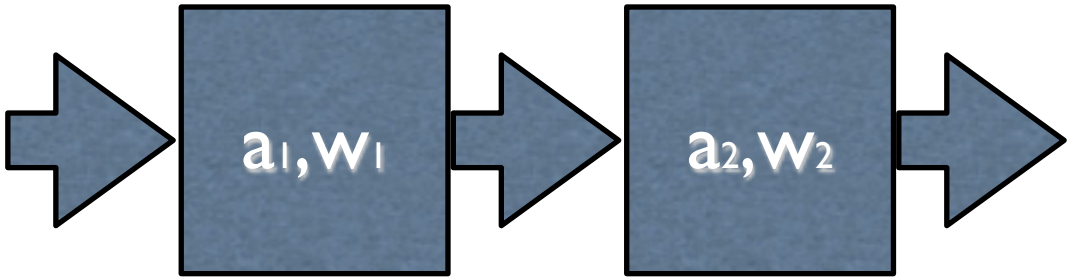
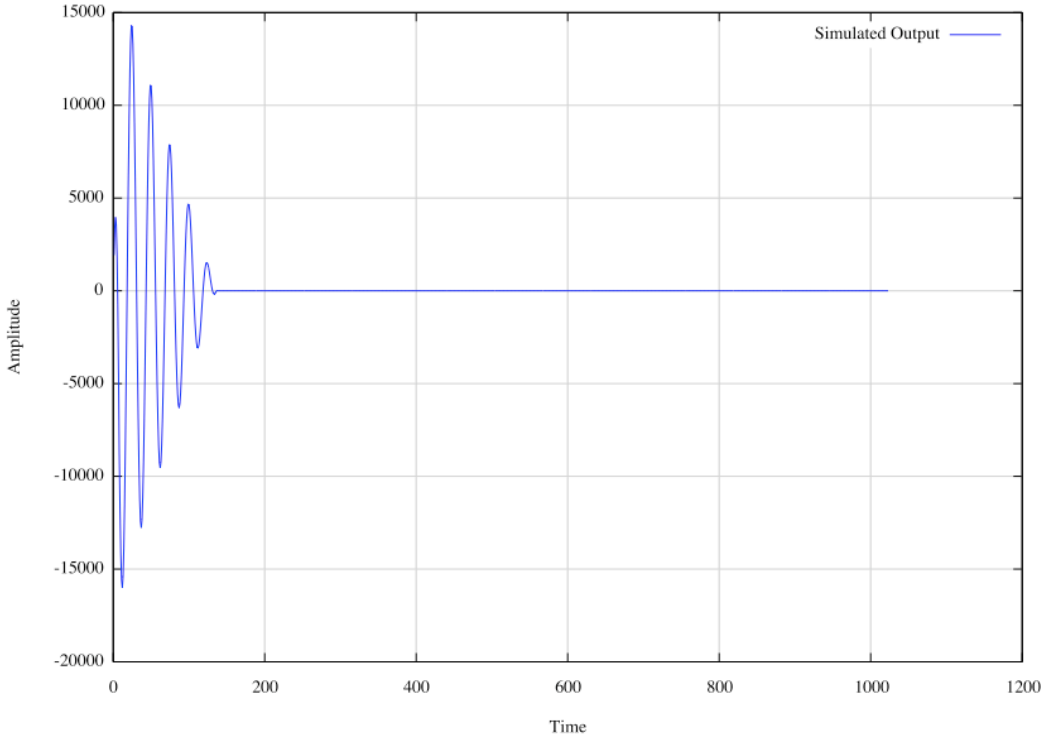
Music Synthesis with SEAforth

