ECE 797:

Speech and Audio Processing

Hand-out for Lecture #4

Thursday, February 5, 2004

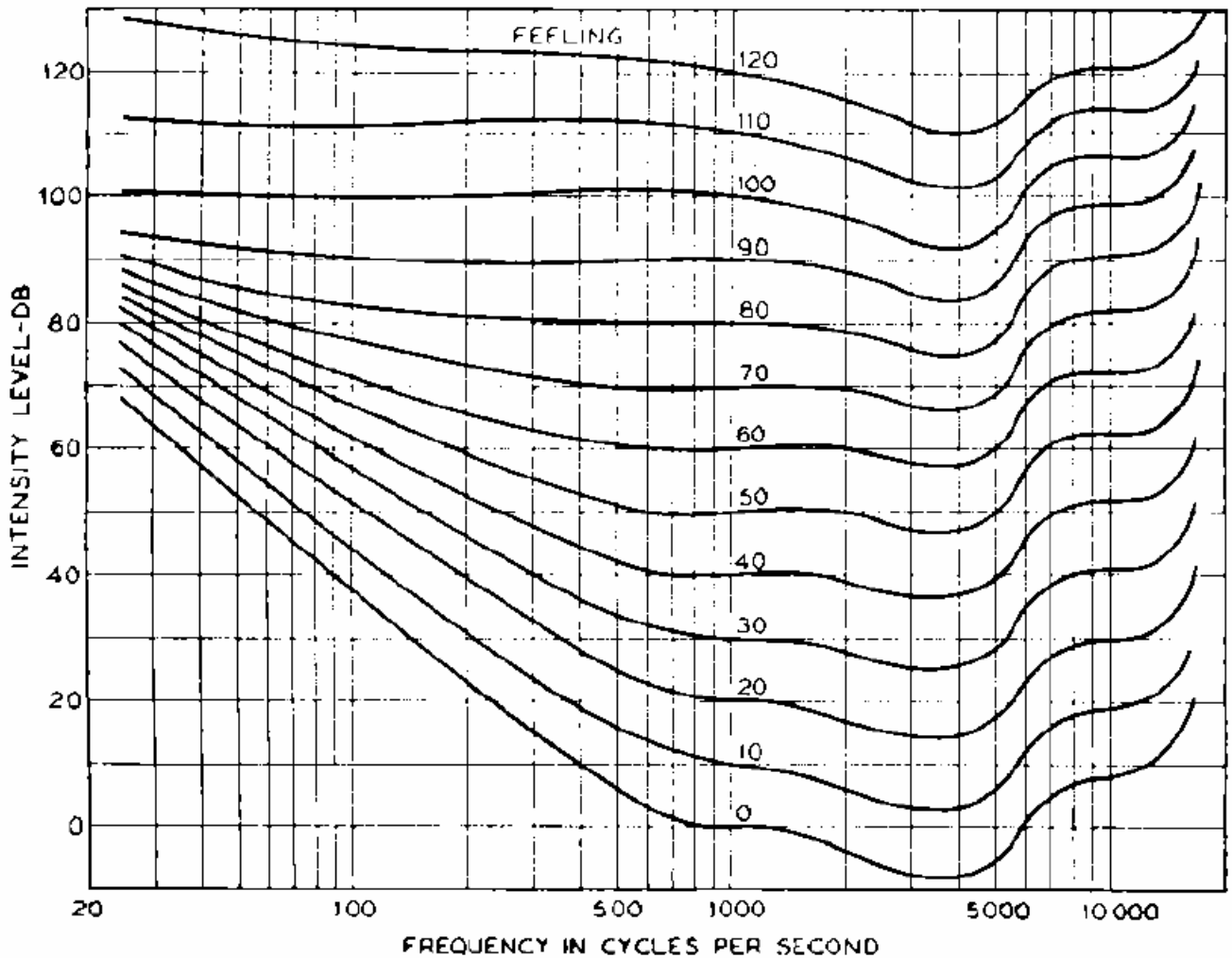
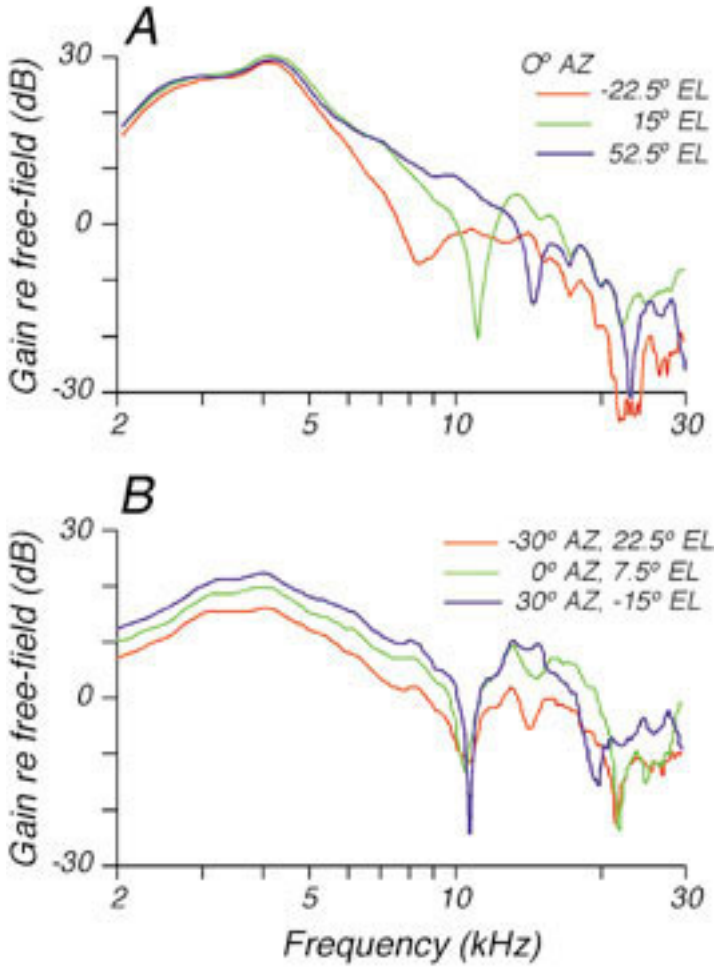
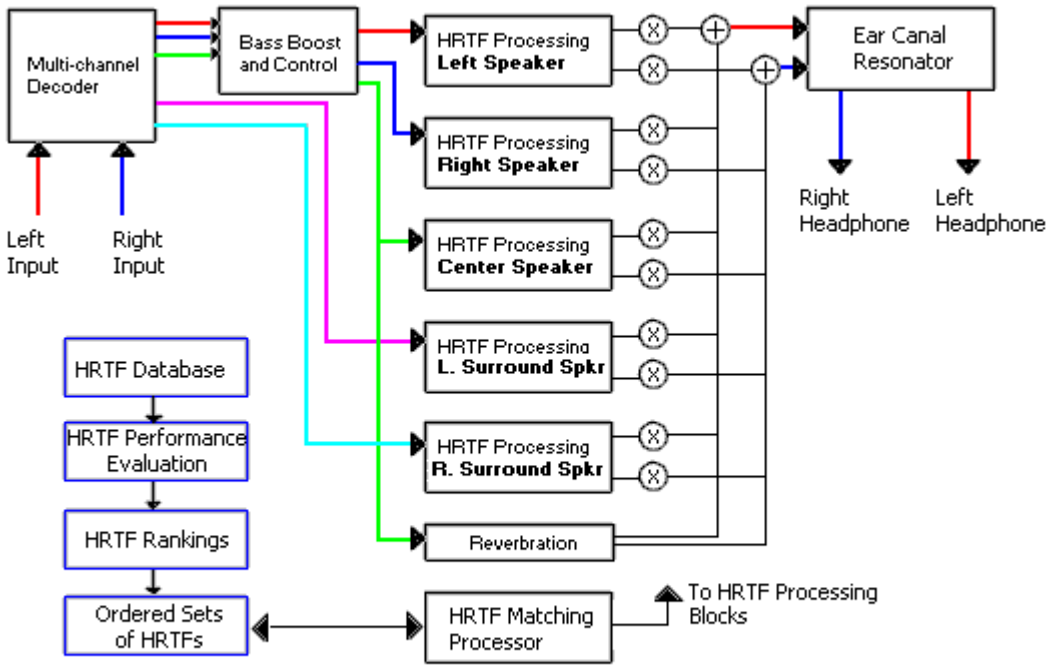


