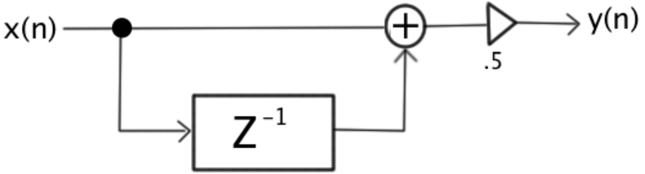
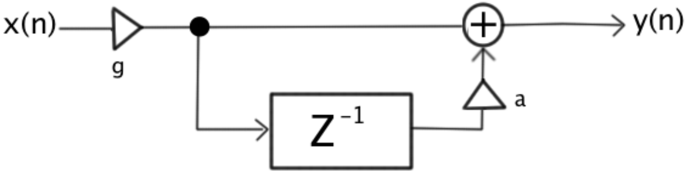
First order FIR, 2-point moving average filter (LP with CF at Nyquist F)

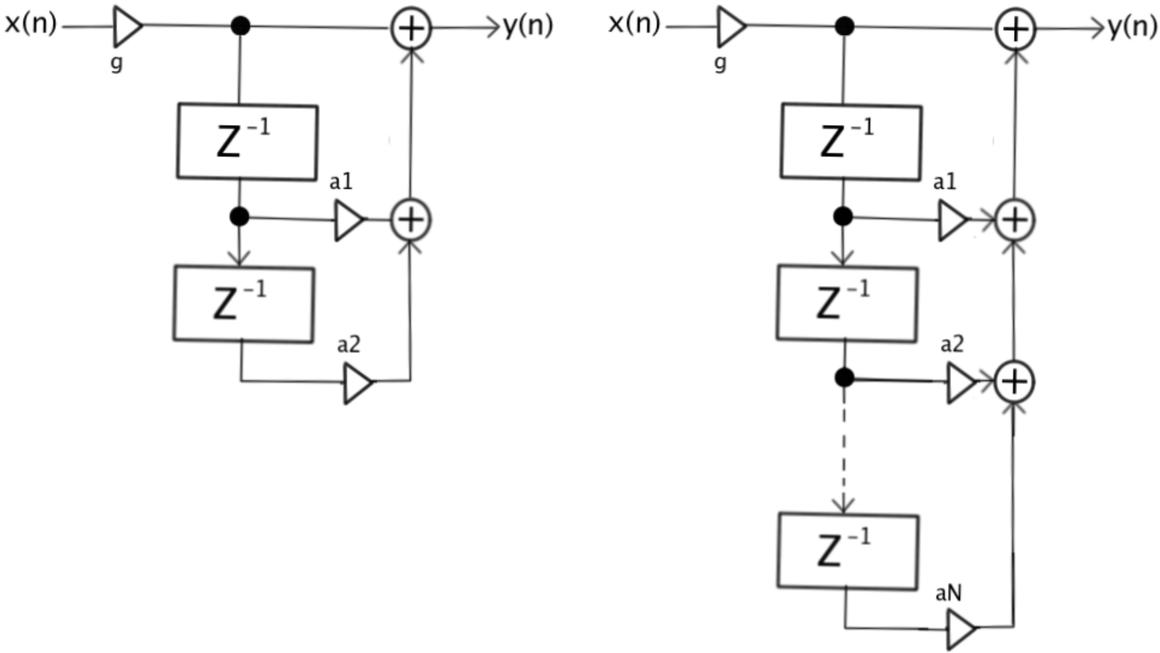


First order general one-zero FIR (LP or HP, depending on delay coefficient)

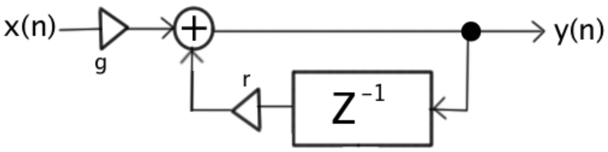


T substitute T (variable delay rather than single sample delay) to generalize further

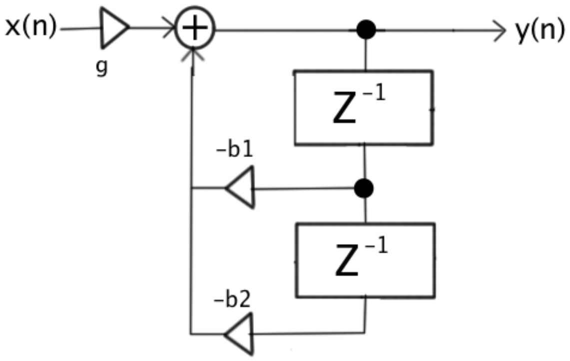
2nd order and higher (Nth) order general FIR filters



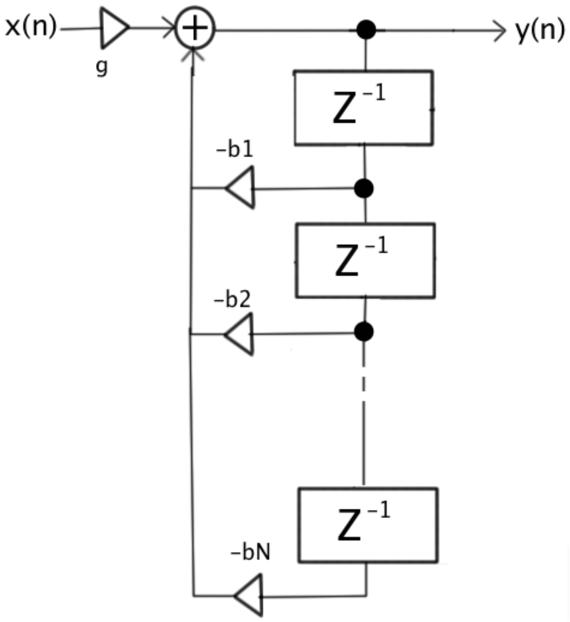
1st order recursive (IIR)



