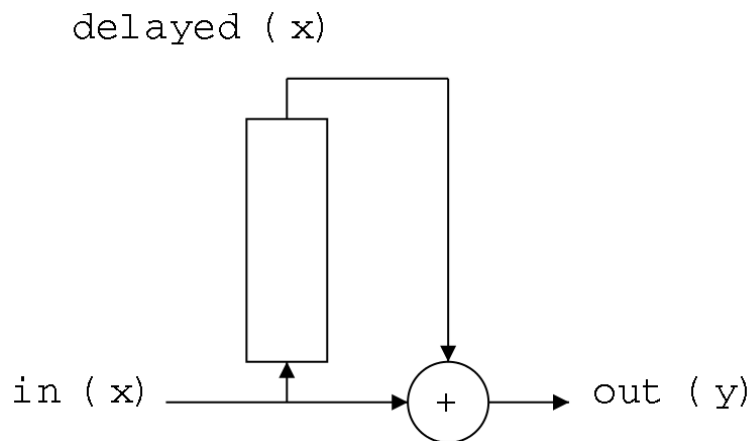


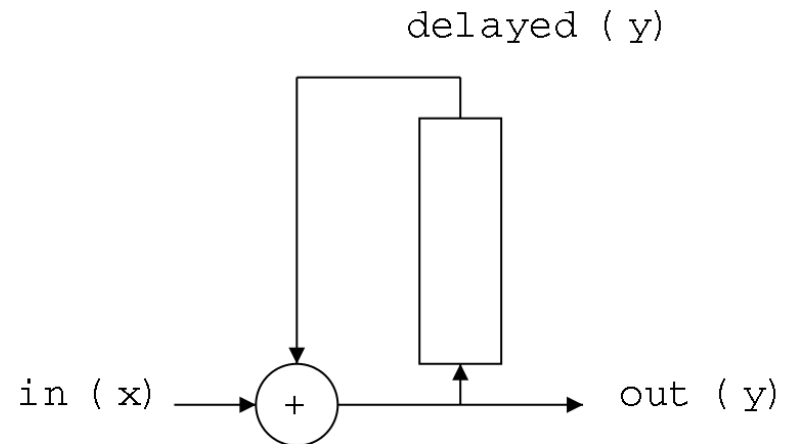
FIR vs. IIR

- one wall
- one-shot delay
- feedforward

- two walls
- recirculating delay
- feedback



$$\text{Out} = \text{in} + \text{delayedIn}$$



$$\text{Out} = \text{in} + \text{delayedOut}$$

...as math

x_n = this input sample
 $x_{(n-N)}$ = Nth previous input

y_n = this output sample
 $y_{(n-N)}$ = Nth previous output

$$y_n = a_0 x_n + a_N x_{(n-N)}$$

$$y_n = a_0 x_n - b_N y_{(n-N)}$$

