switched capacitors.

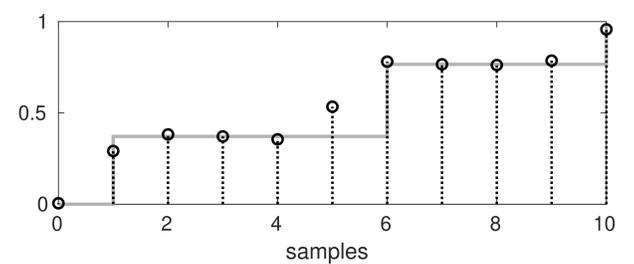
The signal is effectively time-quantized (sampled), thus aliasing is introduced.

Previous digital models [1–4] rely on trivial digital sample-and-hold, thus generating further unwanted aliasing.

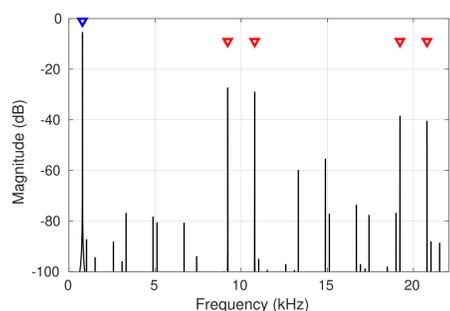
Model



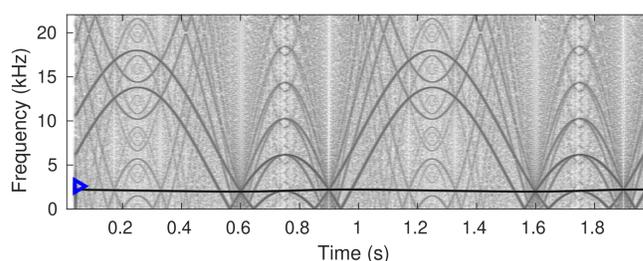
1. When virtual BBD clock triggers, interpolate input then store it into and advance a fixed-length variable-rate delay line.
2. Continuously read the delay line output.
3. Apply BLEP to smooth out the last discontinuities (this needs tracking clock triggering time and scaling).



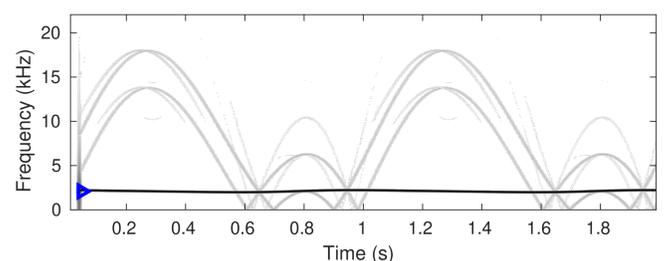
Results



Fixed clock with BLEP



Modulated clock, without (left) and with (right) BLEP



Obtained by using linear interpolation at the input, a 4-samples-long 3rd-order Lagrange PolyBLEP kernel [5], and tracking 7 discontinuities.

Conclusions

- Significant reduction of unwanted aliasing.
- Simple and flexible method allowing for different CPU/quality tradeoffs.
- Choice of BLEP technique has more impact than input interpolation method for aliasing reduction.
- MATLAB/GNU Octave code and audio examples available at <https://www.dangelo.audio/dafx2025-bbd.html>.

References

- [1] A. Huovilainen, "Enhanced digital models for analog modulation effects," in *Proc. DAFX-05*, Madrid, Spain.
- [2] C. Raffel and J. Smith, "Practical Modeling of Bucket-Brigade Device Circuits," in *Proc. DAFX-10*, Graz, Austria.
- [3] J. Mačák, "Simulation of Analog Flanger Effect Using BBD Circuit," in *Proc. DAFX-16*, Brno, Czech Republic.
- [4] M. Holters and J. Parker, "A Combined Model for a Bucket Brigade Device and its Input and Output Filters," in *Proc. DAFX-18*, Aveiro, Portugal.
- [5] V. Välimäki, J. Pekonen, and J. Nam, "Perceptually informed synthesis of bandlimited classical waveforms using integrated polynomial interpolation," *J. of the Acoust. Soc. of America (JASA)*, vol. 131, no. 1, pp. 974–986, 2012.