FIG. 4. Loudness level contours.

(Fletcher and Munson, 1933)

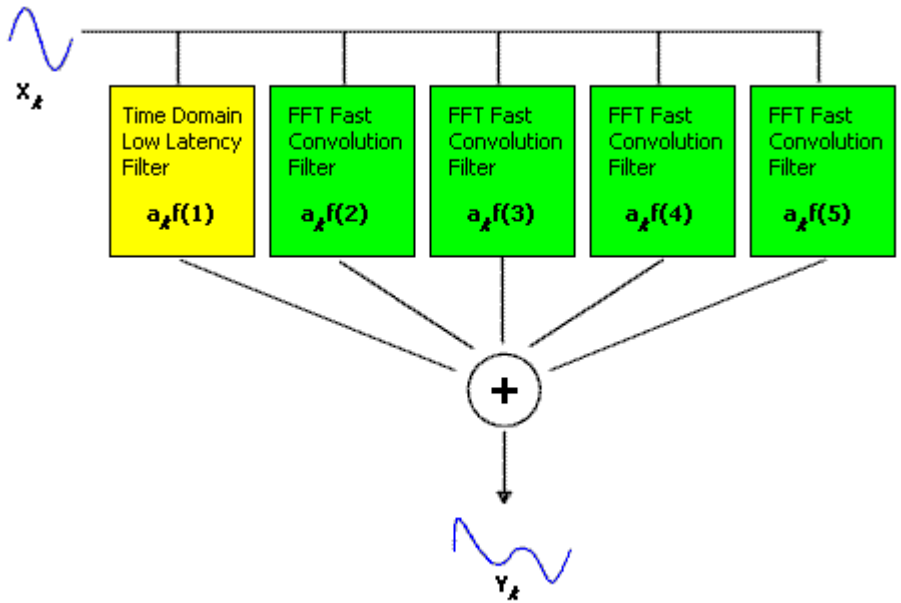


(Davis et al., JARO, 2003)



Multi-channel Signal Processor For Headphones

(T.J. Tucker, D.M. Green, Patent # 5,742,689)



Composite Digital Filter With Low Latency and High Accuracy

(Src: David S. McGrath, Patent No. 5,502,747)

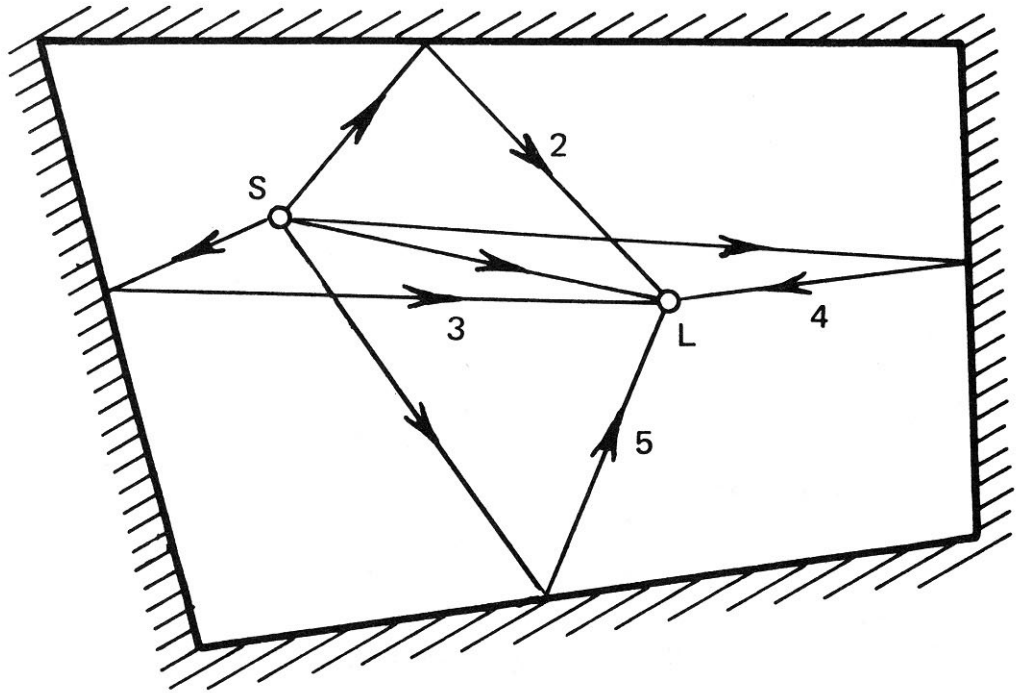
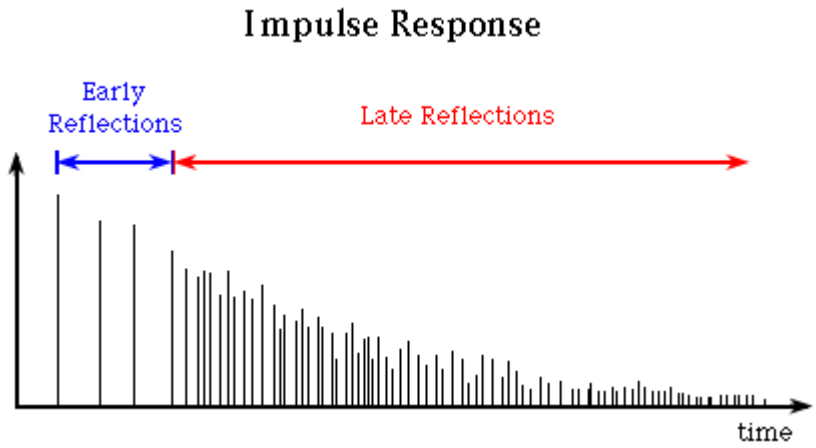