FIR

IIR

use a pencil

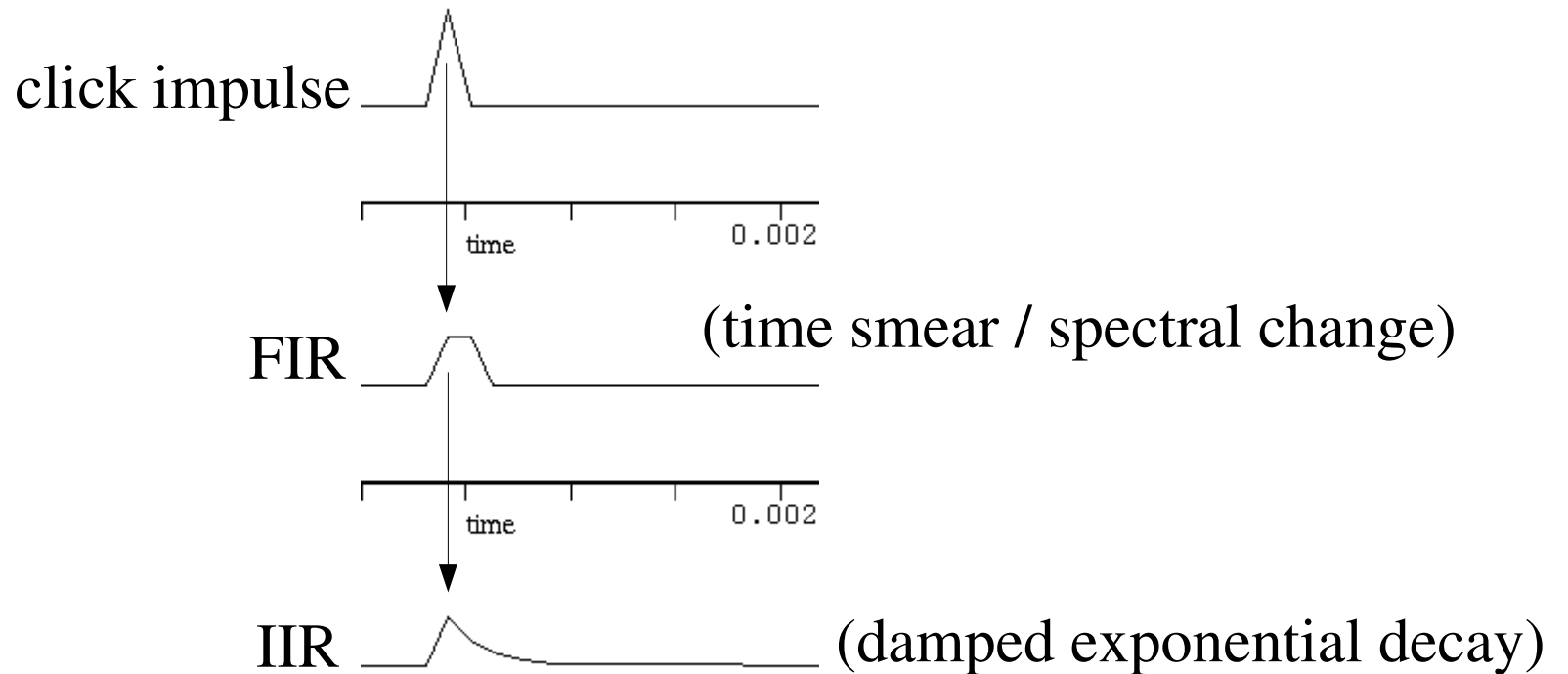
$$x_{0,1,2,3\dots} = \underline{0,1,0,0,0,0,0,\dots}$$

- $a_0 = .5$
- $a_1 = .5$
- $x_0 = 0$
- $y_n = a_0 x_n + a_1 x_{(n-1)}$

- $a_0 = .5$
- $b_1 = -.5$
- $y_0 = 0$
- $y_n = a_0 x_n - b_1 y_{(n-1)}$

write out $y_{1,2,3\dots} = \underline{\dots}$

impulse responses

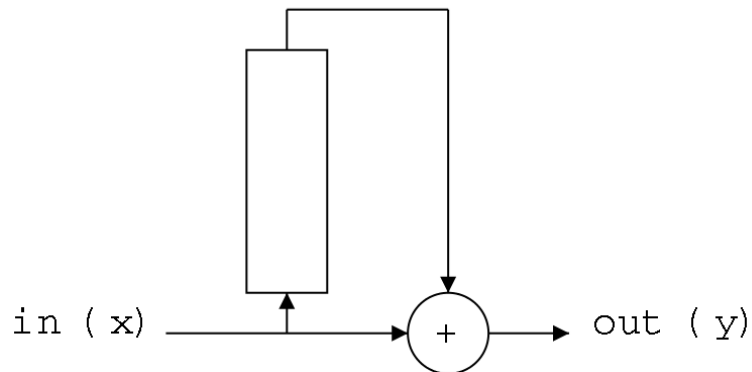


FIR vs. IIR

- one wall
- one-shot delay
- feedforward

test FIR in webchuck

delayed (x)