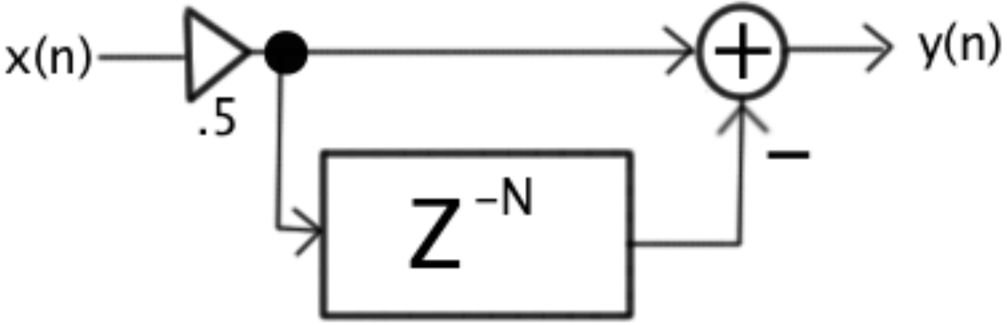
2nd order IIR



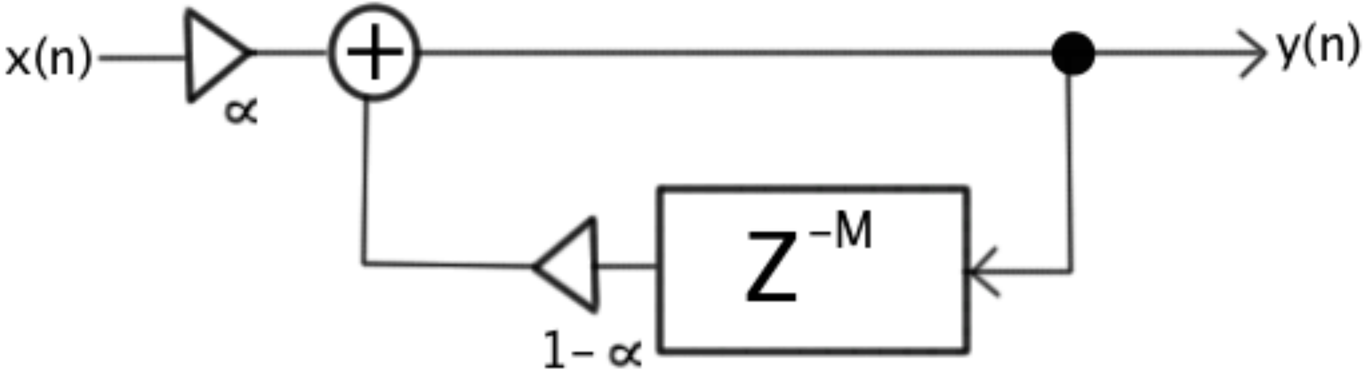
Nth order IIR



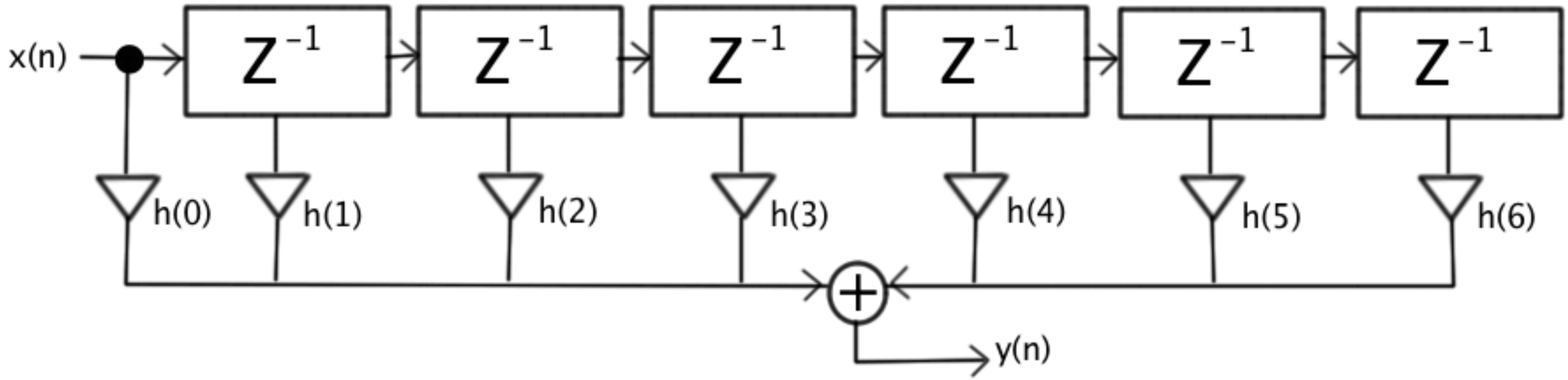
Inverse Comb Filter



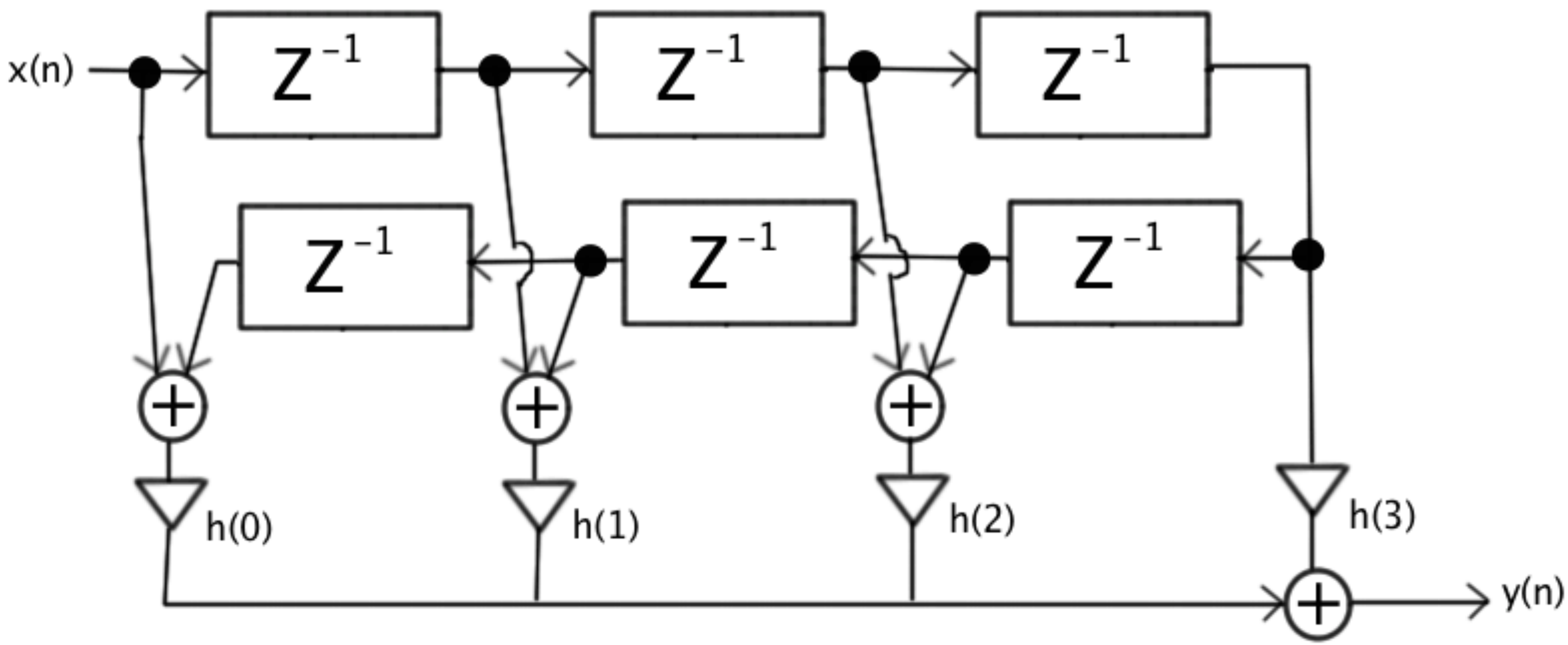
IIR alpha filter



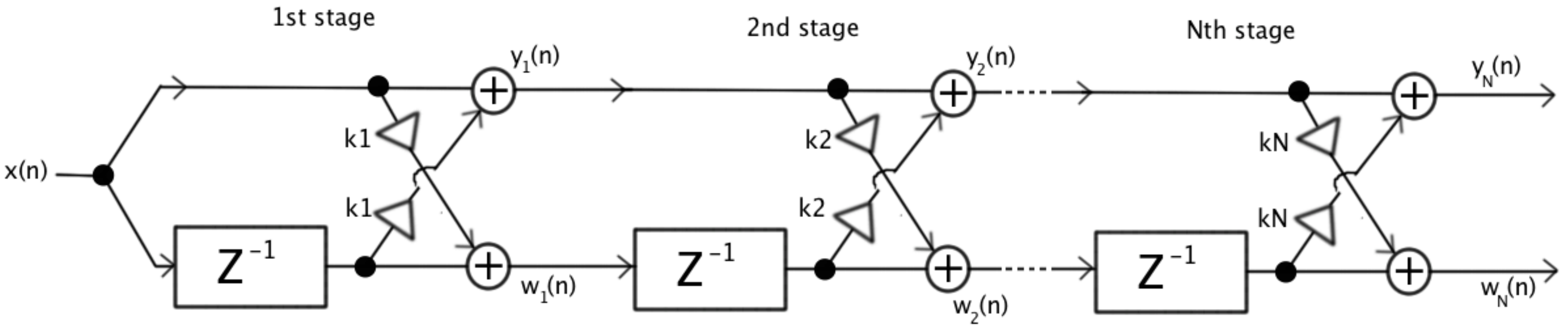
Transverse Filter



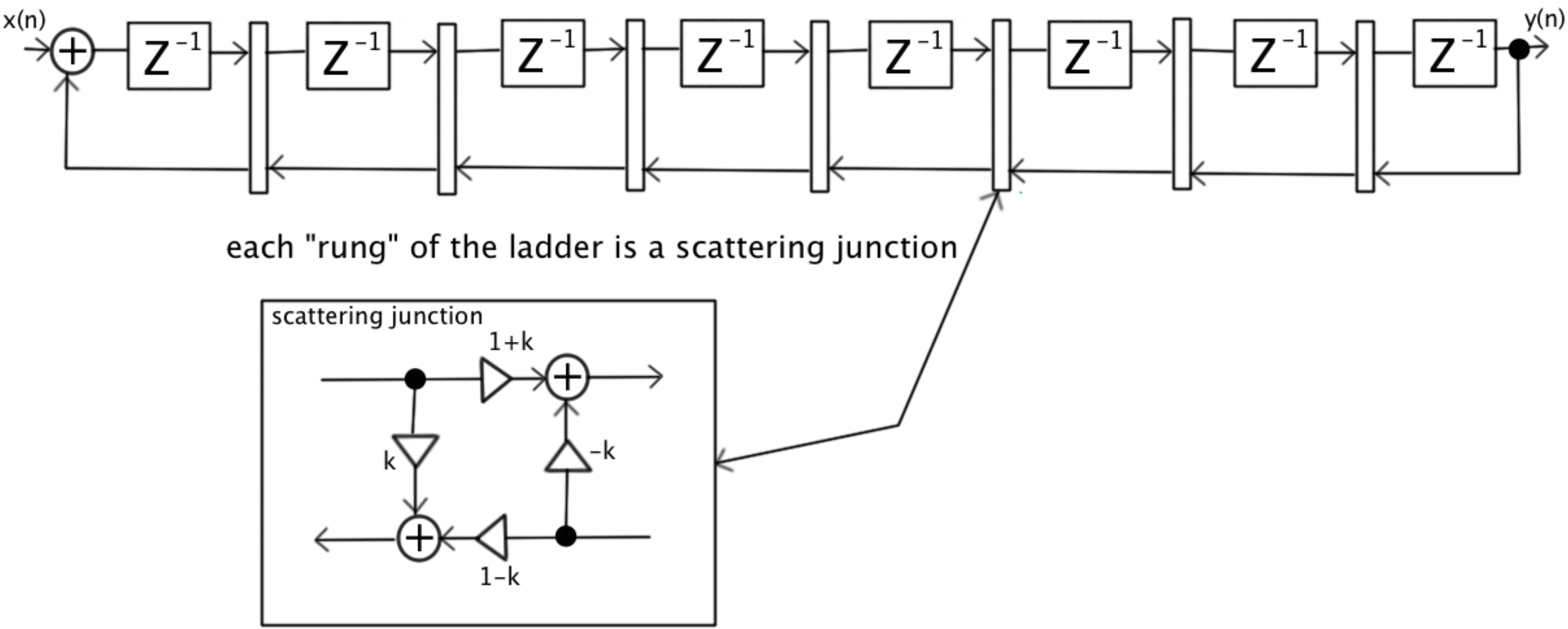
with Linear Phase Structure



FIR Lattice Structure

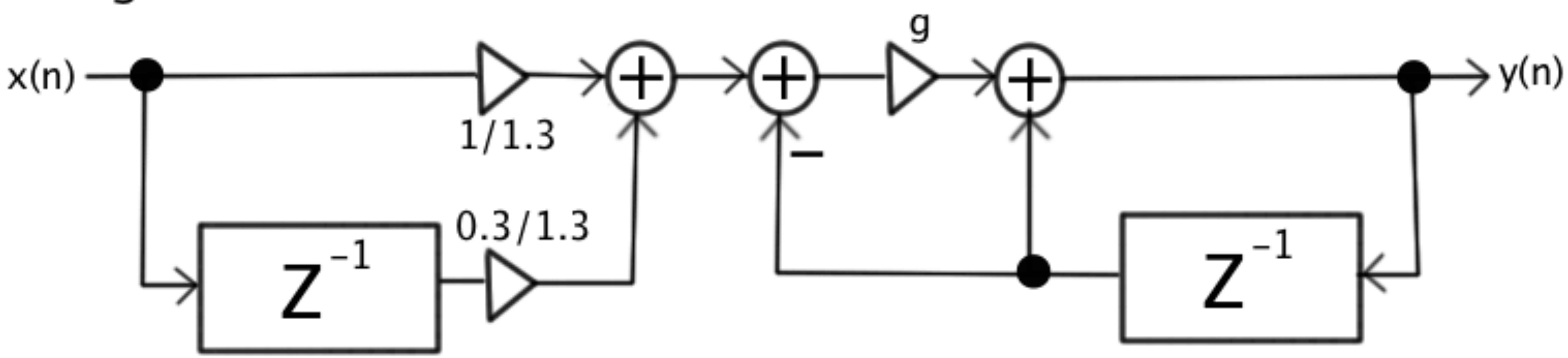


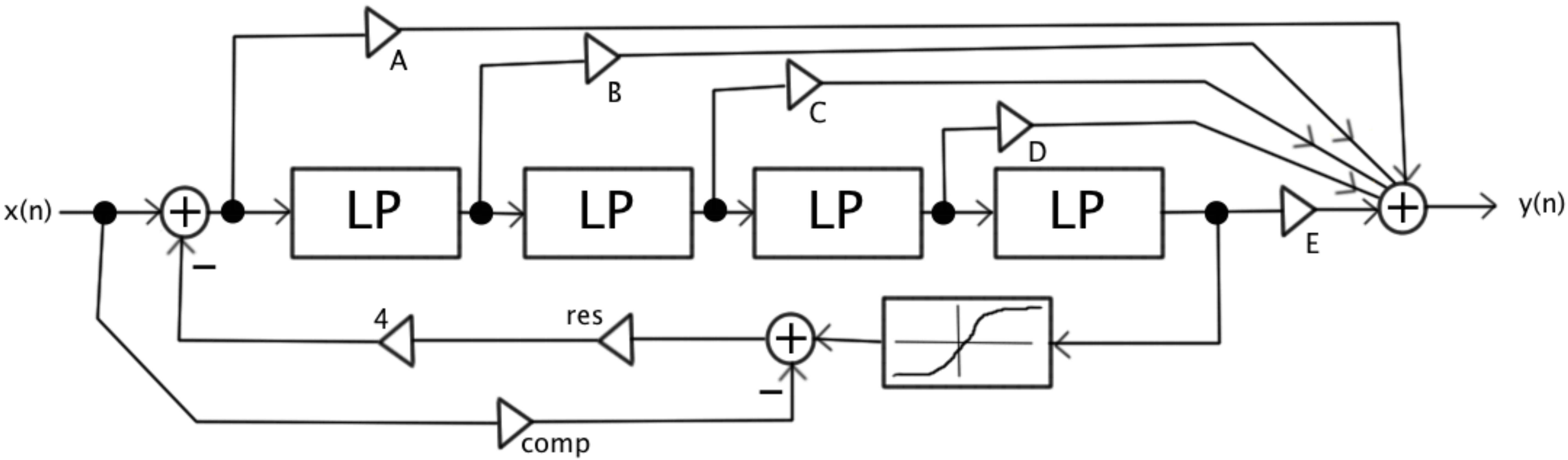
IIR Ladder (lattice) Filter



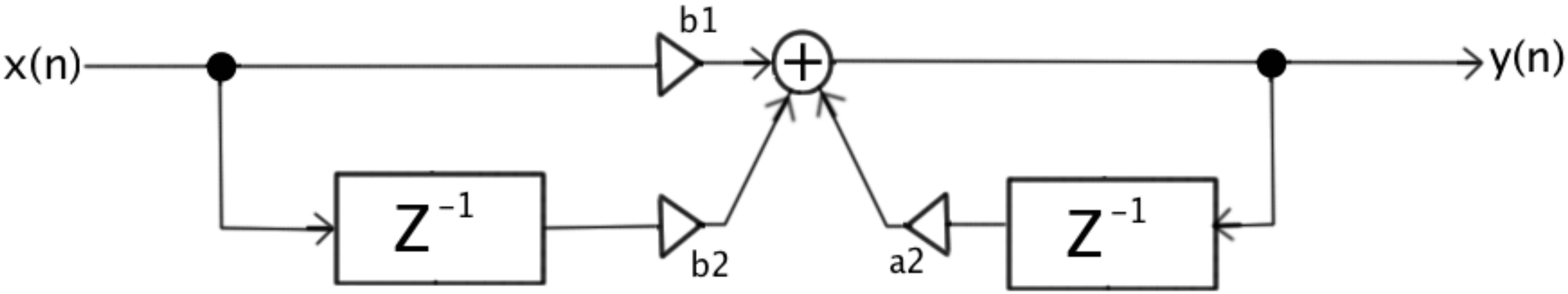
Moog Ladder and Improved Digital Emulation

Moog ladder filter

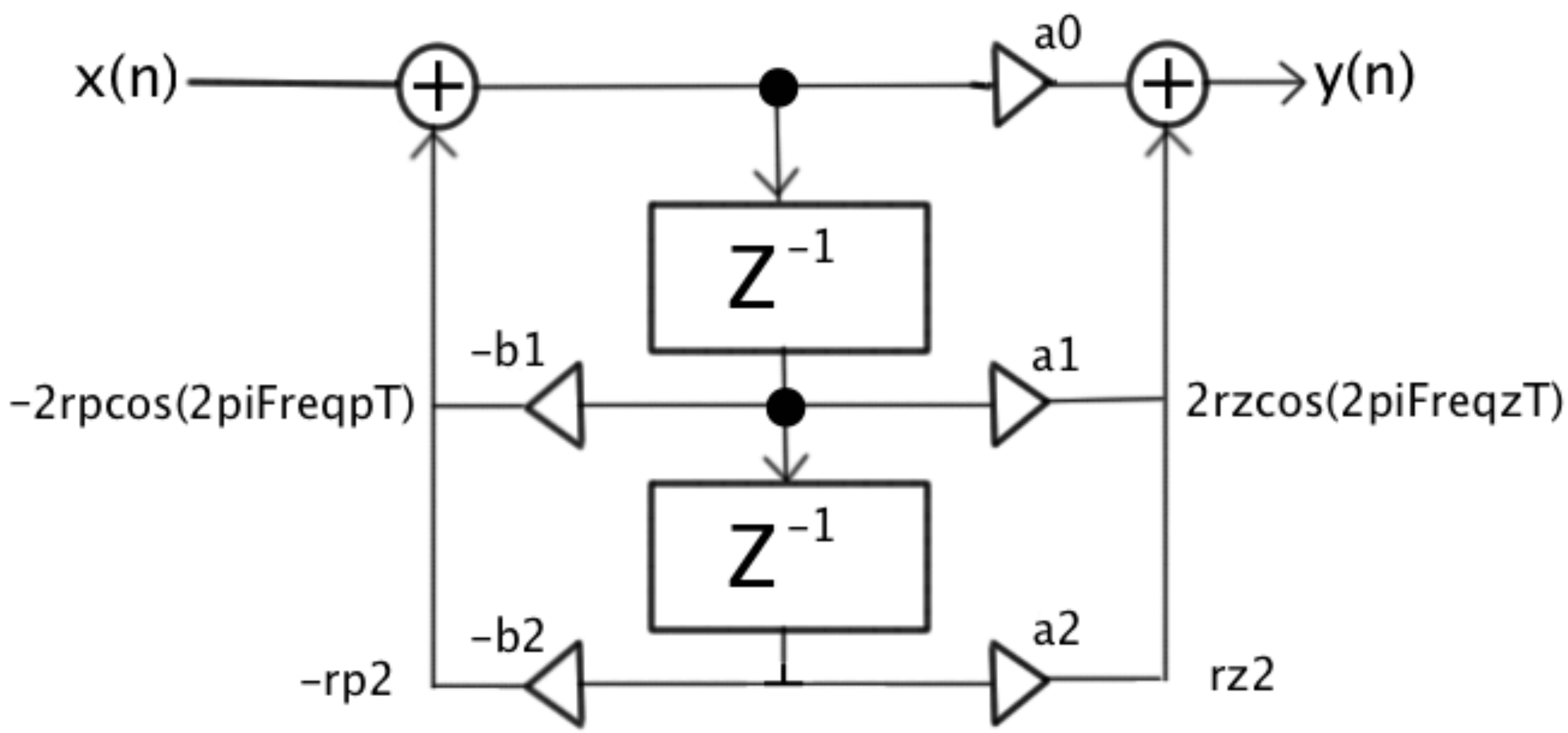




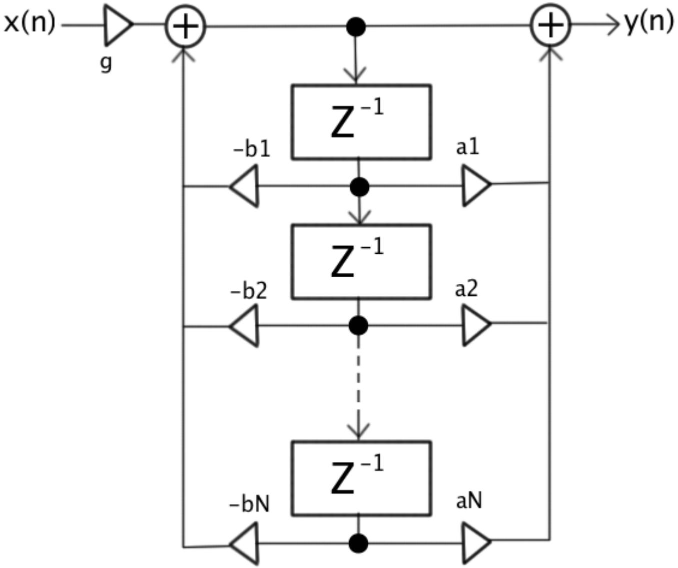
1st order pole zero filter



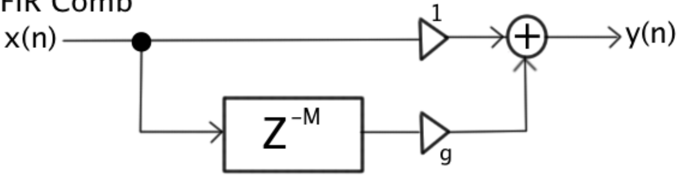
2nd order pole-zero (biquad) filter



Nth order general pole-zero IIR filter



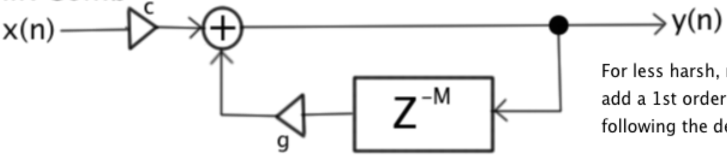
FIR Comb



g=positive, attenuates Freq in between

g=negative, attenuates Freq

IIR Comb

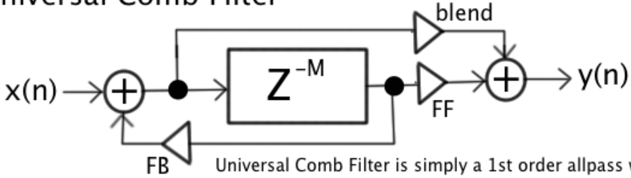


For less harsh, metallic comb filtering add a 1st order LP into the signal path following the delay.