FIGURE 4.26 Example of different propagation paths of a sound wave from souce point S to a listener at L.

(Roederer, 1994)


Impulse Response
Early
Reflections
Late Reflections
time

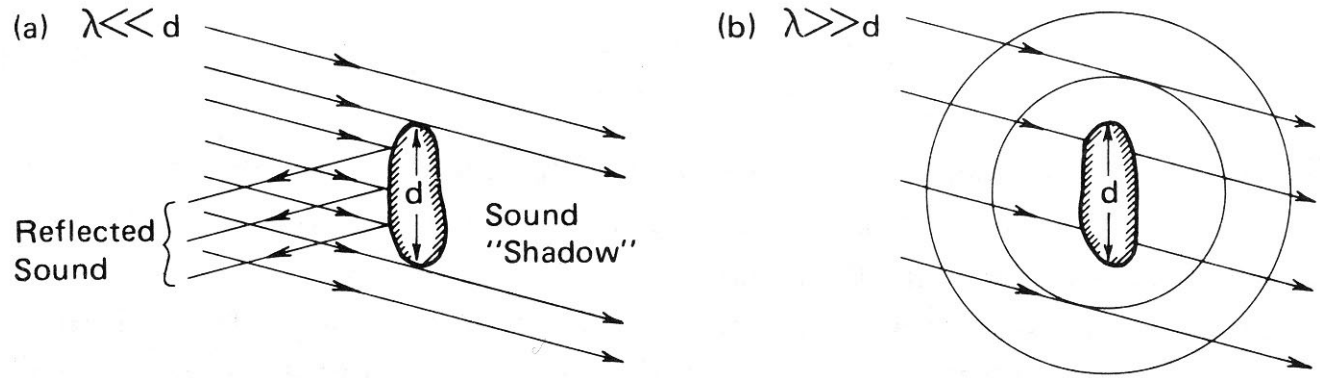


FIGURE 4.28 Sound wave interation with an obstacle. (a): short wavelengths (reflection and/or absorption); (b): long wavelengths (diffraction).

(Roederer, 1994)