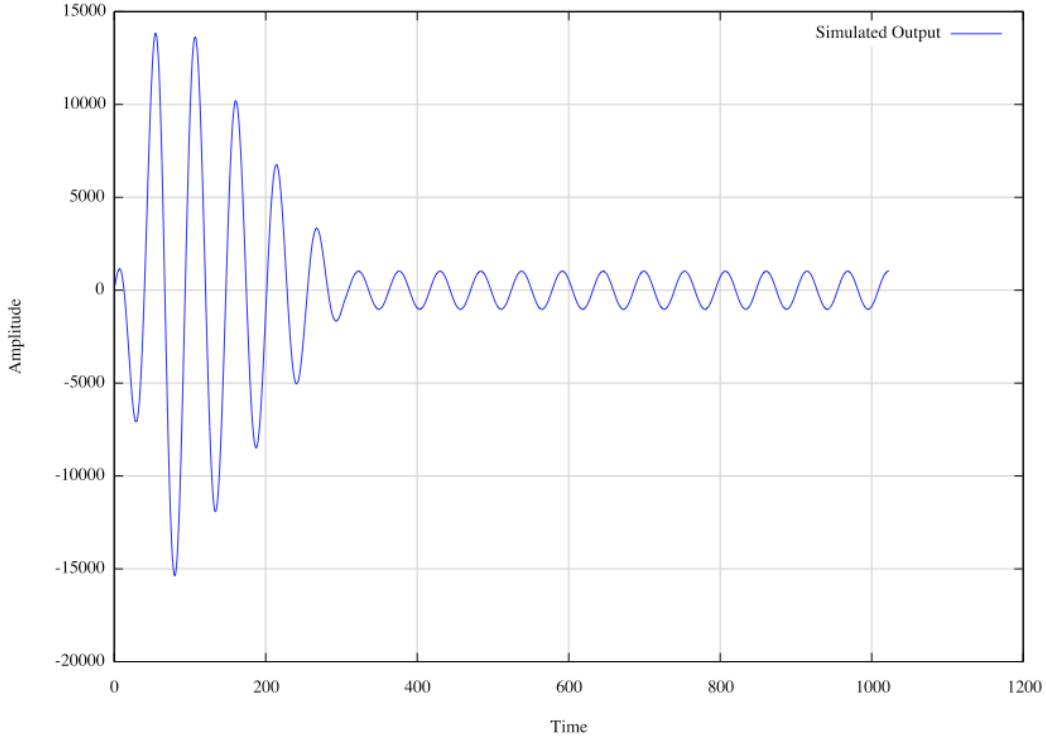
FM synthesis

- John Chowning, 1967
- $A_1 = a_1 \cos(w_1 t)$, $A_2 = a_2 \cos(w_2 t)$
- $A = a_1 \cos((w_1 + a_2 \cos(w_2 t))t)$
- Yamaha DX-7, 1983