g=positive, attenuates Freq in between

g=negative, attenuates Freq

Universal Comb Filter



Universal Comb Filter is simply a 1st order allpass with variable delay. It can generate the following:

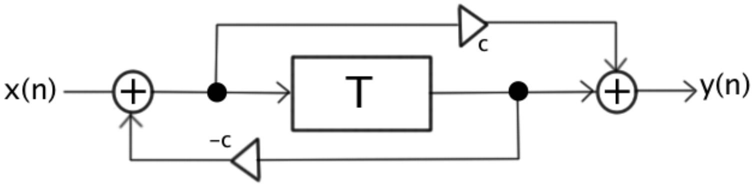
FIR Comb: blend=X FB=0 FF=X

IIR Comb: blend=1 FB=X FF=0

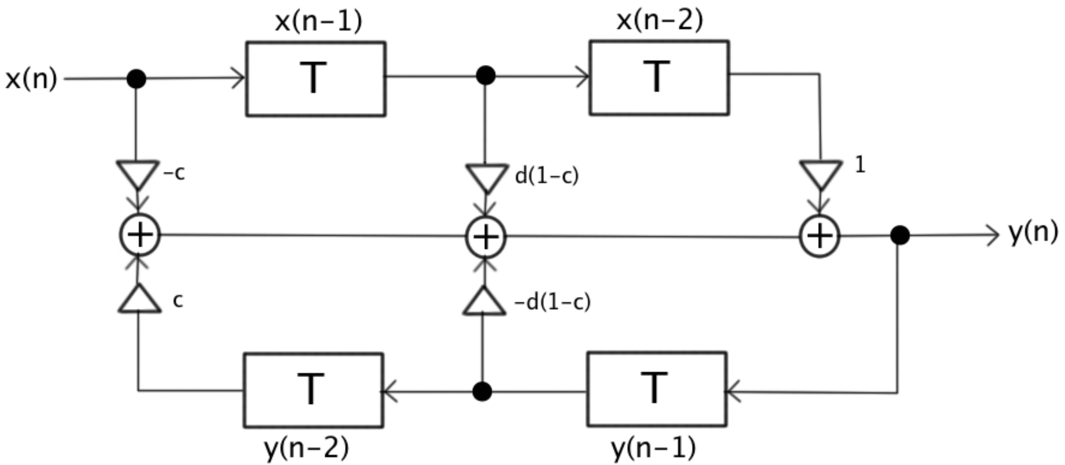
Allpass: blend=a FB=−a FF=1

Delay: blend=0 FB=0 FF=1

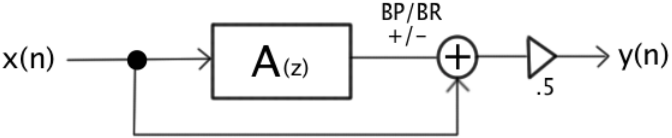
1st order allpass filter



2nd order allpass filter

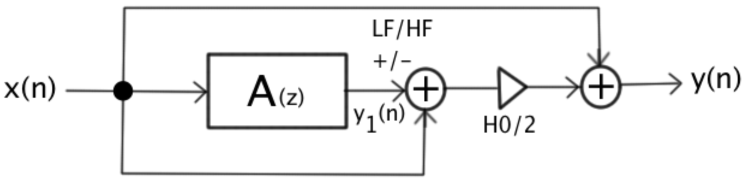


2nd order BP/BR

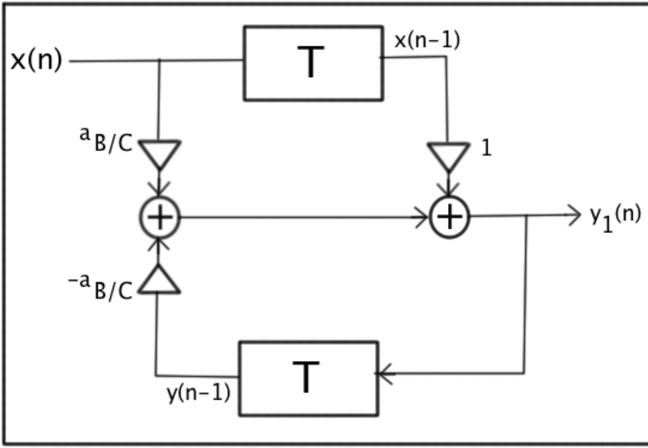


where $A_{(z)}$=2nd order allpass

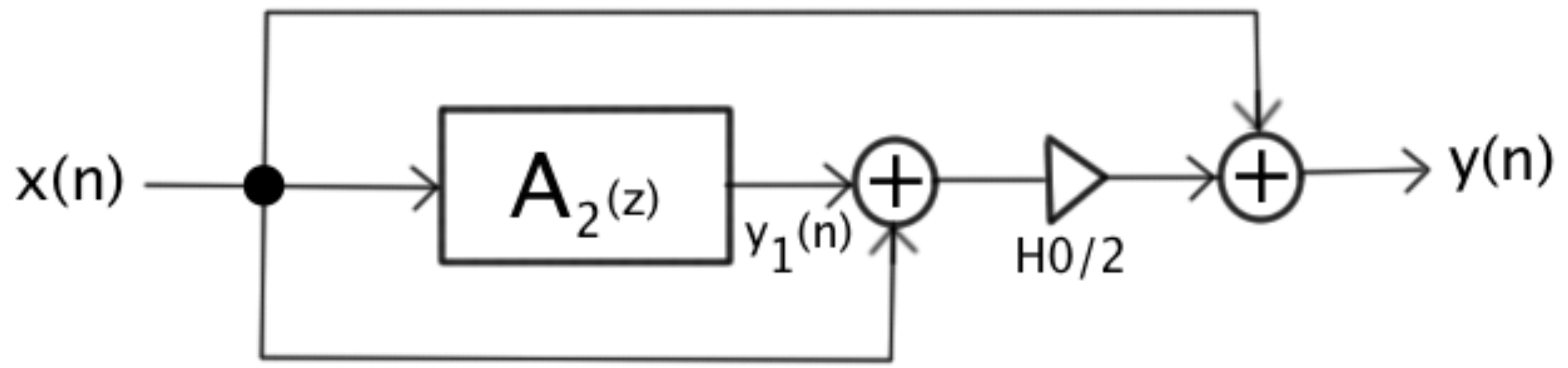
1st order low/high shelving filter



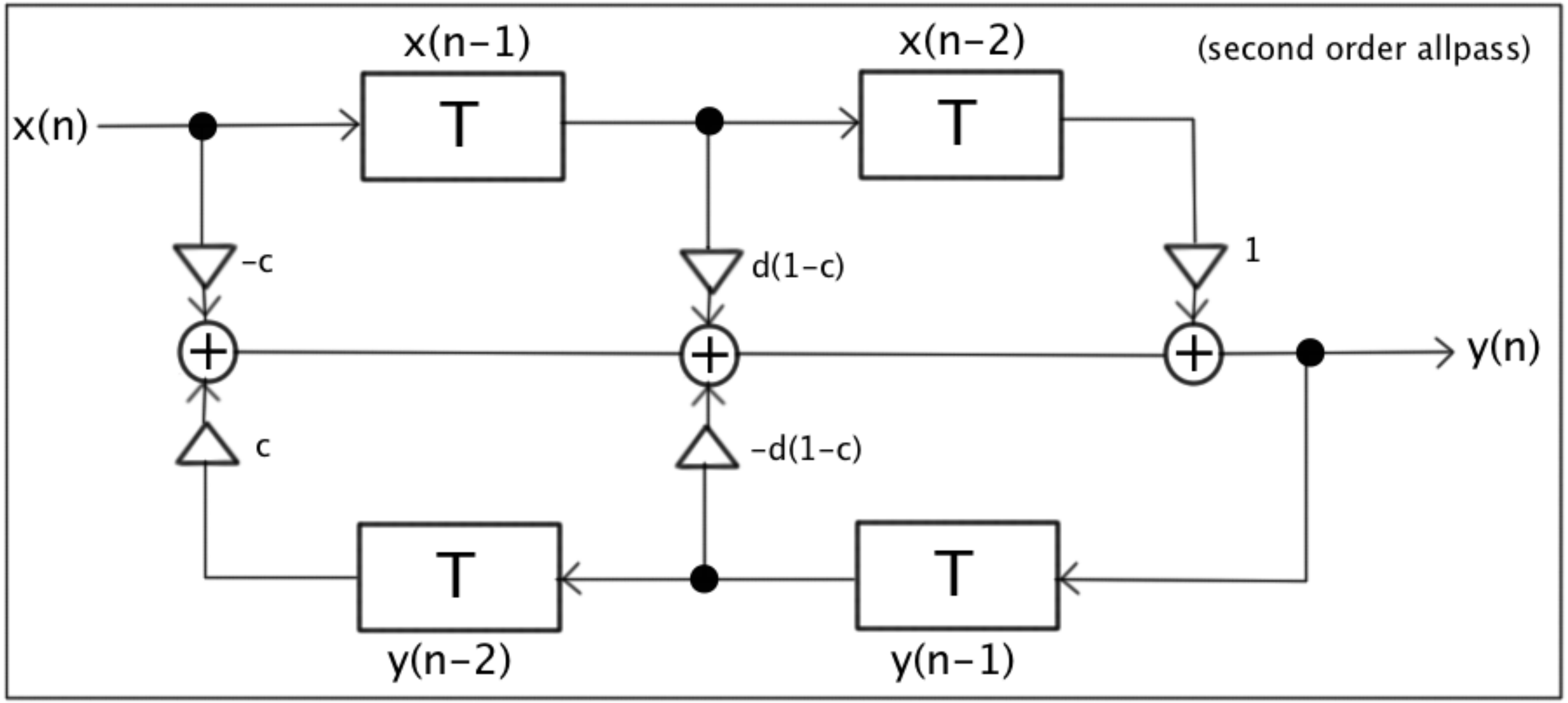
where A(z) =
(first order allpass)



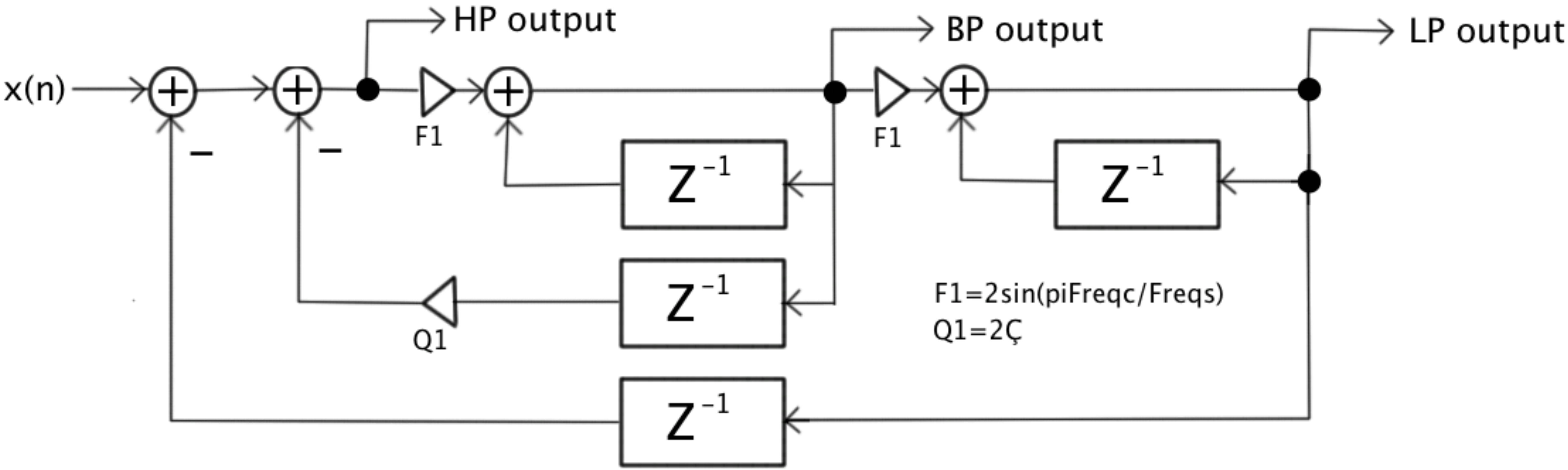
2nd order peak filter



where $A_2(z)$ =

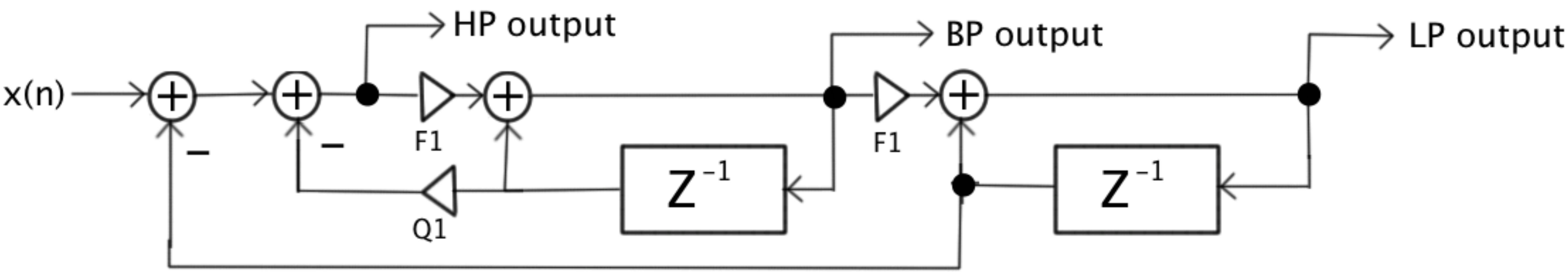


State Variable Filter

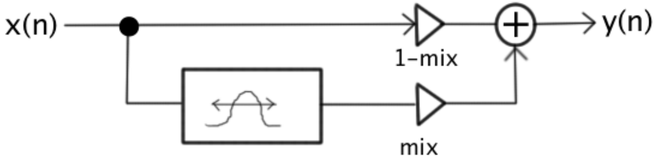


Notch (BR) = HP+LP

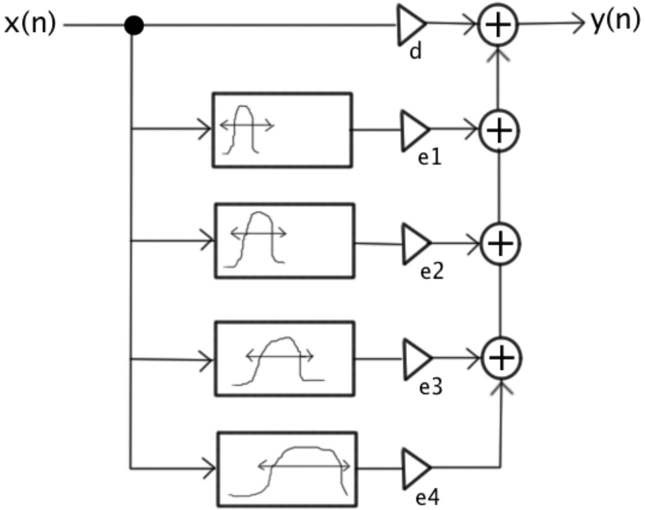
(simplified version below, reduces delays required)