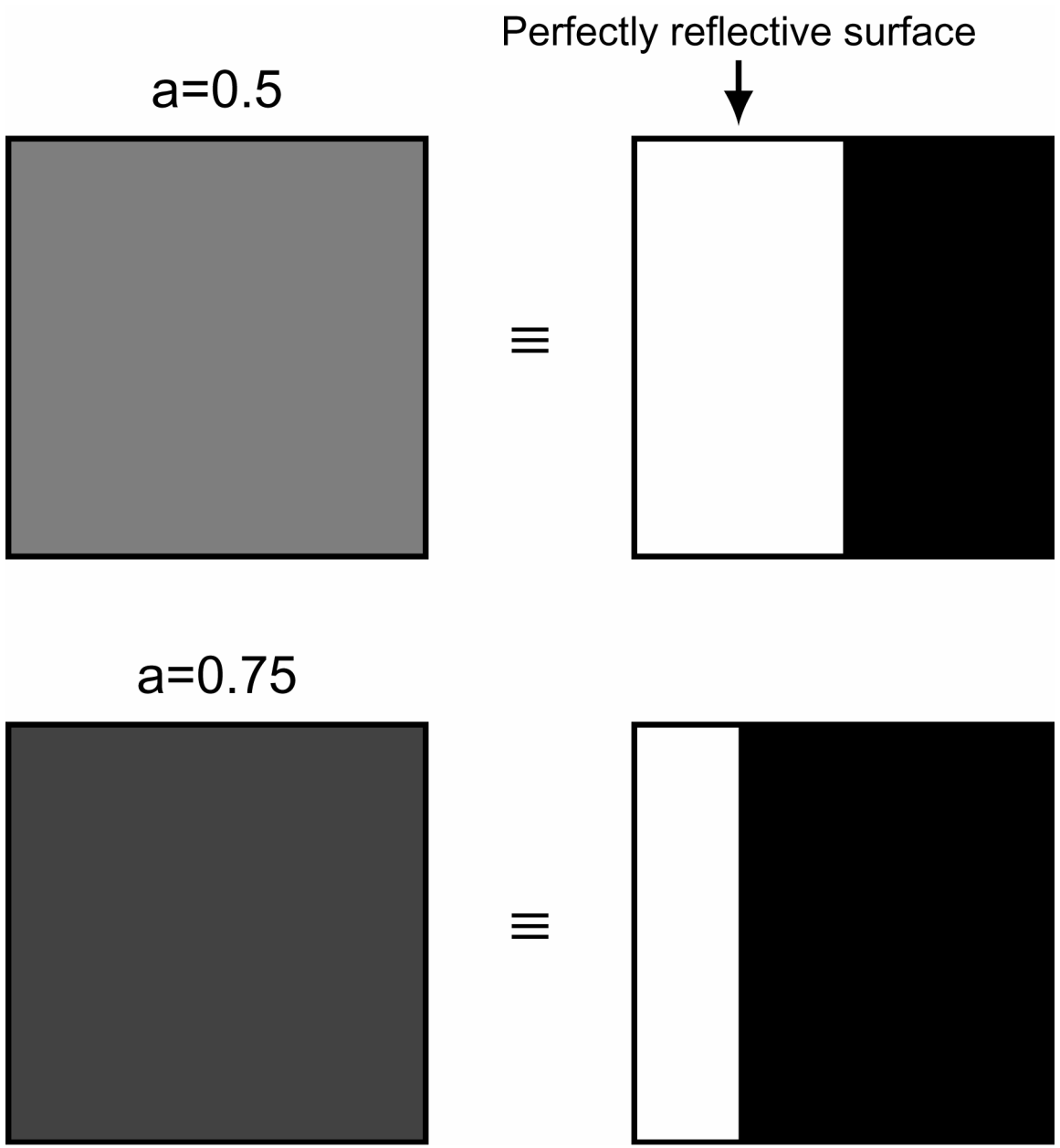
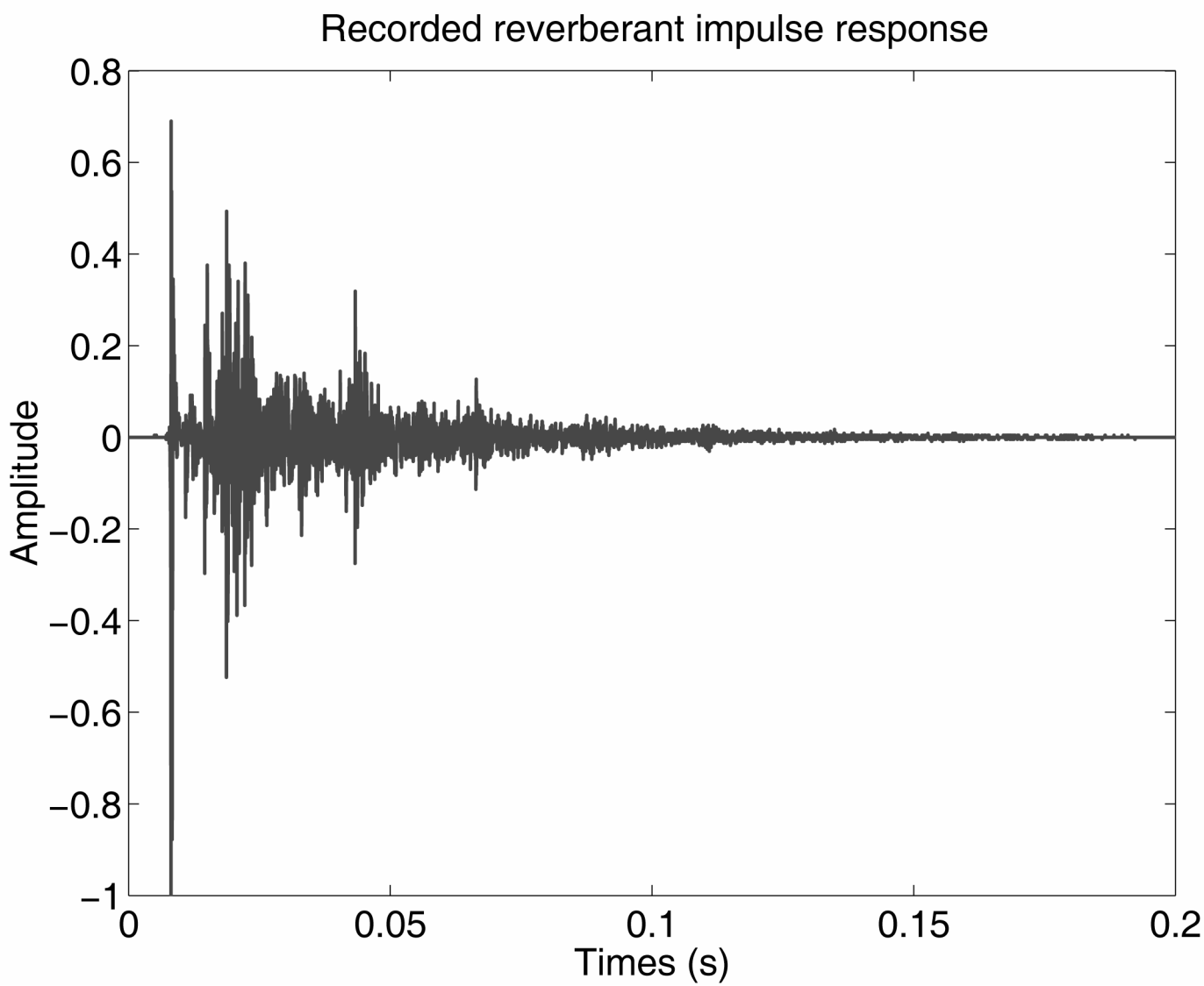

Perfectly reflective surface
a=0.5
≡
a=0.75
≡

TABLE 13.1 Effective Absorption Coefficients of Common Building Materials[a]

	Frequency in Hz		
Material	**125**	**500**	**2000**
Acoustic paneling	0.16	0.50	0.80
Acoustic plaster	0.30	0.50	0.55
Brick wall, unpainted	0.02	0.03	0.05
Draperies			
light	0.04	0.11	0.30
heavy	0.10	0.50	0.82
Felt	0.13	0.56	0.65
Floor			
concrete	0.01	0.02	0.02
wood	0.06	0.06	0.06
carpeted	0.11	0.37	0.27
Glass	0.04	0.05	0.05
Marble or glazed tile	0.01	0.01	0.02
Plaster	0.04	0.05	0.05
Rock wool	0.35	0.63	0.83
Wood paneling, pine	0.10	0.10	0.08

[a]From [3]. The coefficients listed here are only representative.

(Gold and Morgan)

