

MTE 1001

Fundamentals of Sound Synthesis

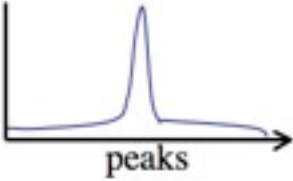
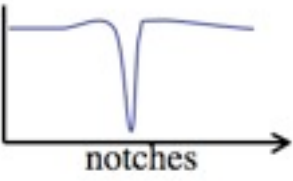
Readings:

Previously: “Digital Filters”, Chapter 10, pp. 406-411
(Readings 10b)

New: None

Review

The Two Types

spectral features	 peaks	 notches
filter type	recursive	non-recursive
acoustic analog	stored energy resonance	cancelled energy anti-resonance

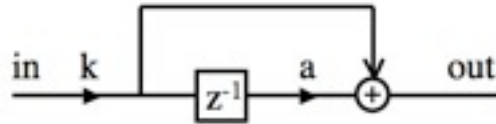
Review

The Two Types

non-recursive

feed forward

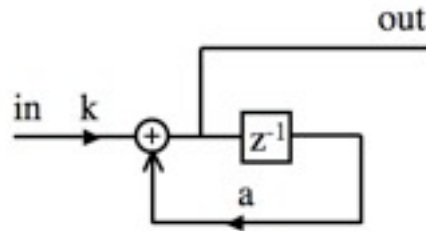
Finite Impulse Response (FIR)



recursive

feed back

Infinite Impulse Response (IIR)

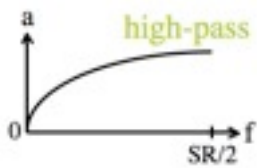


Review

First-order Filters

Non-recursive / FIR

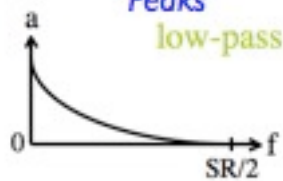
Notches



high-pass

Recursive / IIR

Peaks

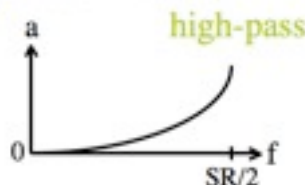


low-pass

FIR and IIR filters have different curvature.



low-pass



high-pass

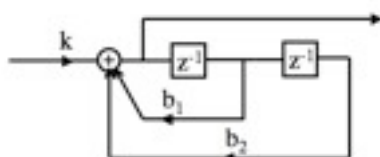
Review

Filter Order

The **'order'** of a filter depends on the number of delays.



First-order non-recursive



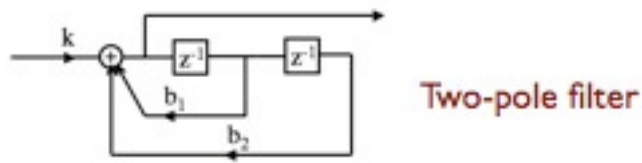
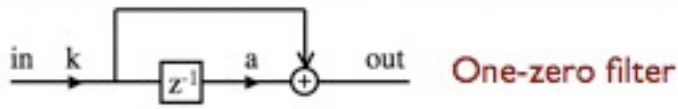
Second-order recursive

The higher the order, the more sharp or complex the amplitude response.

Digital Filters

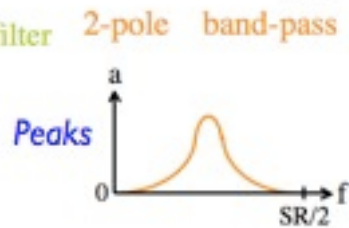
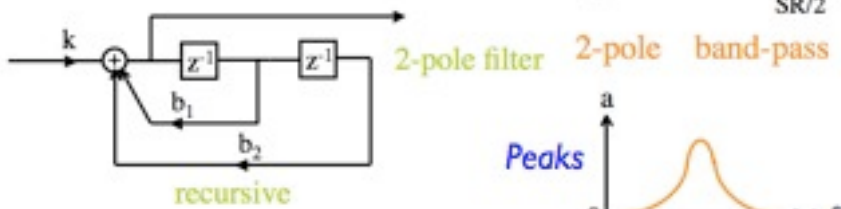
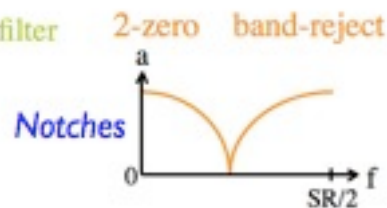
Poles & Zeros

Recursive filters are also classified by relating the number of delays to **'poles'** and non-recursive filters to **'zeros'**.