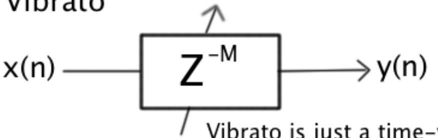
wah-wah pedal



time-varying octave BP filters

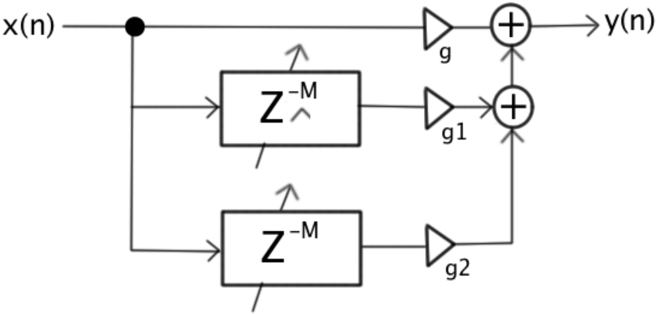


Vibrato



Vibrato is just a time-variable delay line using an LFO to change the delay

Chorus



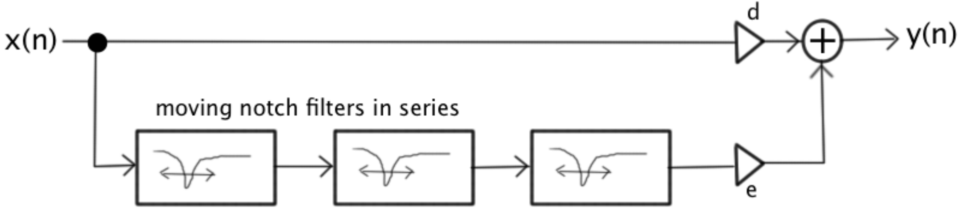
2 (minimum) randomly deviating delays with deviation in the 10-25 ms range

Other Delay-Based Effects Using Comb Filters (FIR or IIR):

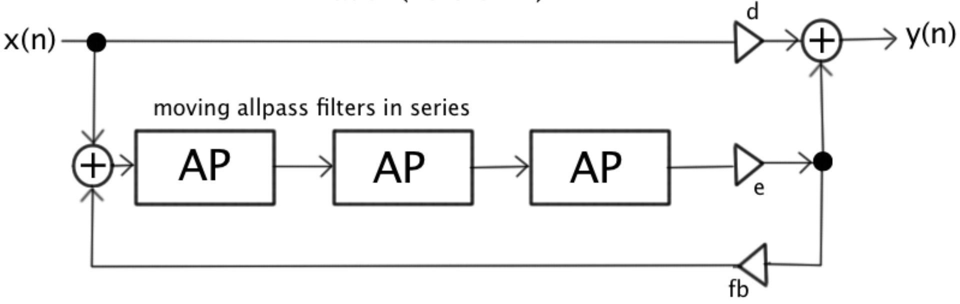
Effect:	Modulation:	Delay (ms):
Resonator	none	0-20
Flanger	sine	0-15
Chorus	random	10-25
Slapback	none	25-50
Echo	none	>50

Use of FIR vs. IIR will impact the effect. For example, echo with FIR will produce just one echo while IIR will produce multiple echoes.

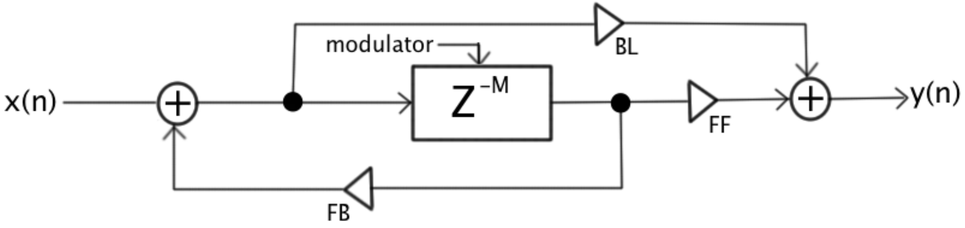
Phaser (version A)



Phaser (version B)



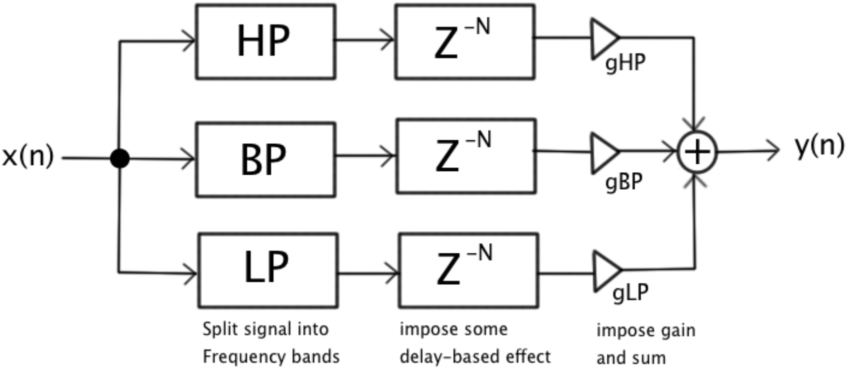
Generalized Effects Structure proposed by Dattoro



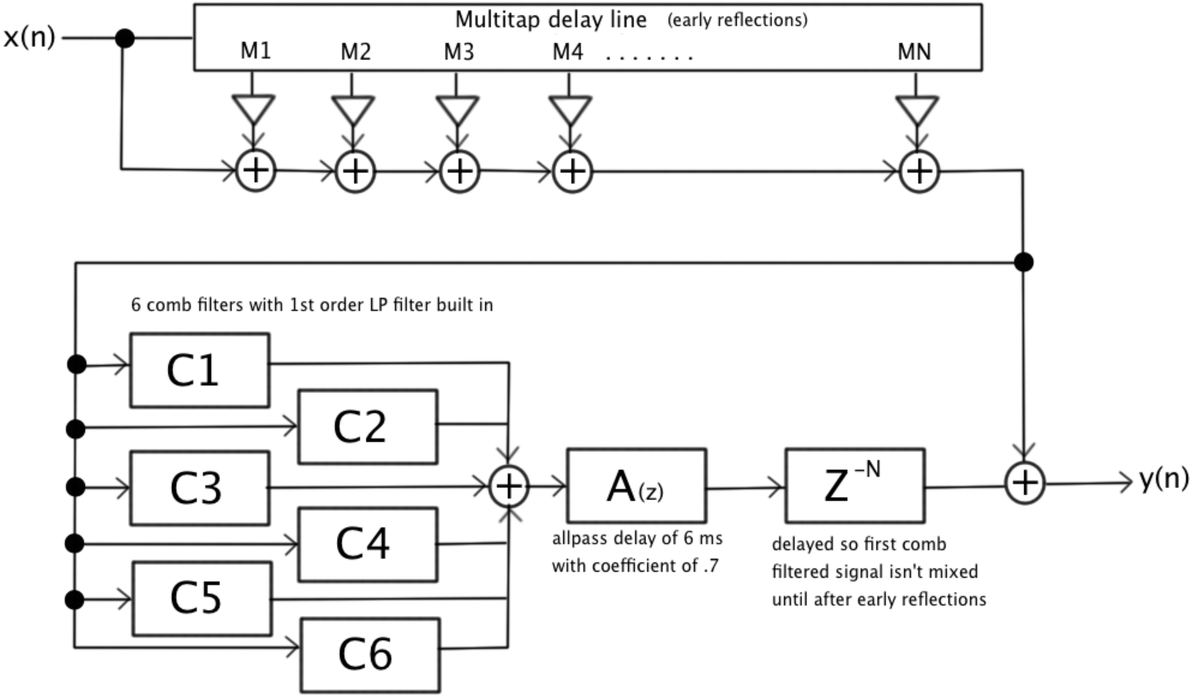
modulator is either an LFO or lowpass noise

Effect:	BL:	FF:	FB:	Delay (ms):	Depth (ms):	Modulator:
Vibrato	0	1	0	0	0–3	0.1–5 Hz sine
Flanger	.7	.7	.7	0	0–2	0.1–1 Hz sine
Chorus	.7	1	–.7	1–30	1–30	lowpass noise
Doubling	.7	.7	0	10–100	1–100	lowpass noise