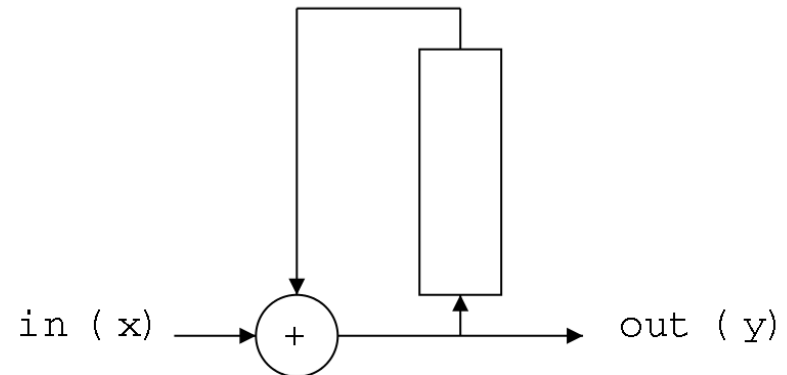


$$Out = in + delayedIn$$

- two walls
- recirculating delay
- feedback

test IIR in webchuck

delayed (y)



$$Out = in + delayedOut$$

- $a_0 = .5$

- $a_1 = .5$

- $x_0 = 0$

- $y_n = a_0 x_n + a_1 x_{(n-1)}$

coeffs

state

system

- $a_0 = .5$

- $b_1 = -.5$

- $y_0 = 0$

- $y_n = a_0 x_n - b_1 y_{(n-1)}$

the all-in-one filter difference equation (as C code)

```
/* This code implements the standard difference equation, (Cook: pg. 26)
y[0] = g * (x[0] + a[1] * x[1]... +a[N] * x[N])
      - b[1] * y[1] - ... -b[M] * y[M]
For simplicity, N = M = "ORDER" */
```