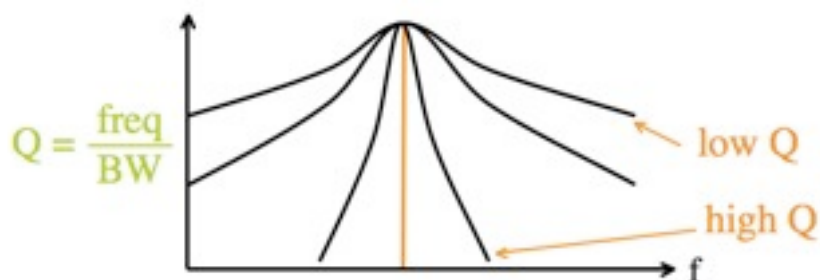
Digital Filters

Second-Order Filters



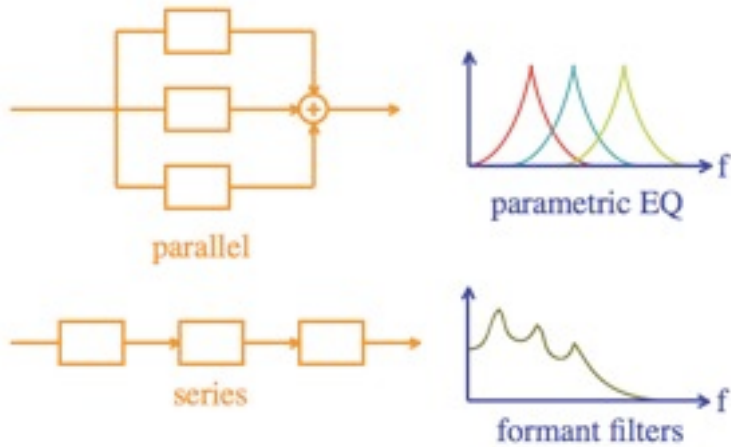
Digital Filters

Filter Q for Recursive Filters



Digital Filters

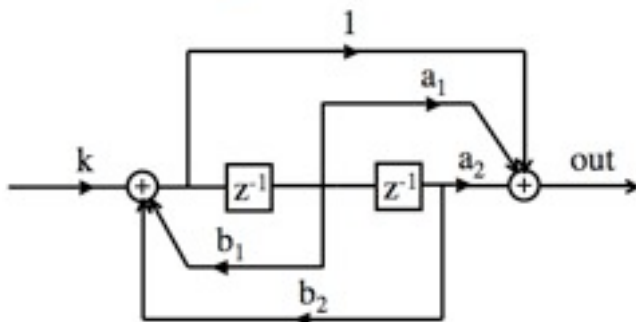
Higher Order Filters are usually made from combinations of 1st and 2nd order sections



Digital Filters

Biquad Filters are a common building block for higher-order filters.

Biquad Filter

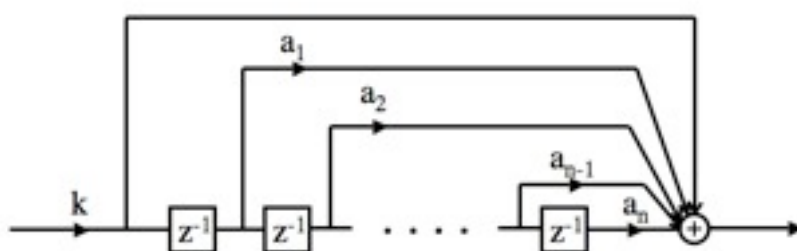


combined IIR/FIR 2nd-order

Digital Filters

High-Order FIR Filters

FIR filters are often extended to high order.



Non-recursive filter of order n !

Digital Filters

Time Domain Aspect of Filters

Transient Response

- The transient response is how the filter behaves in response to changes in the input.
- The *impulse response* is one way of conceptualizing the transient behavior of a filter. This is probably the most important for us.
- The other kind of transient response that is often discussed is the *step response*, that is, how the filter behaves in response to a step function input.

Digital Filters

Transient Response

- For FIR filters, the impulse response is as long as the order of the filter plus 1.
- For IIR filters, the impulse response is infinite and decays exponentially.

one-pole filter
first-order IIR



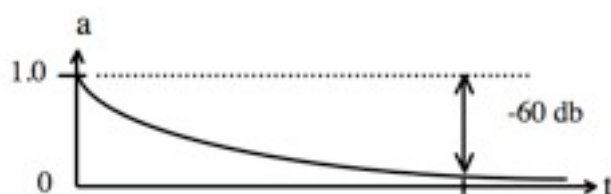
two-pole filter
second-order IIR



Digital Filters

Transient Response

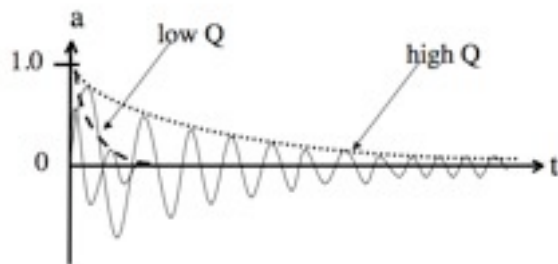
- By convention the *decay time* is defined like reverberation time to be the time required for the signal to decrease amplitude by 60 dB.



Digital Filters

Transient Response of Second-Order Recursive Filter

The decay time of a 2-pole filter increases with Q .



Digital Filters

Physical Analogies

The impulse response of a two-pole filter is analogous to the response of a physical resonator to an impulsive input or the response of a resonating bar to an impulsive strike.



Next Topic:

Poles & Zeros