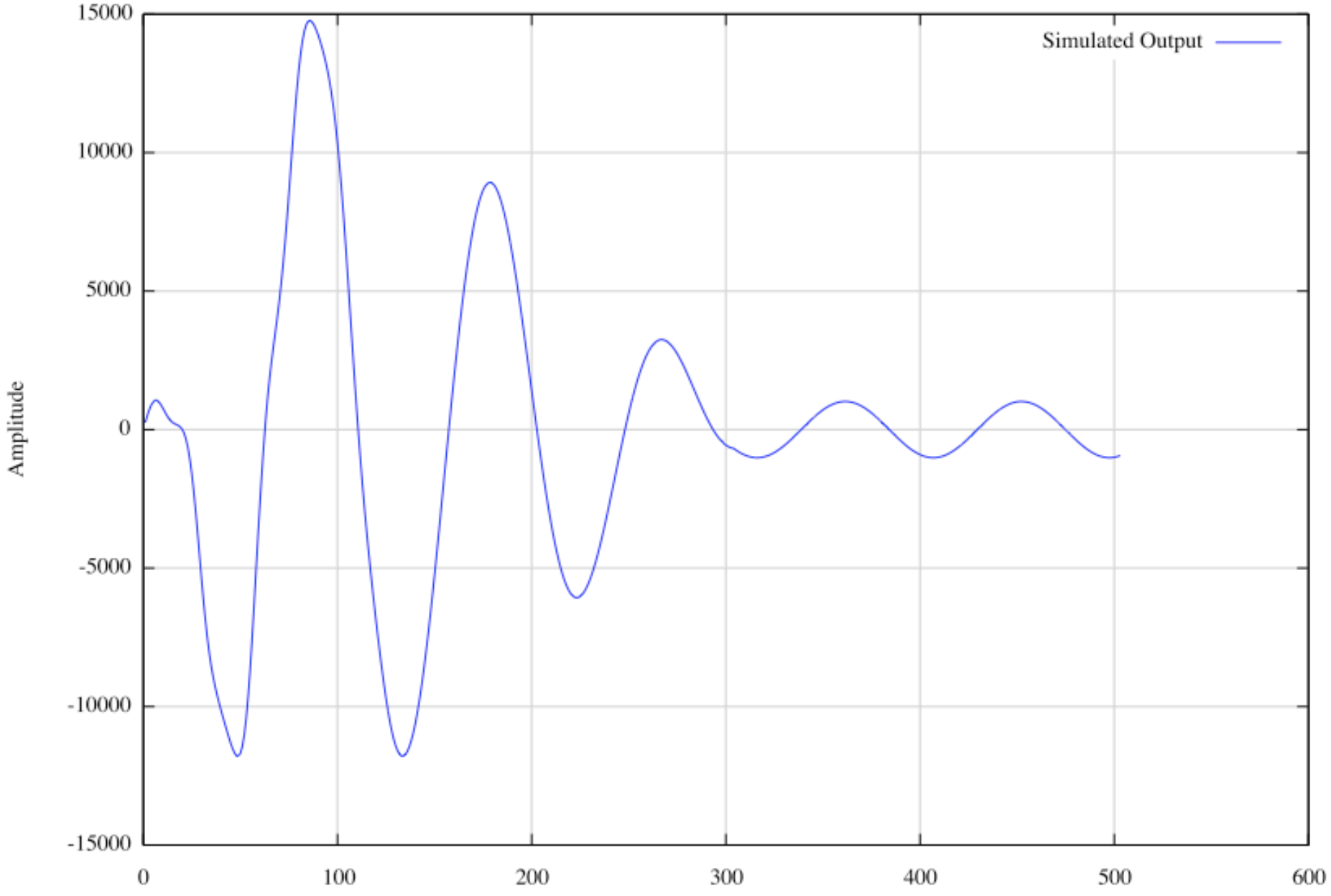
FM synthesis # 2







FM synthesis # 3



The Math behind the Oscillator

$$A = \begin{bmatrix} 1 & -w \\ w & 1 - w^2 \end{bmatrix}$$

$$Det(A) = 1 - w^2 + w^2 = 1$$

$$a' = a - wb$$
$$b' = b + wa'$$

The Code (Oscillator)

```
: op
  pop  a!   @a+  .    +    a@   push dup
  push push @a+     @a+  not  over
  pop  u*           .    +    not
  pop  over push    u*
  .    +    pop     ( 9 words)
```

Code Size

- Multiply hook - 2 words
- Oscillator - 9 words
- Saturator - 11 words
- ADSR Envelope - 11 words

Data Size

- Oscillator's State/Parameters - 6 words
- ADSR envelope segment - 2 words
- The Script ~ 3 words/operator

Hybrid DAC

- 13 bits PWM
- 5 bits PAM
- 18 bits @ 48kHz

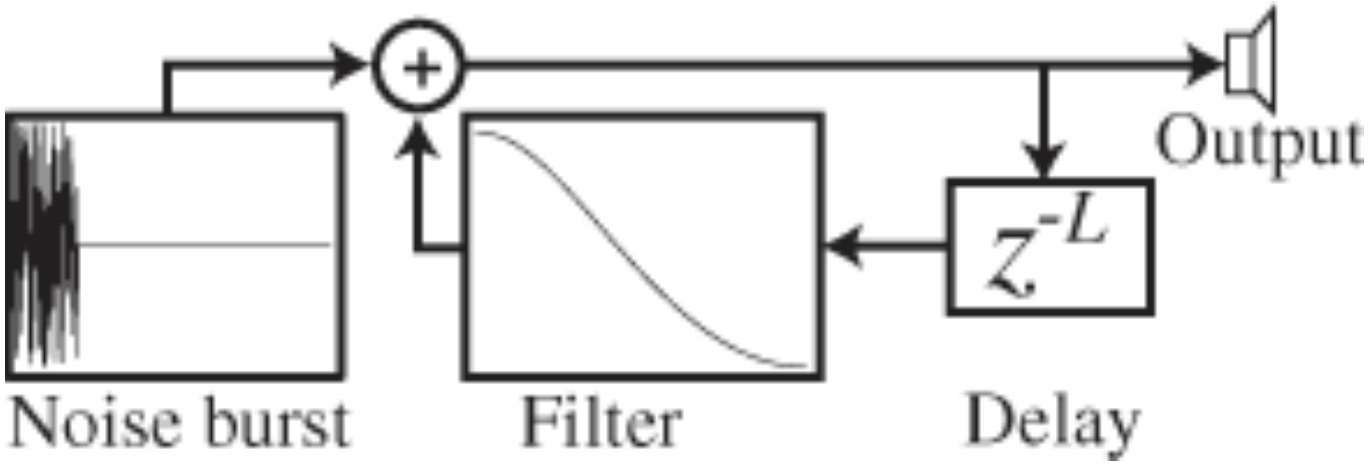
Comparison

- Yamaha DX-7 16x6 = 96 operators
- S24 2x22 = 44 operators
- S24 (spec. ROM) 5x22 = 110 operators

Physical Modeling Synthesis

- Kevin Karplus, Alex Strong, 1983
- Julius O. Smith III, Digital Waveguide Synthesis, 1987
- Yamaha VL-1, 1994

Physical Modeling Synthesis



Pros

- Most realistic sound
- Highly customizable

Con

- Cost ($8000 - $20000)

Wave Guides on SEAforth

- 2 cores per voice
- Up to 10 voices per chip

Demo # 1

- J. S. Bach: Bourree from Lute Suite in E-minor BWV 996

Demo # 2

- Music fractals
- Algorithm MusiNum by Lars Kindermann
- http://reglos.de/musinum/
- Very simple, based on bit counting

Thanks to Peter Sovietov

What questions?
The Music answered them all!