General Multiband Effects

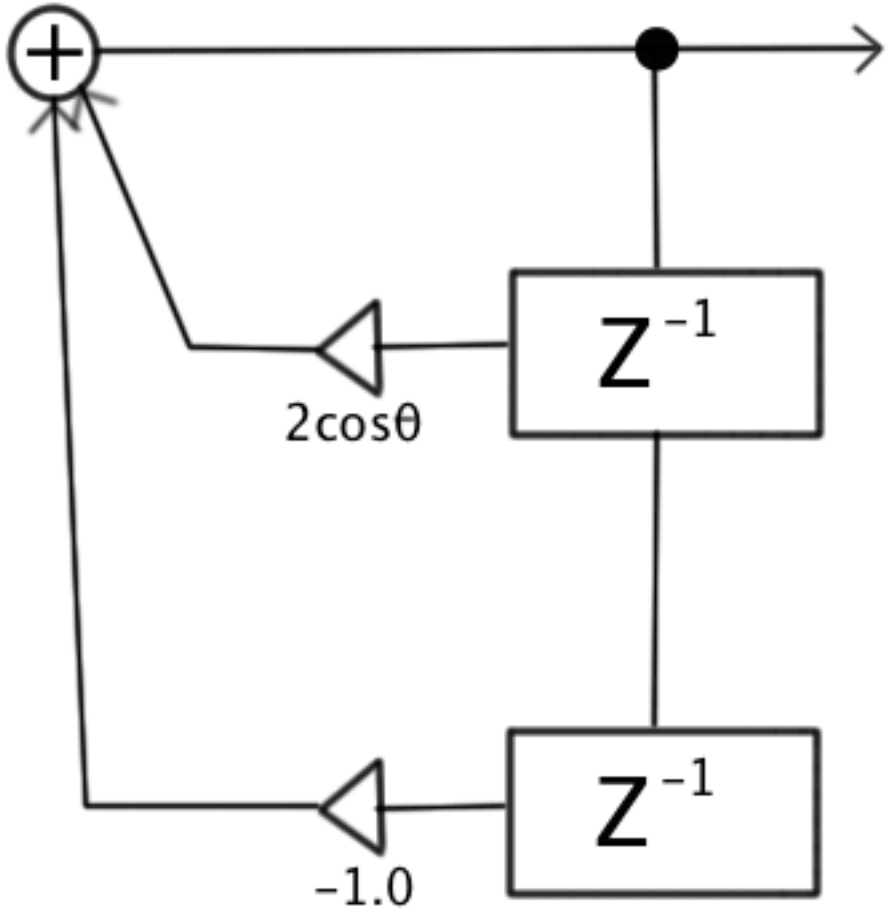


Moorer's Reverb

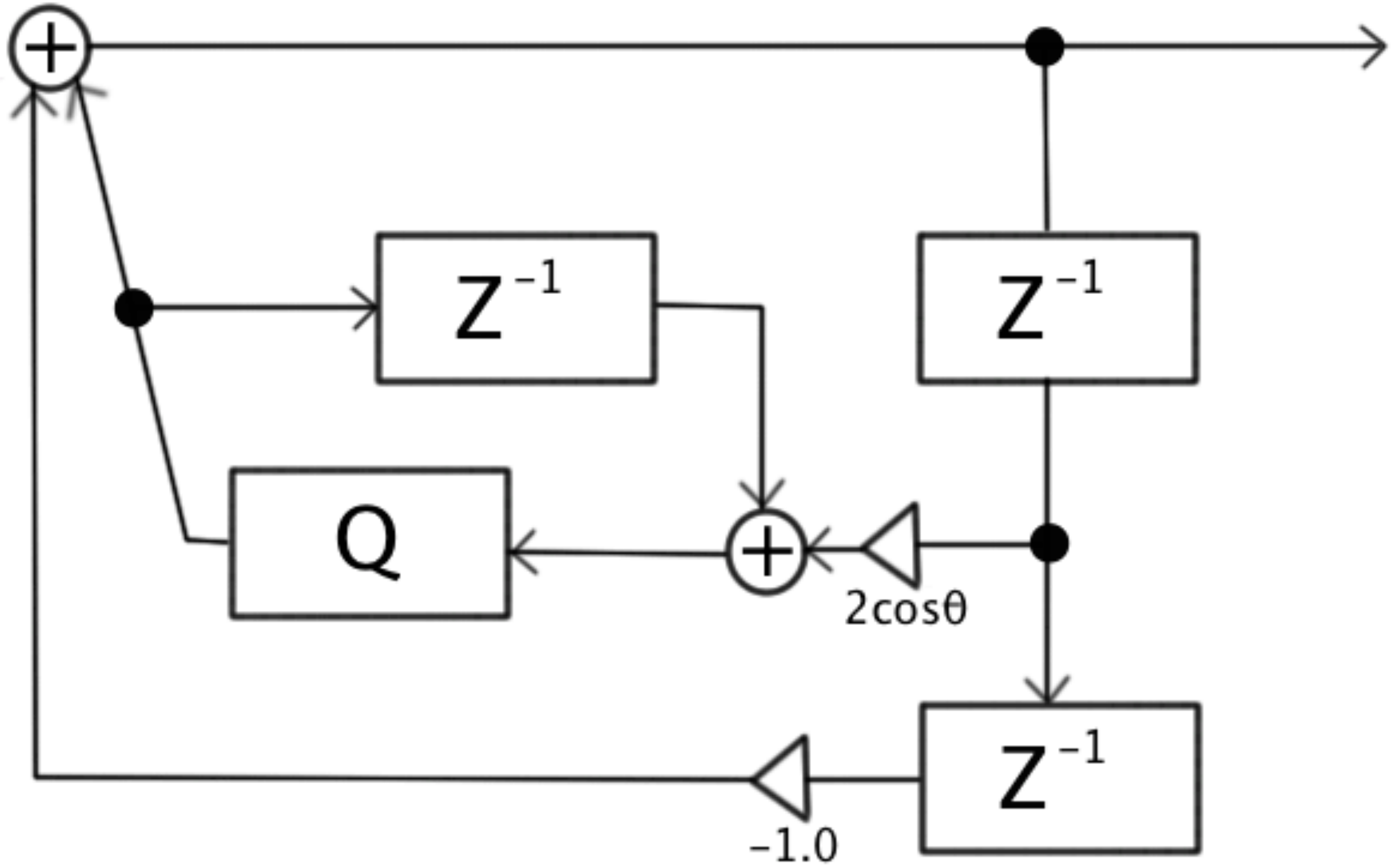


Digital Oscillators

simple oscillator

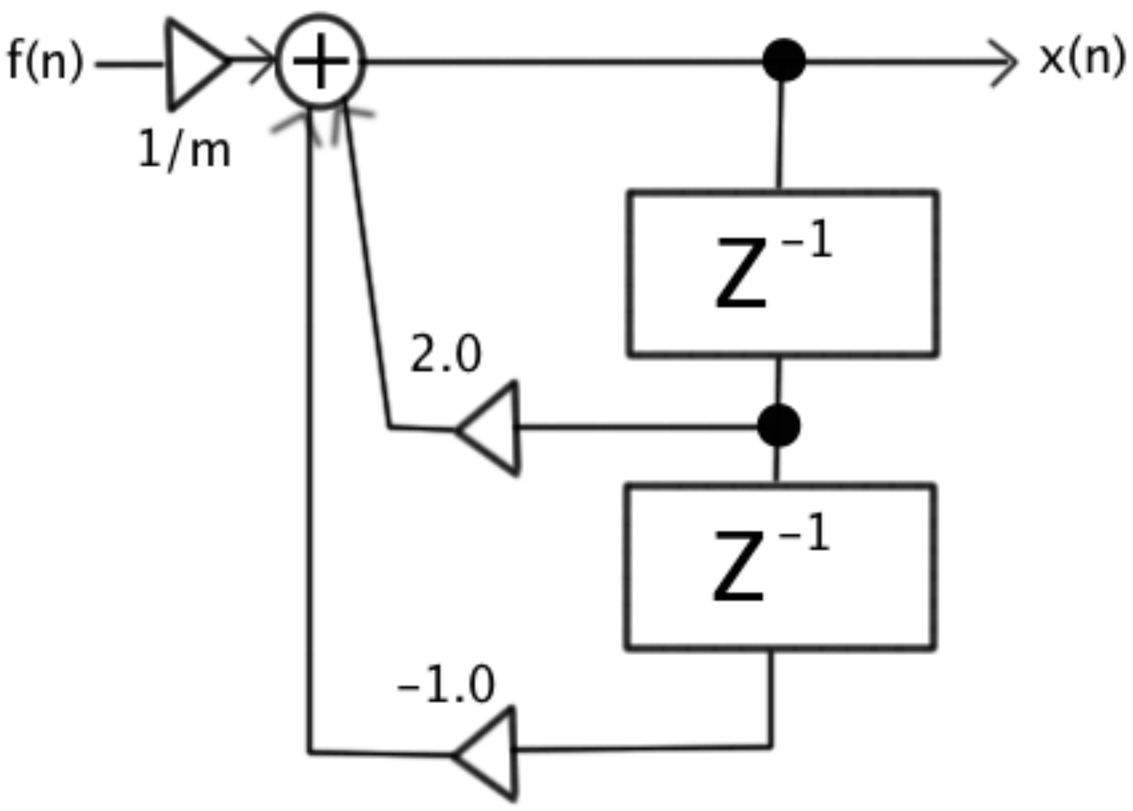


with added 1st order error spectral shaping

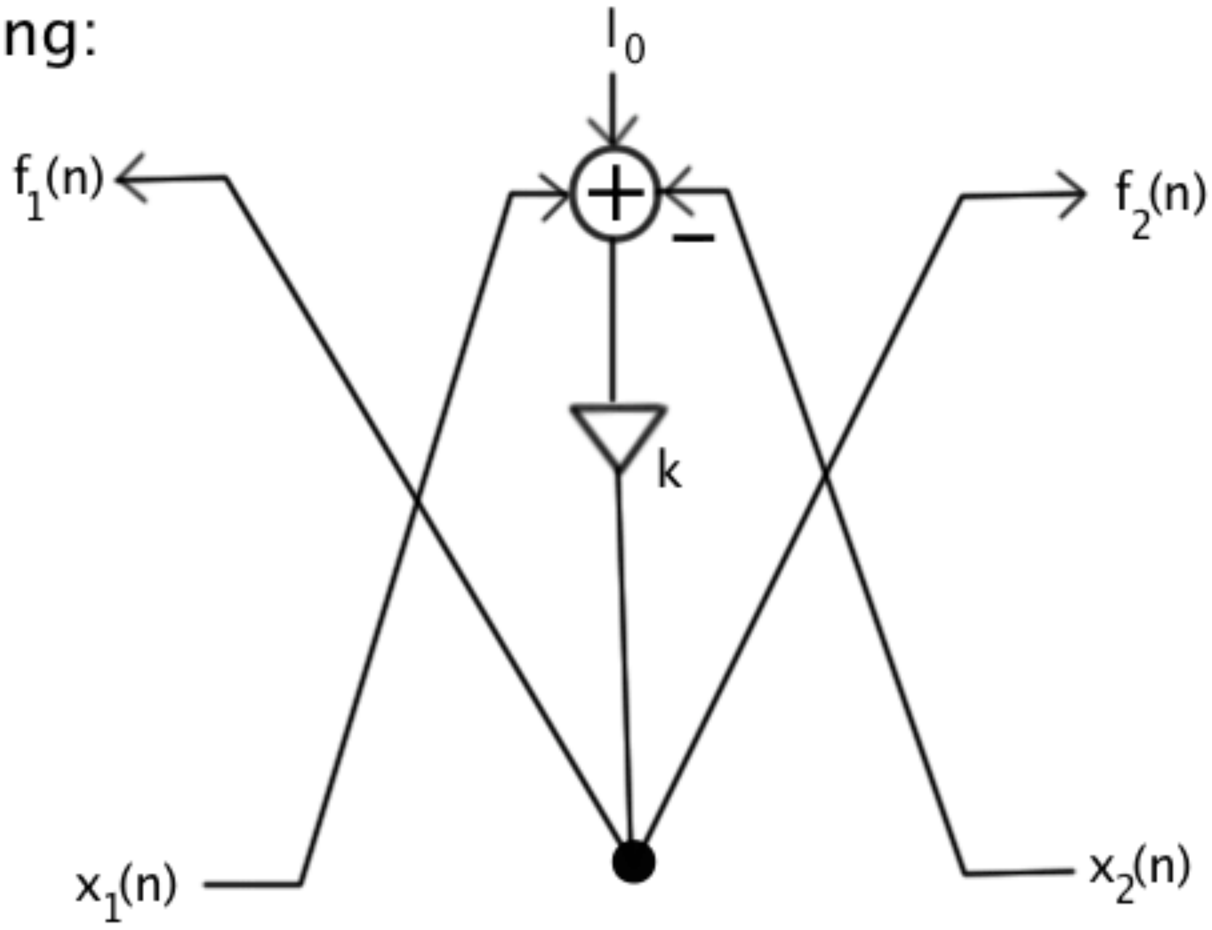


Mass Spring Network

Mass:

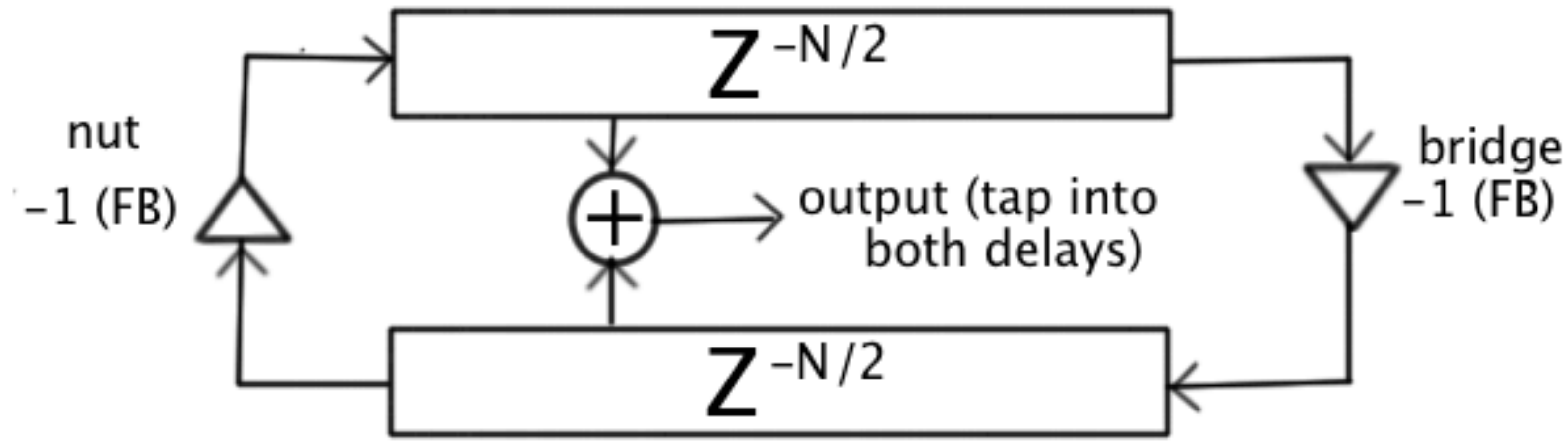


Spring:

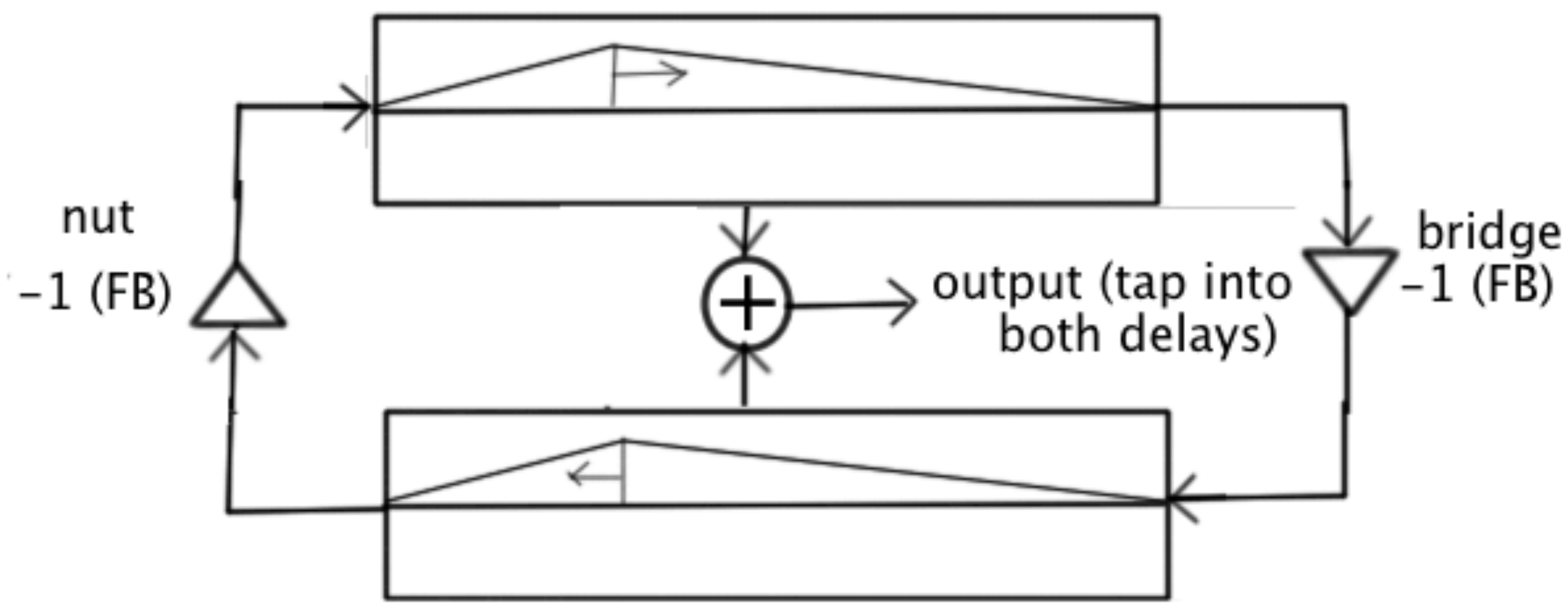


Basic Strings

Rigidly Terminated Ideal String



Initial Conditions for Ideal Plucked String

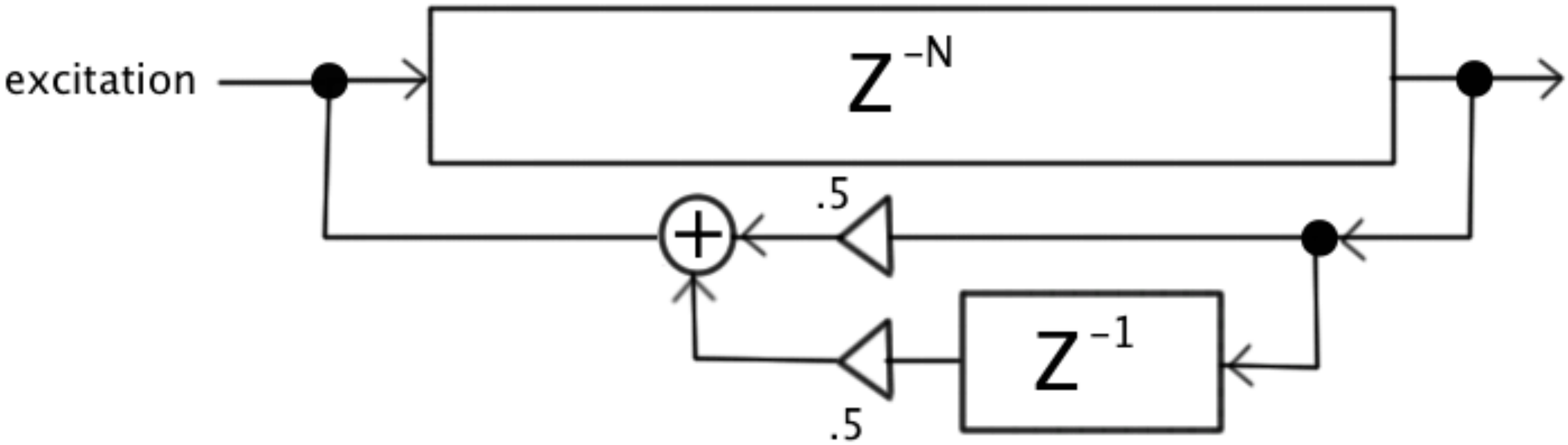


pluck position (initial delay or scattering junction)

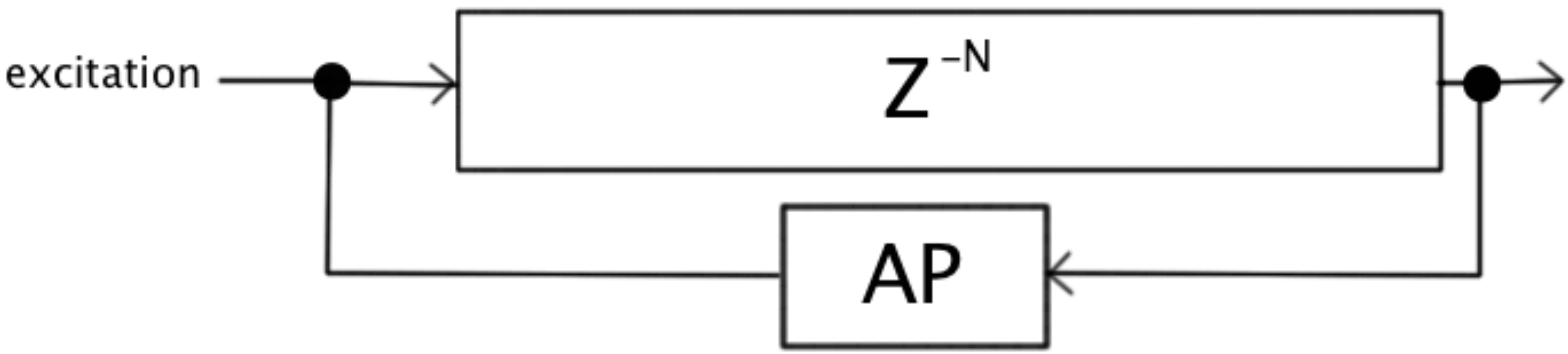
pluck is just an impulse response or short burst of noise