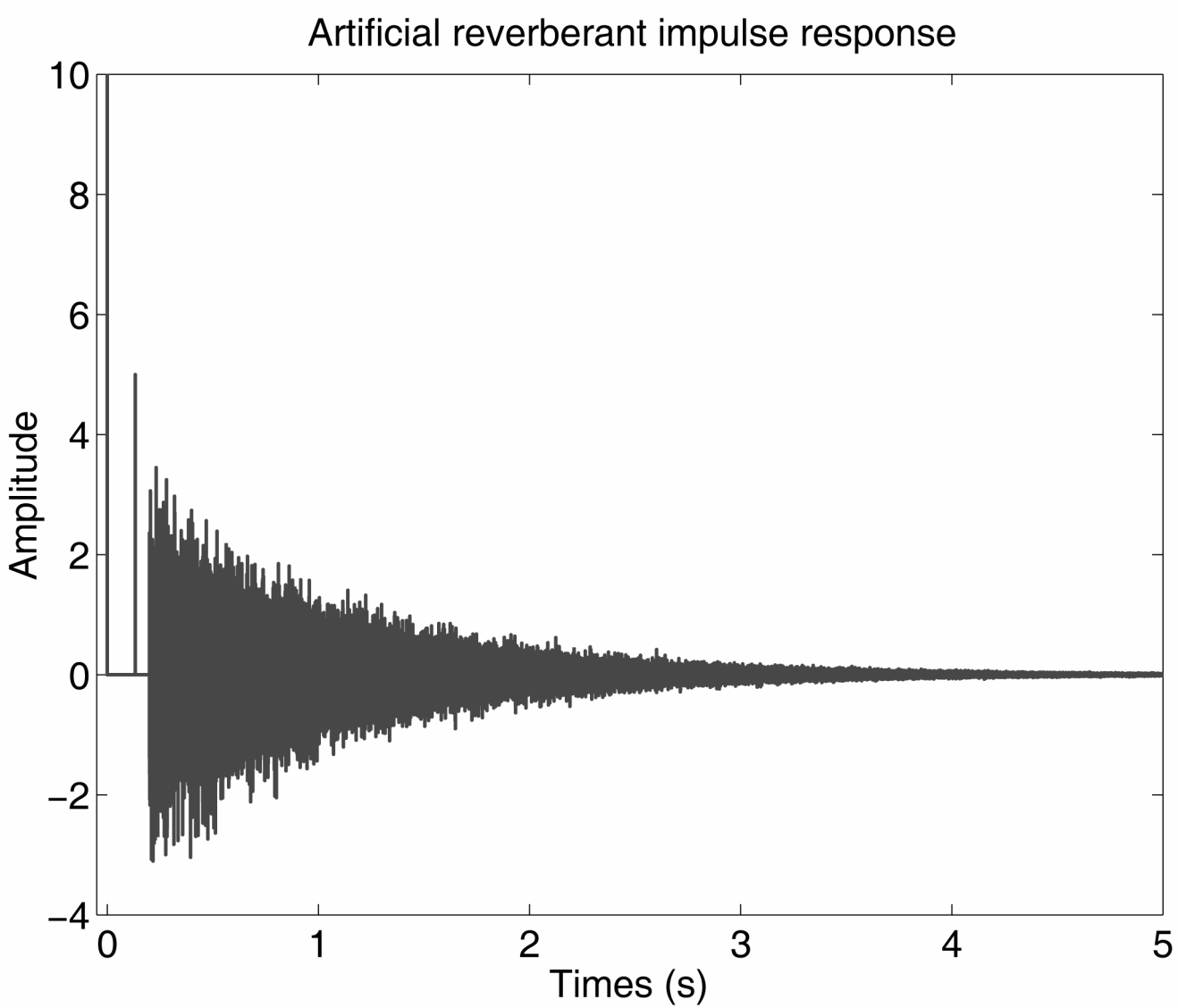


Clean speech

Reverberant speech

Clean music

Reverberant music



Clean speech

Reverberant speech

Clean music

Reverberant music

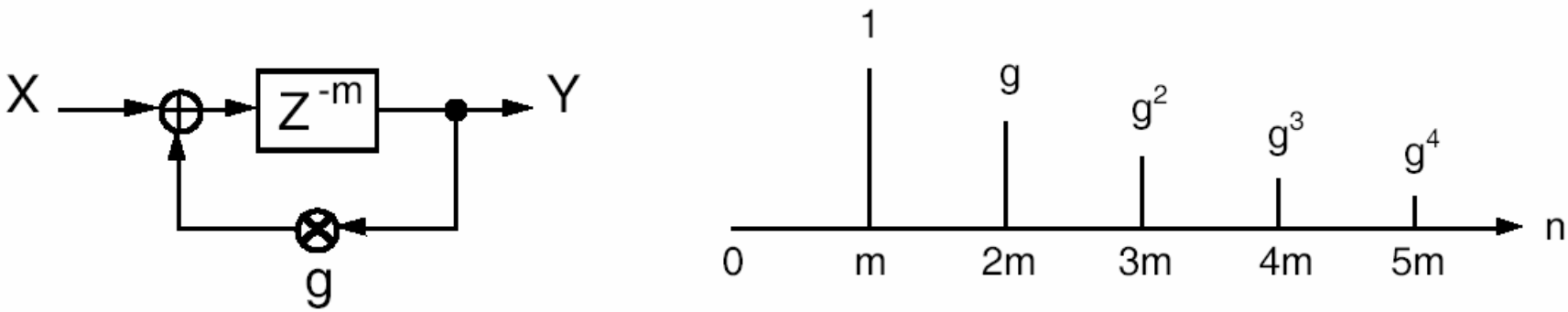
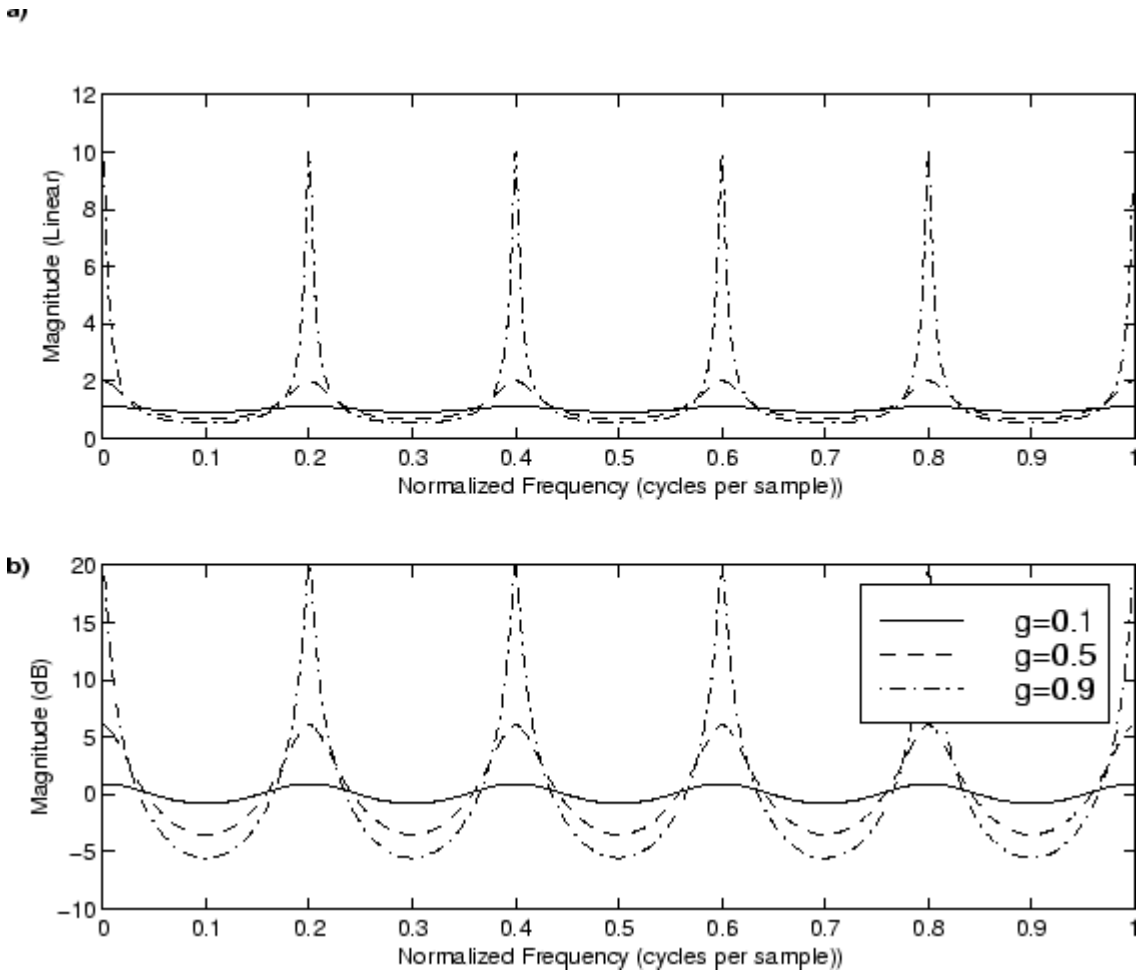