Out = In + delayedIn - delayedOut

[0] = this sample

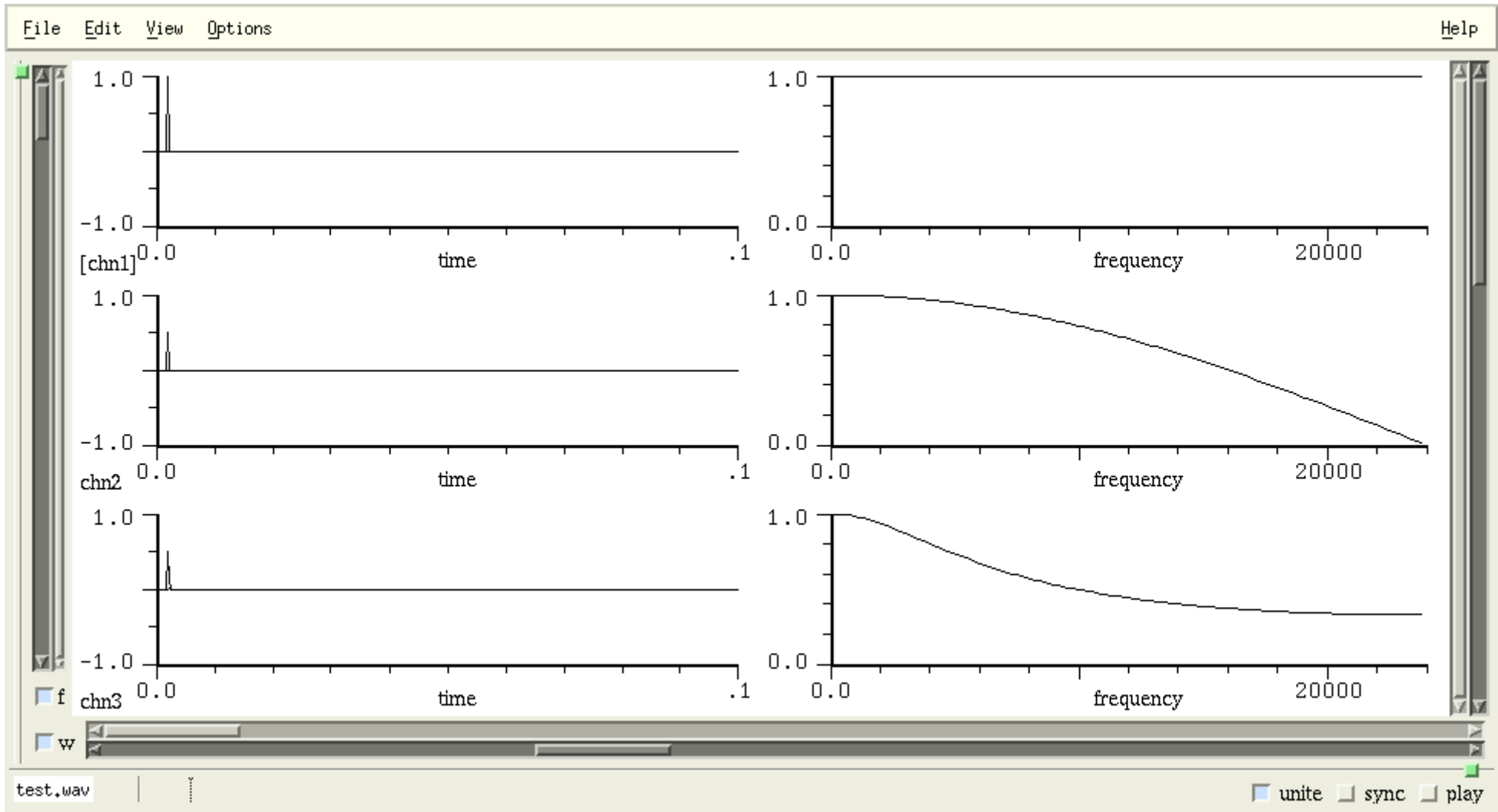
[1] = last sample

.

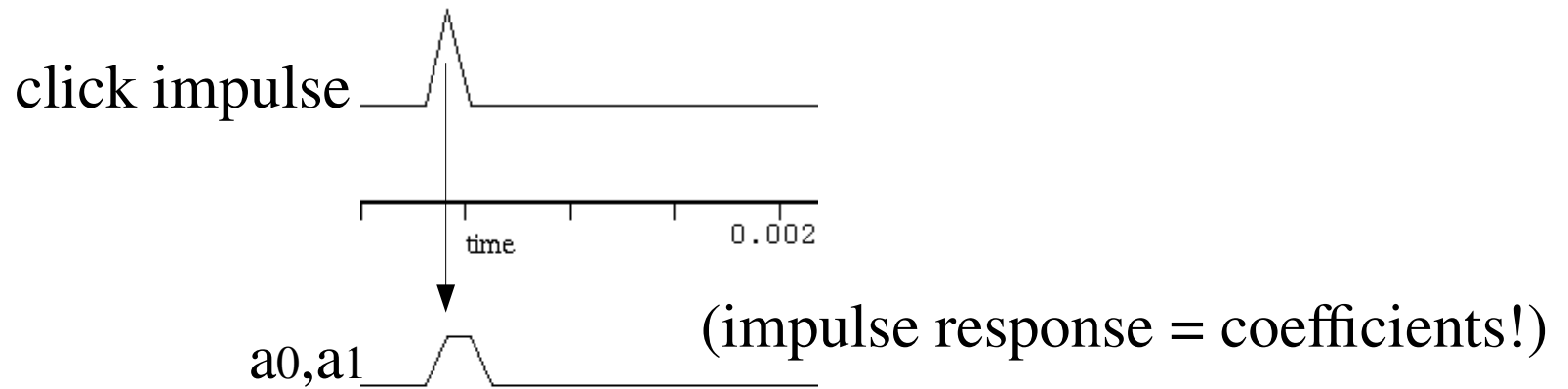
.

.

[N] = Nth delayed sample



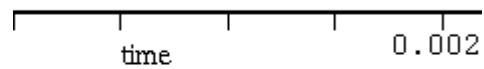
convolution (FIR)



convert any IR to FIR

Low order FIR

a_0, a_1



High order FIR

$a_0, a_1, a_2, a_3, a_4, \dots$



(coefficients made from IR of IIR)

summary

- filters, linear, don't add frequencies (as opposed to modulation or distortion, non-linear)
- filters change duration and spectral weighting
- size from big to little: echo, pitch, eq, image pos.
- Sharpness ('Q') from high to low: string, tube
- it's hard to find simple filters in nature, most are combinations, complexes