More Simple Strings

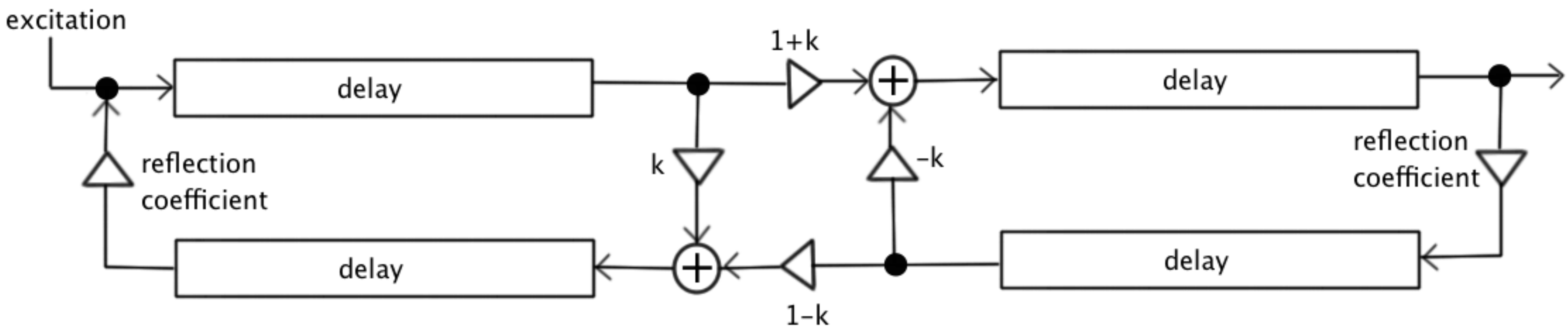
Simplest string with lowpass (no FB gain)



Simulation of stiff string (no FB gain)



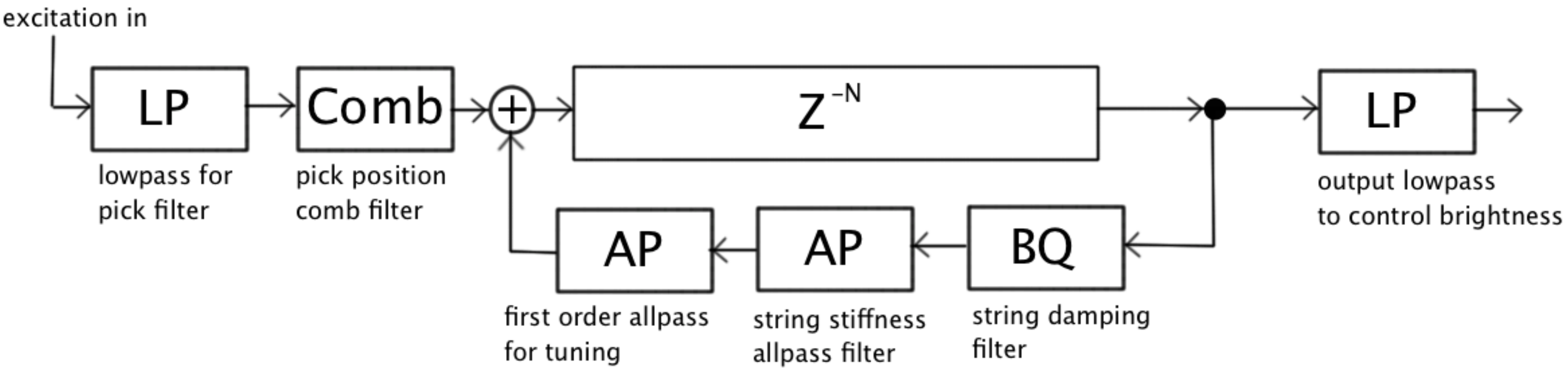
2D Waveguide with Scattering Junction



k=(radius R - radius L)/(radius R + radius L)
k values of 0-.075 (or 0-0.1) generally work well

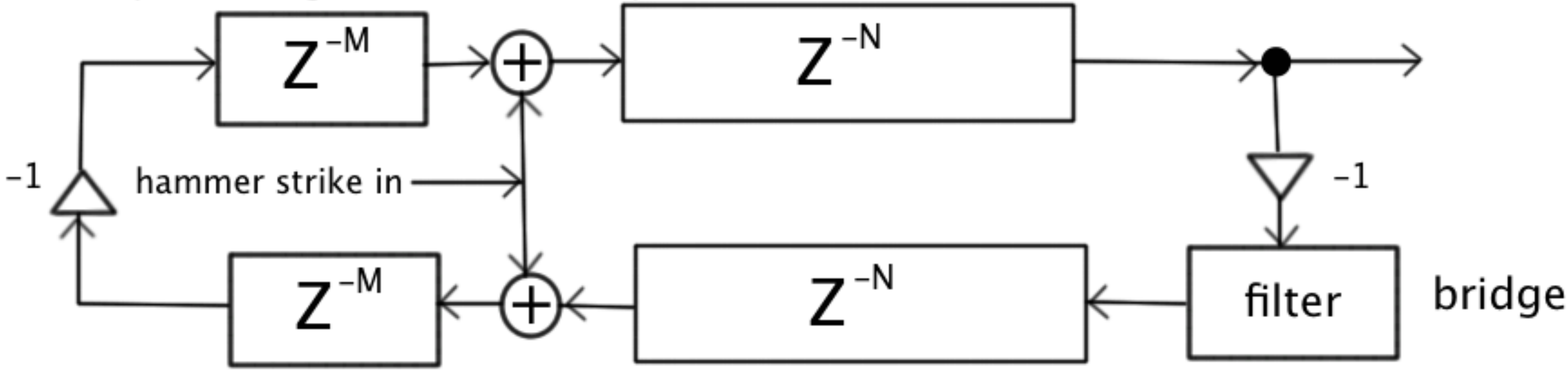
Scattering junctions can represent a tone hole, harmonic, or change in bore size. They can be used to model multiphonics as well.

Extended Karplus-Strong

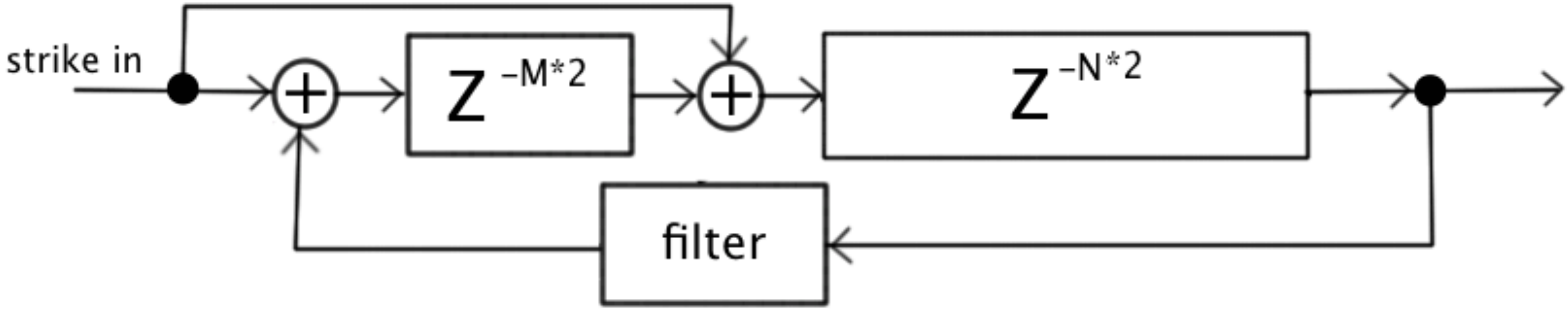


Piano Hammer Strike Models

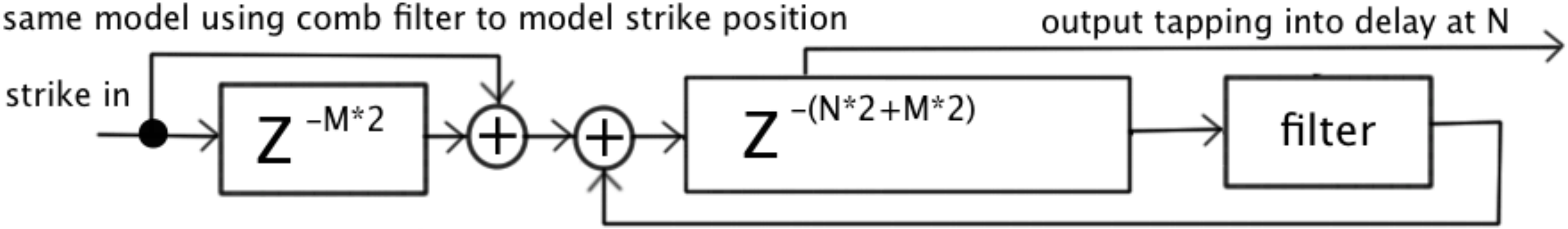
model of piano string struck in interior by hammer



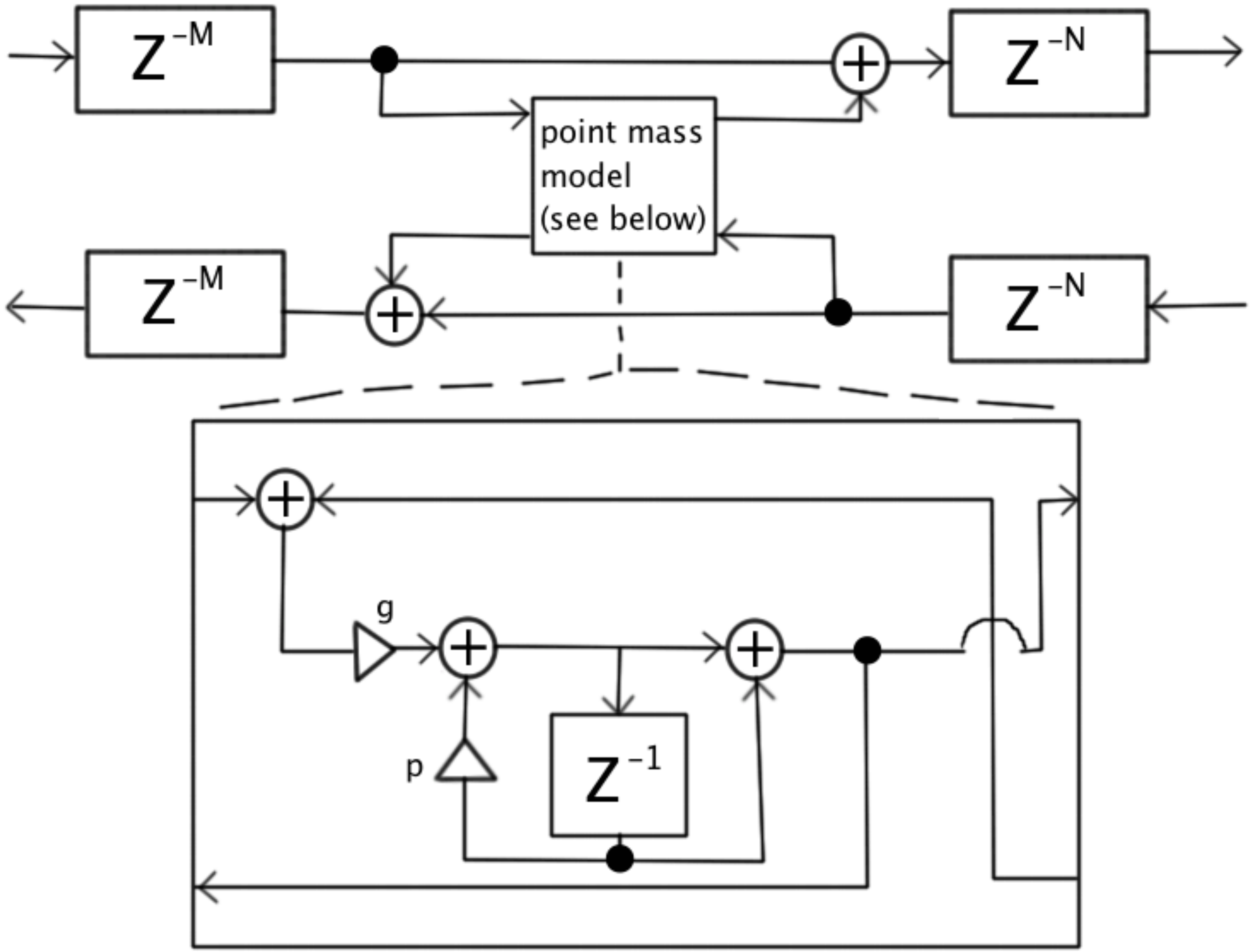
exact same model simplified by combining upper and lower delay lines