Figure 2.1 Comb filter flow diagram and impulse response.

(Gardner, 1992)



Comb filter frequency response

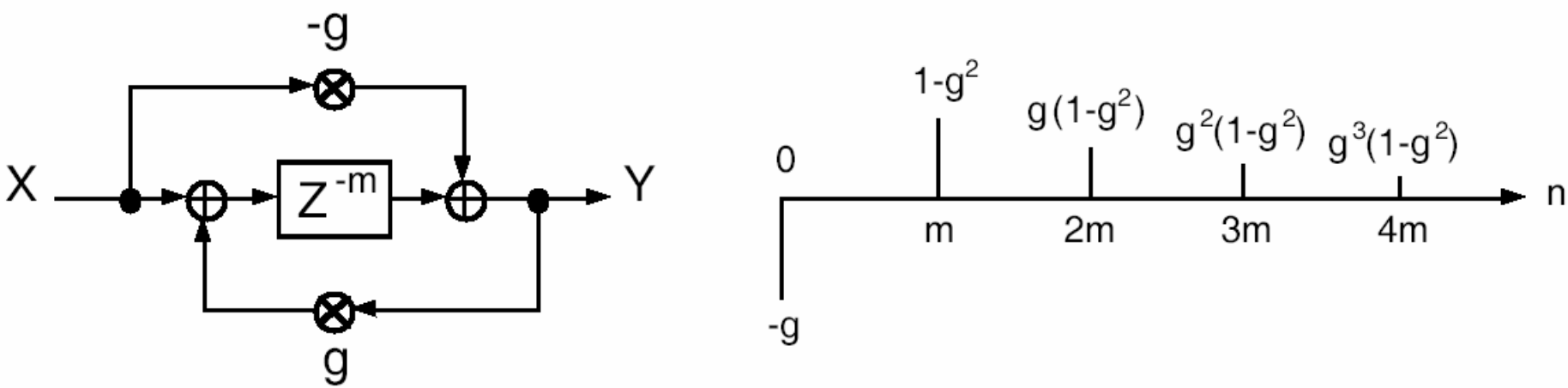


Figure 2.2 Allpass filter flow diagram and impulse response.

(Gardner, 1992)

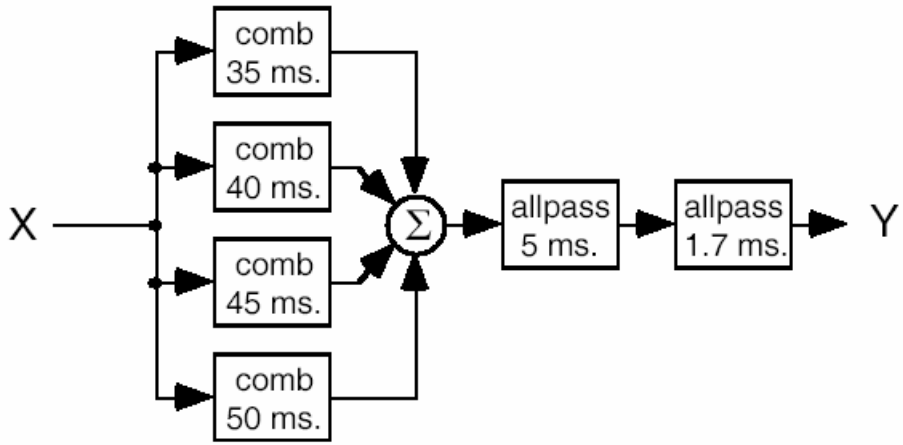


Figure 2.3 Flow diagram of Schroeder reverberator. Delay lengths shown in milliseconds, allpass filter gains are 0.7, comb gains are determined by desired reverberation time.

(Gardner, 1992)

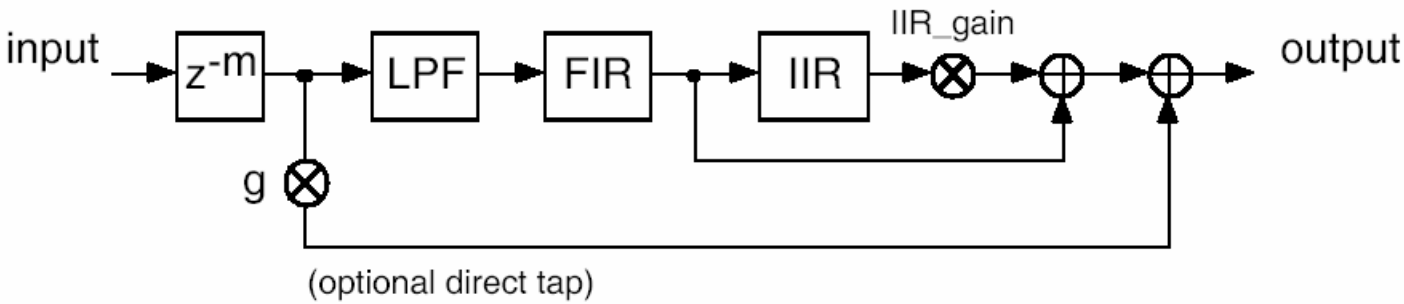


Figure 4.12 Combining FIR and IIR reverberators.