same model using comb filter to model strike position

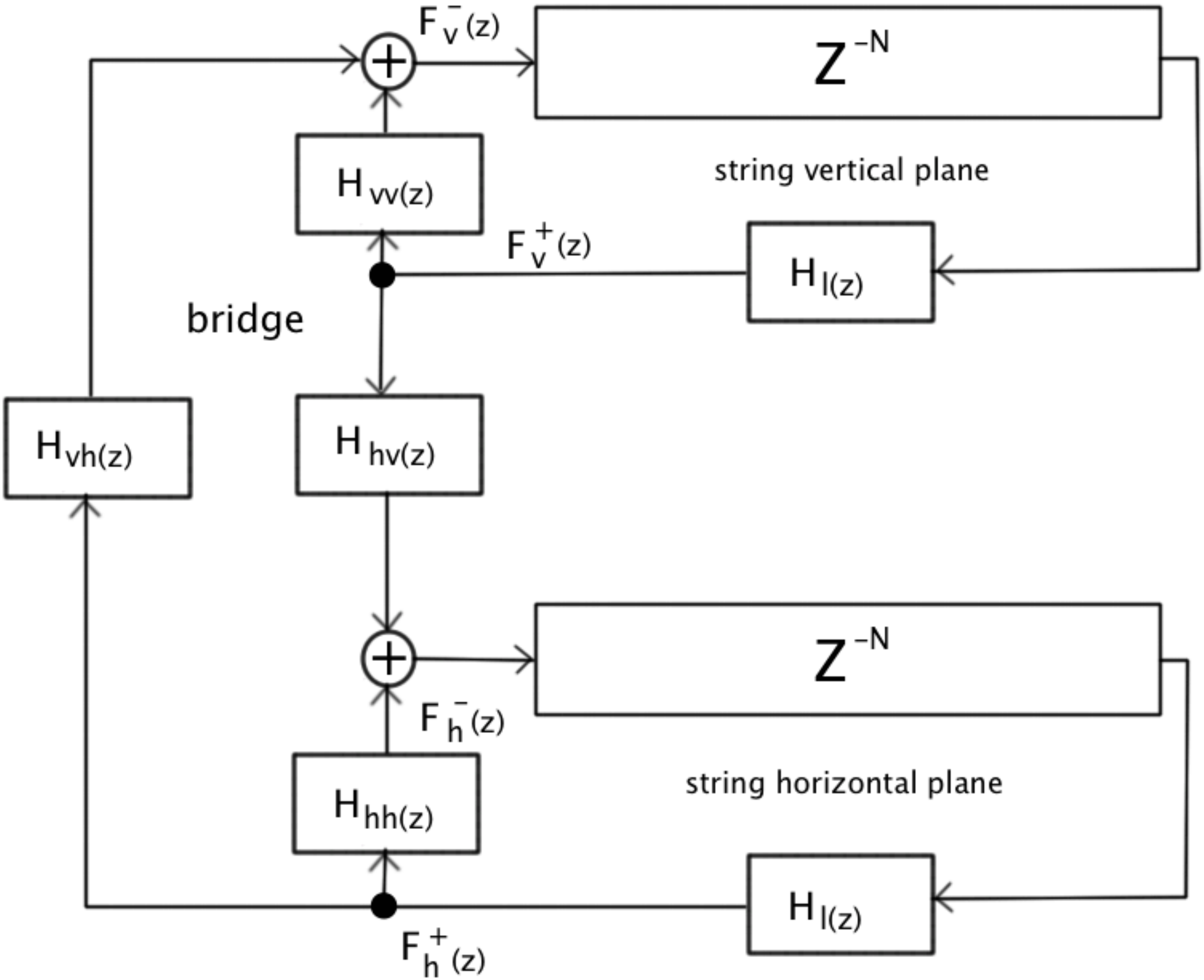


Ideal String with Point Mass Attached

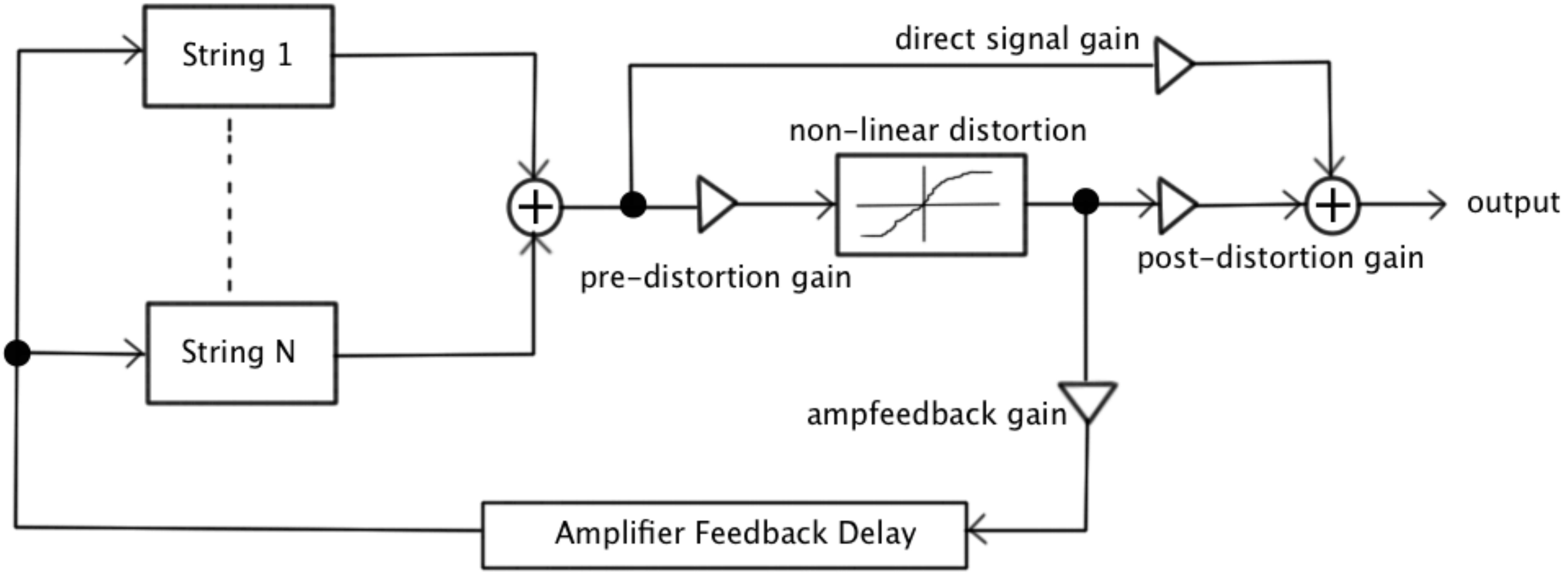


3D waveguide model of string

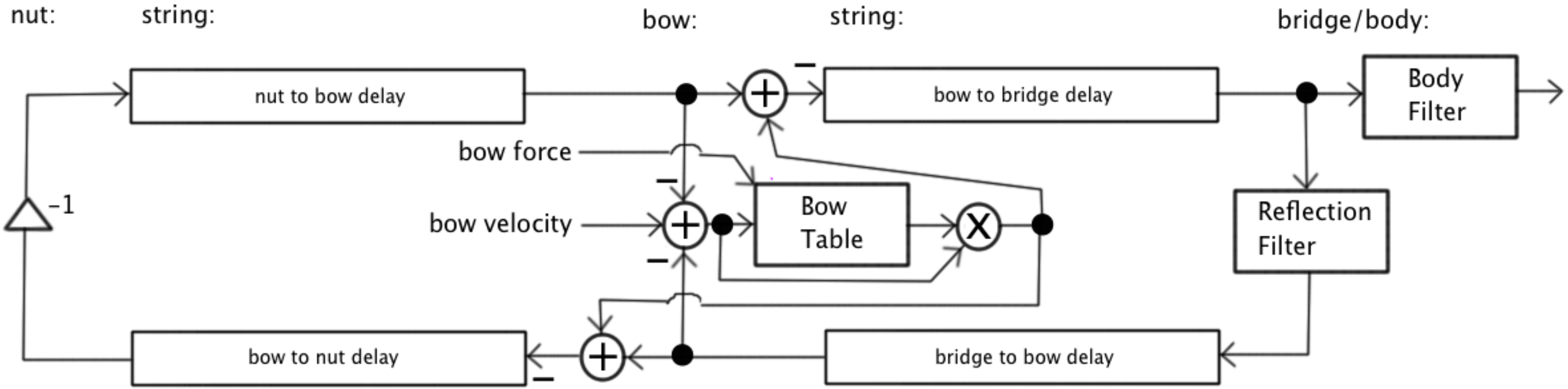
vertical and horizontal planes coupled linearly at bridge



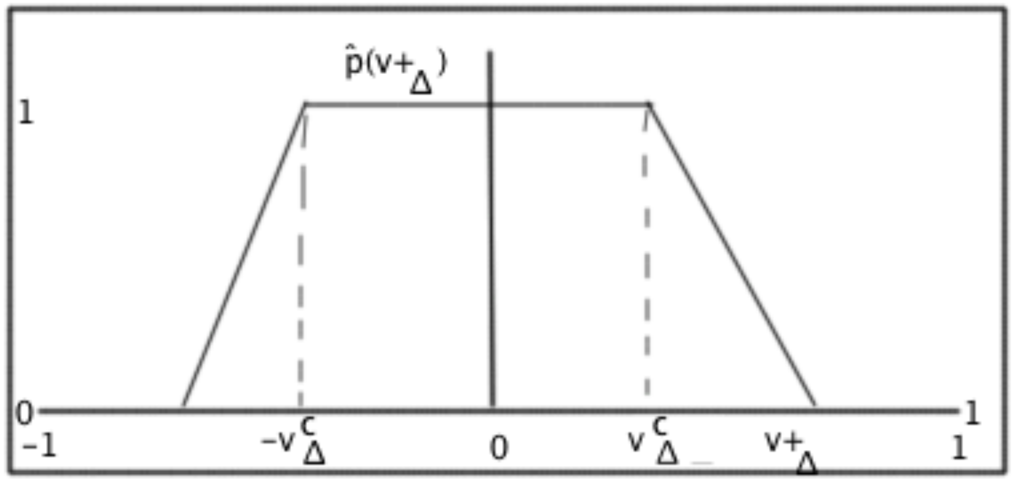
Basic Distorted Electric Guitar



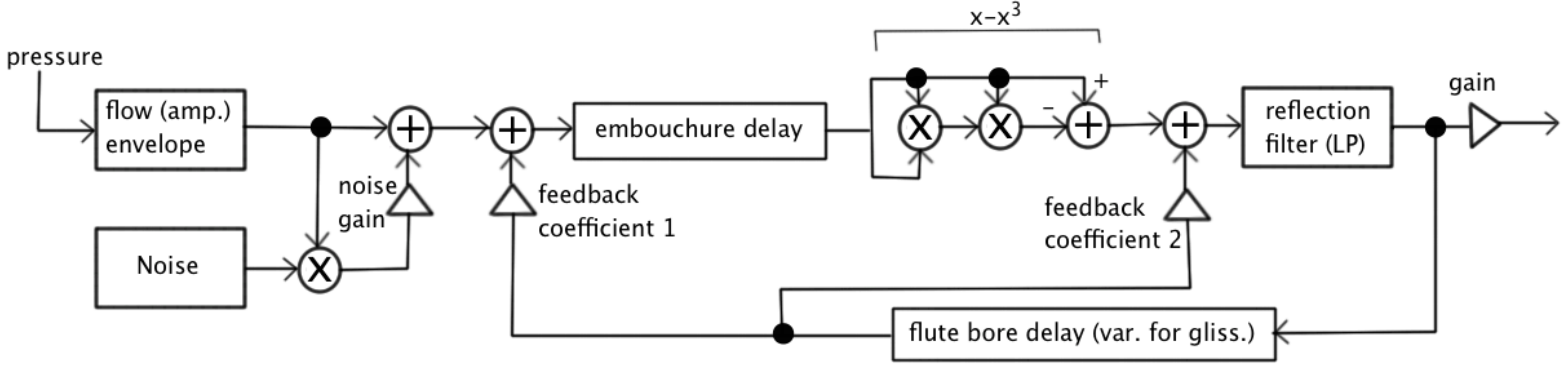
Bowed String Model by Julius O. Smith



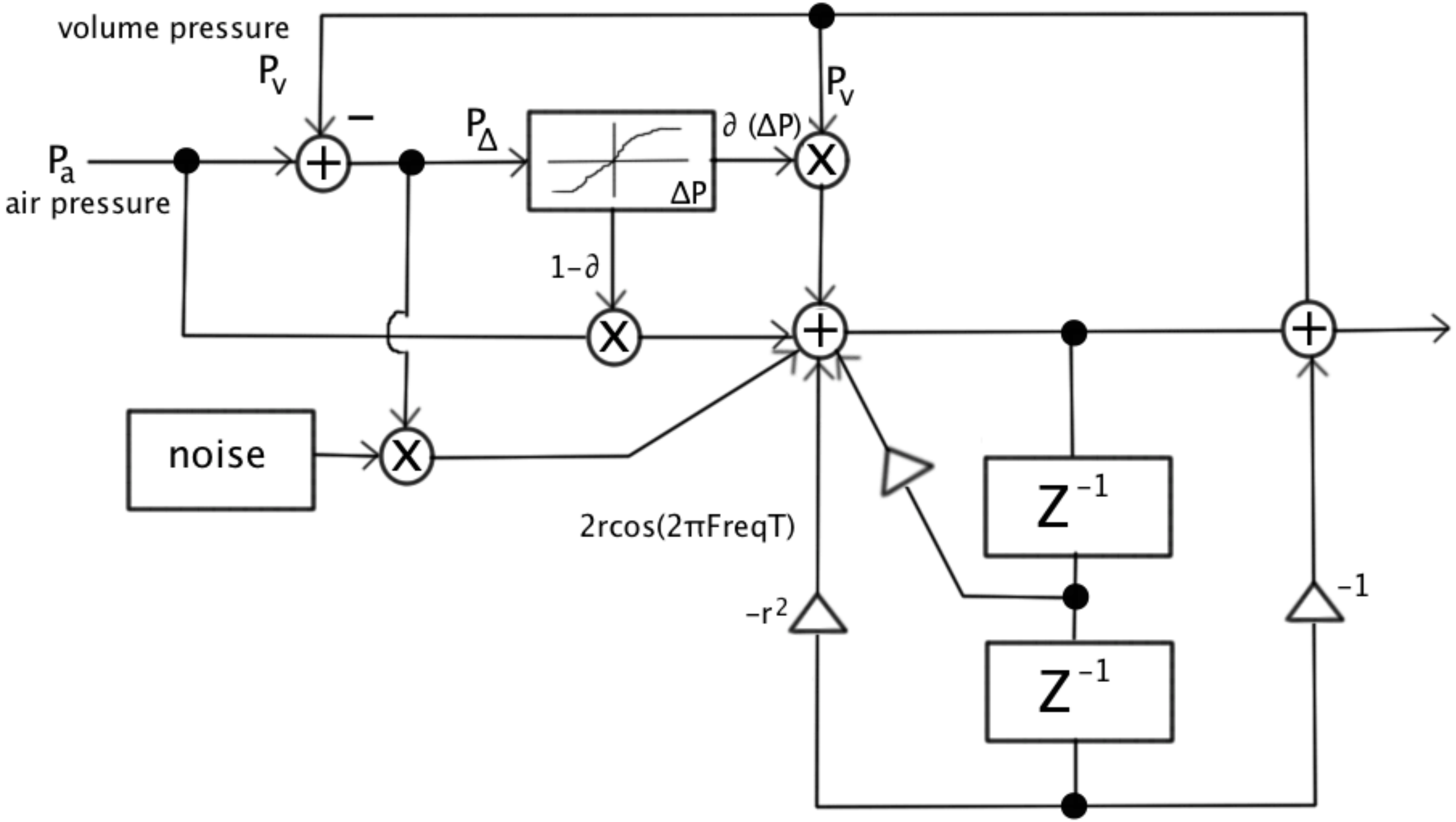
bow table:



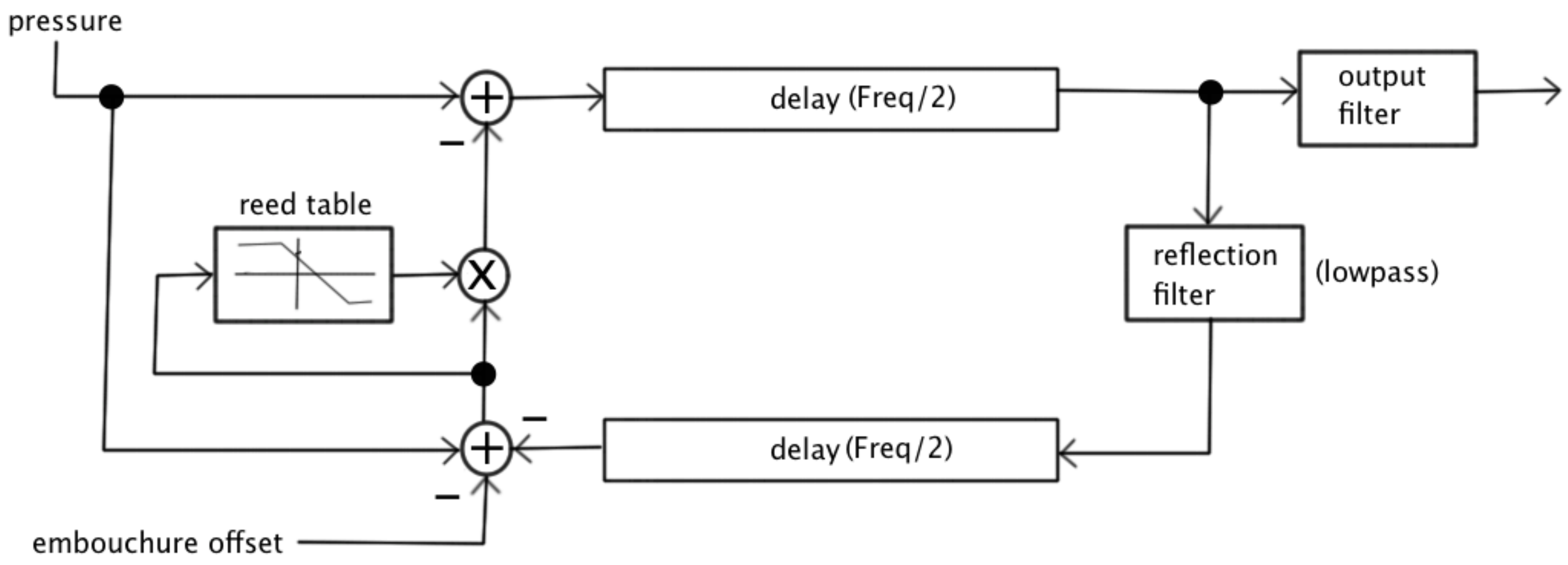
Slide Flute Model



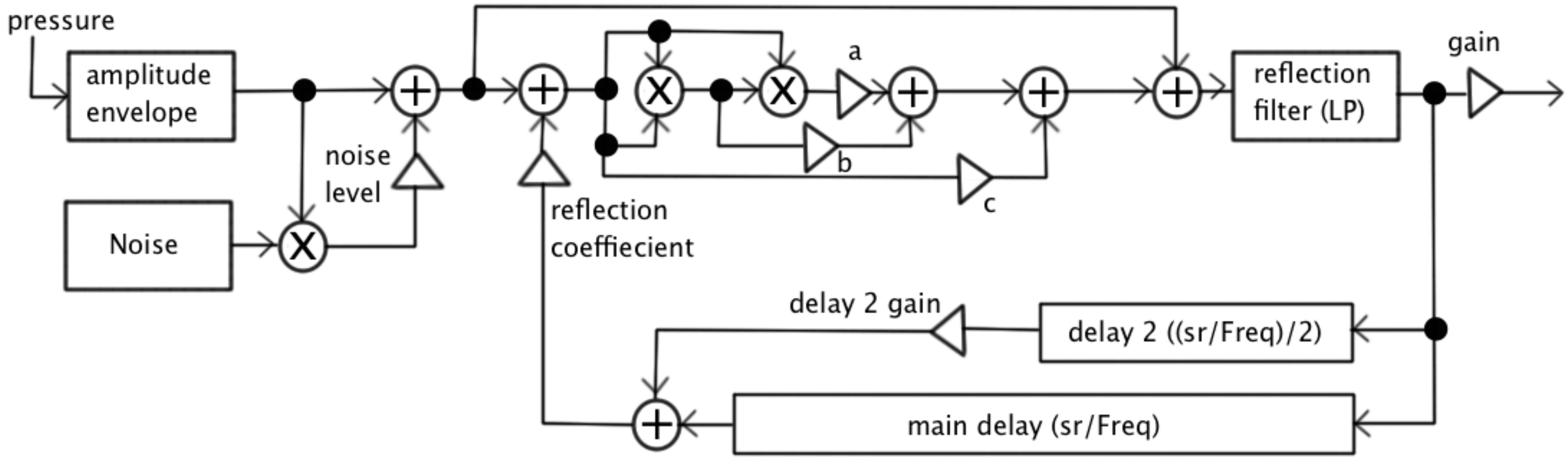
Resonant Air Cavity (blown bottle)



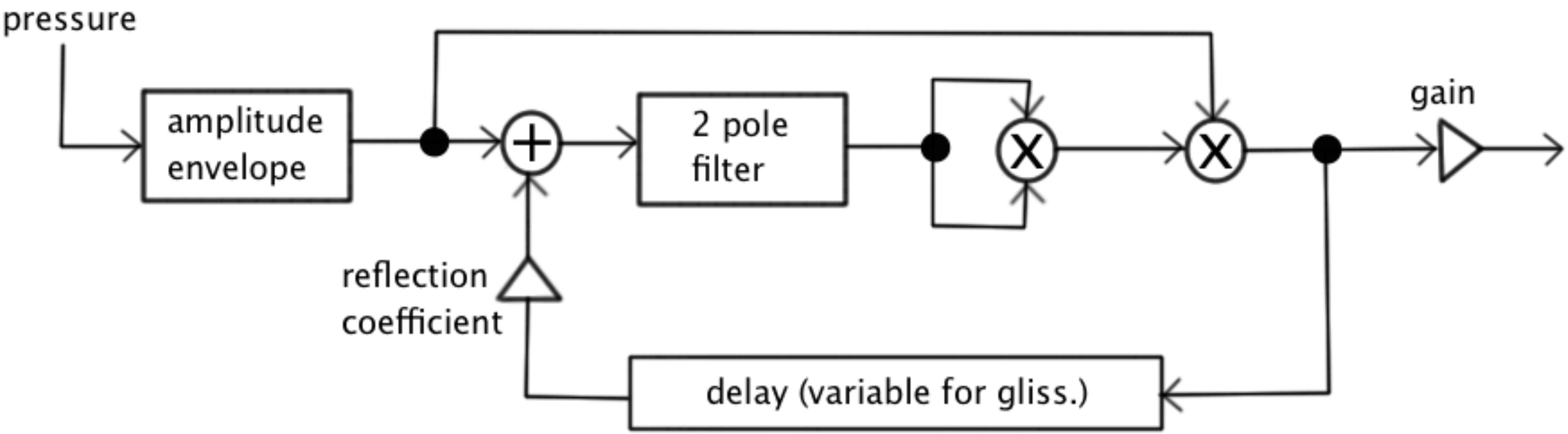
Waveguide Clarinet



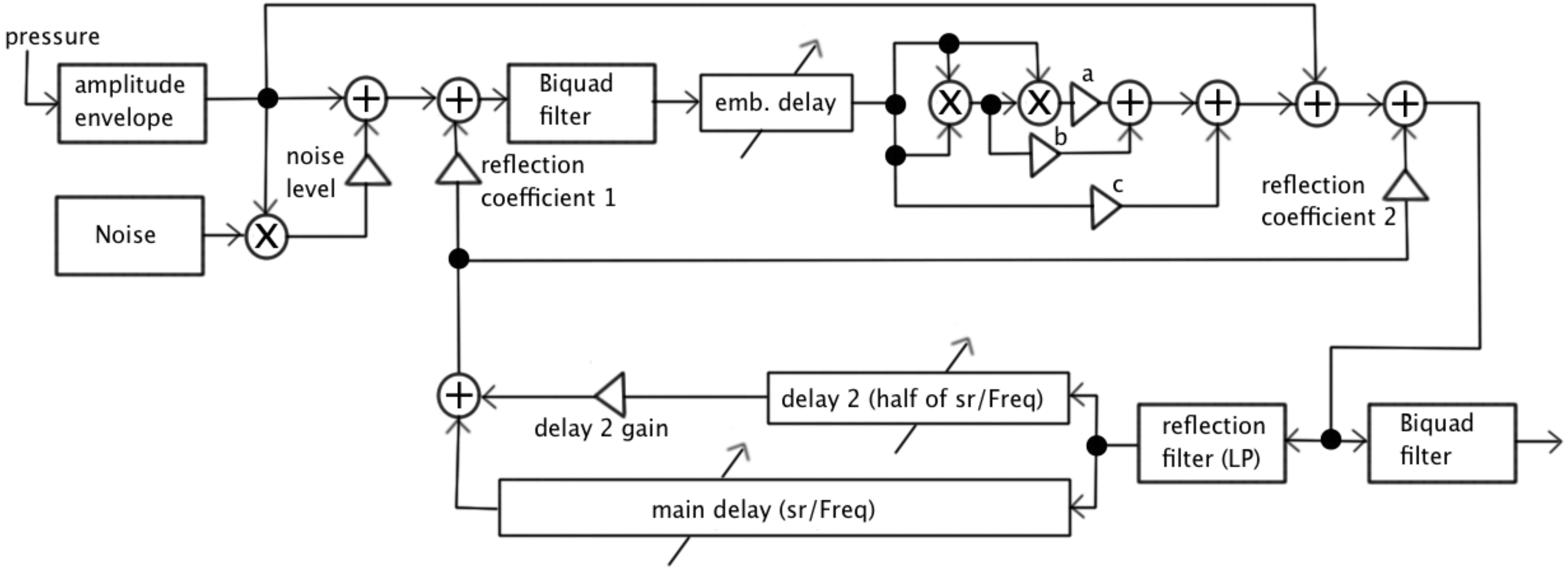
Clarinot (Perry Cook Model)



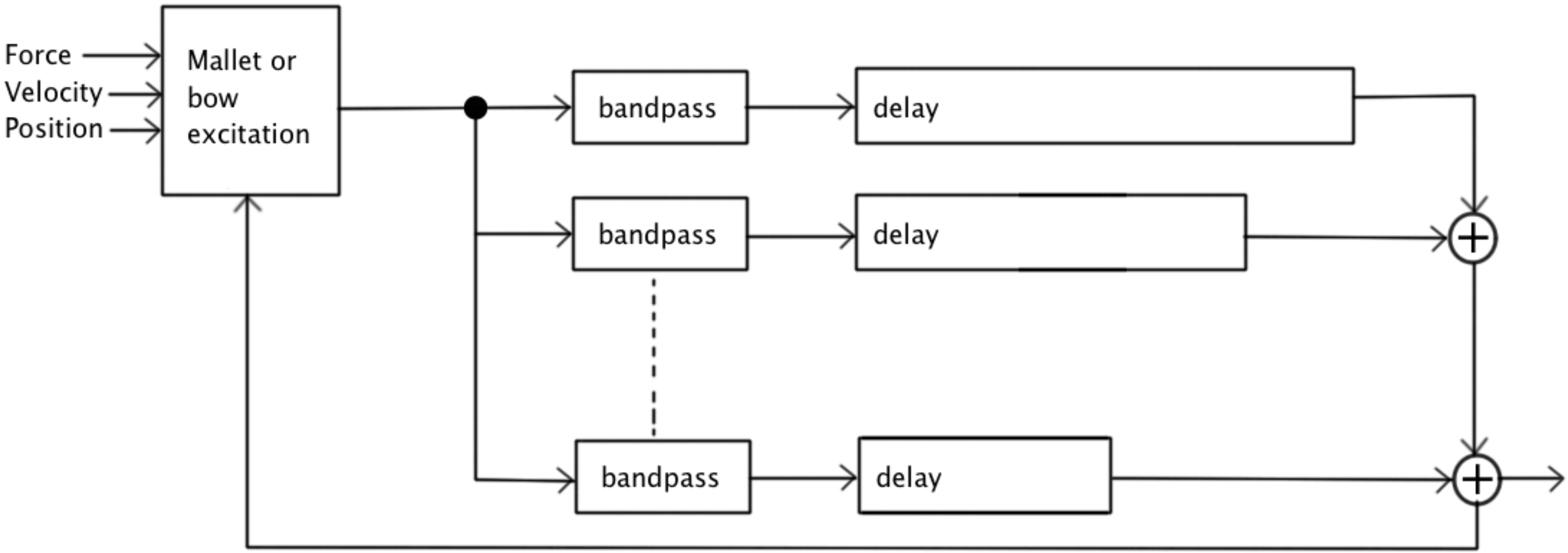
Brass Waveguide Model



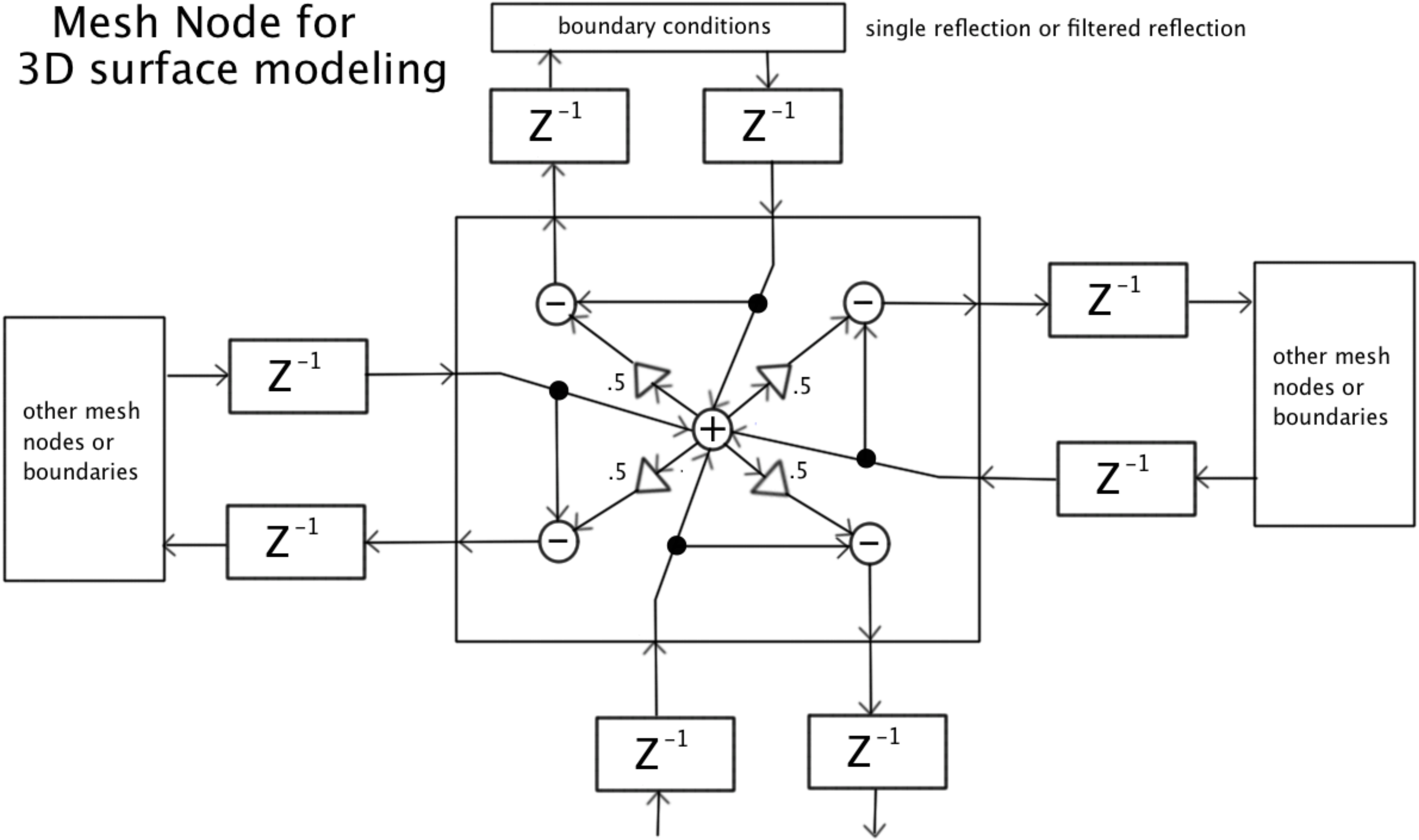
Meta-Instrument (Perry Cook)



Rigid Bars/Blocks with Banded Waveguides



Mesh Node for 3D surface modeling



3D Mesh

Mesh nodes (scattering junctions) are connected to each other using waveguides. These can be single sample delays or variable length delay lines. One can model a wide variety of shapes. It is also possible to connect one boundary to another to create various shapes (spheres, cubes, Moebius strips, etc.).

boundaries can either simply reflect back with a reflection coefficient (0 to -1.0) or wrap around to another side.