(Gardner, 1992)

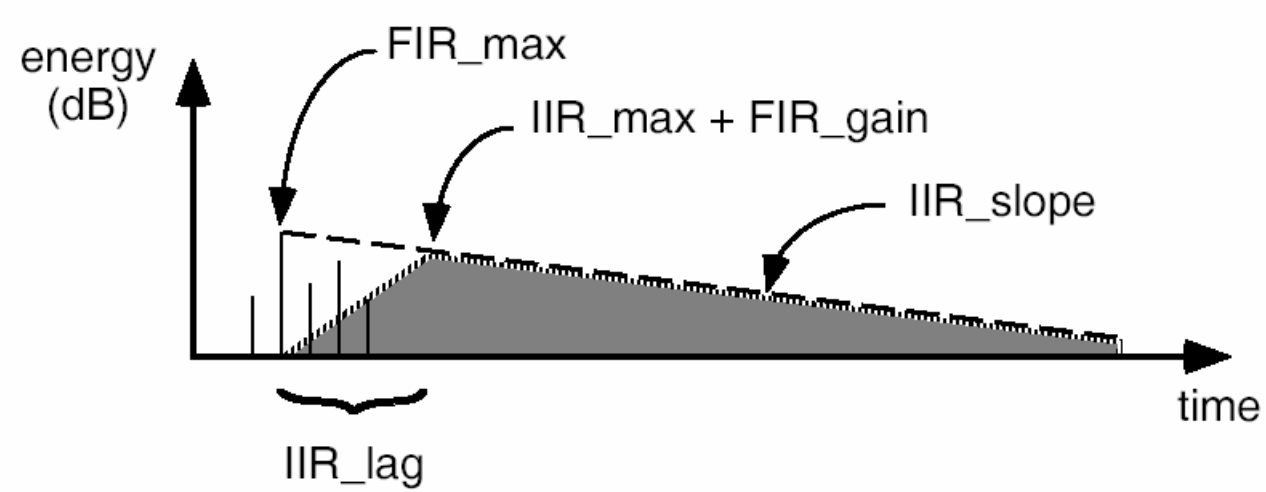


Figure 4.13 Combining FIR and IIR responses.

(Gardner, 1992)

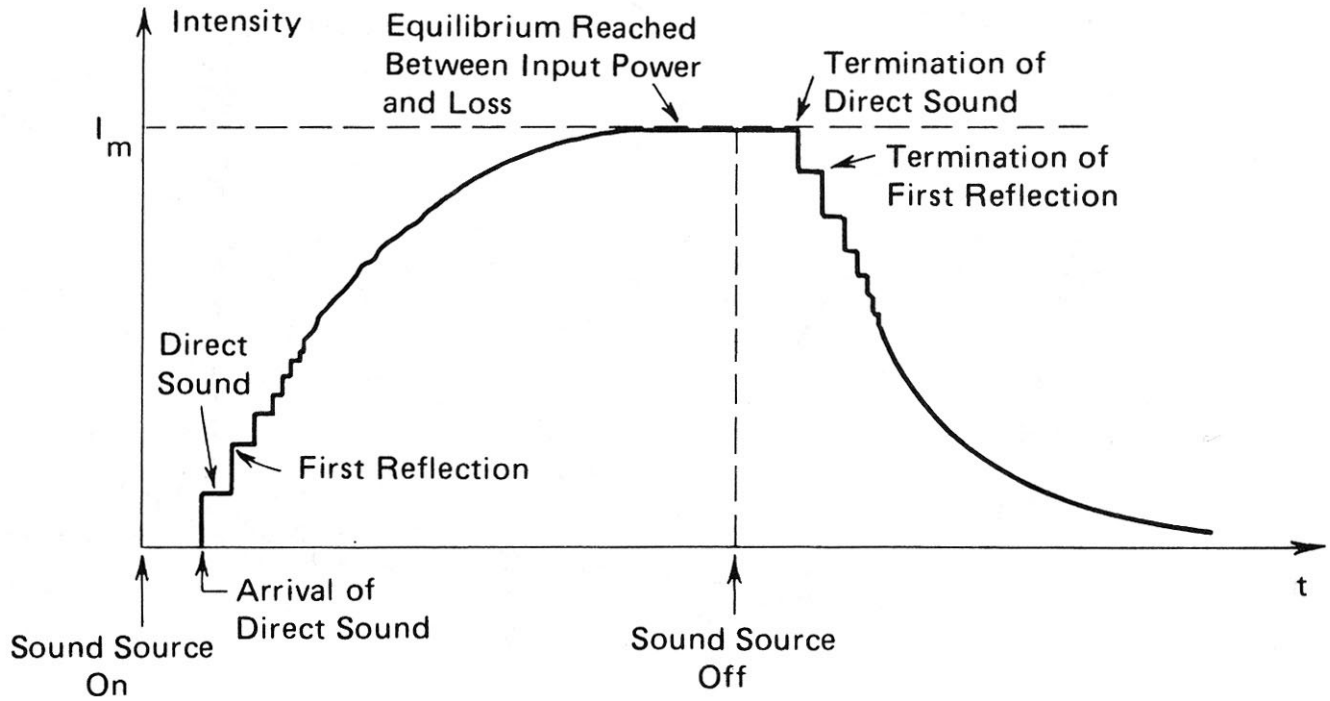
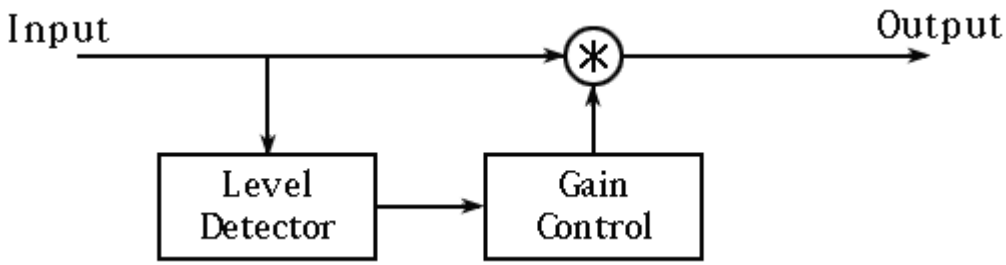
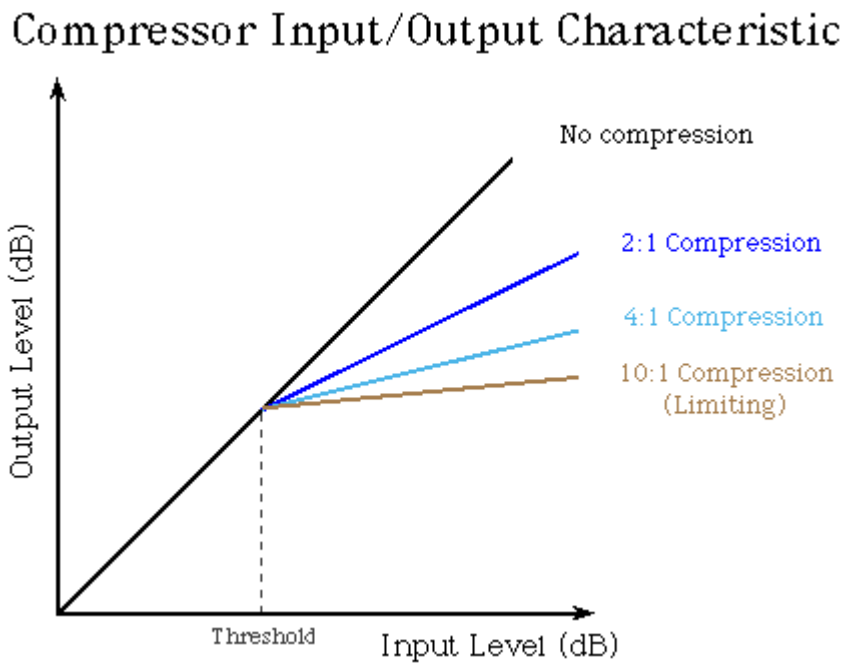


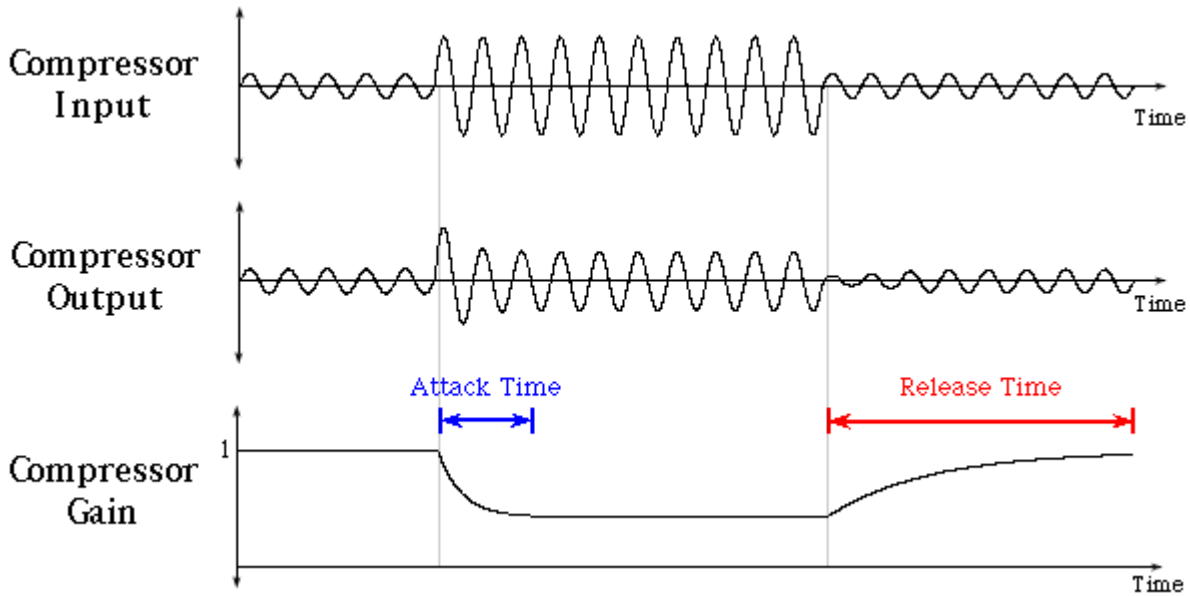
FIGURE 4.27 Typical tone intensity buildup and decay in a hall (linear scale).

(Roederer, 1994)

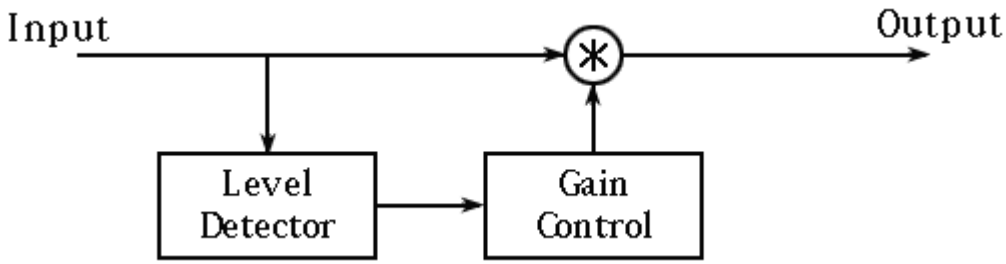
“Compressor/limiter” effect

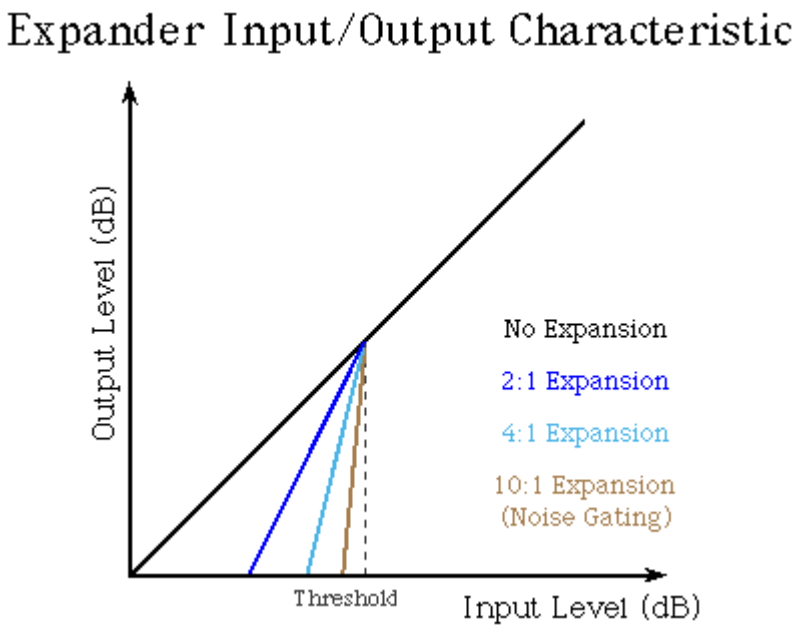


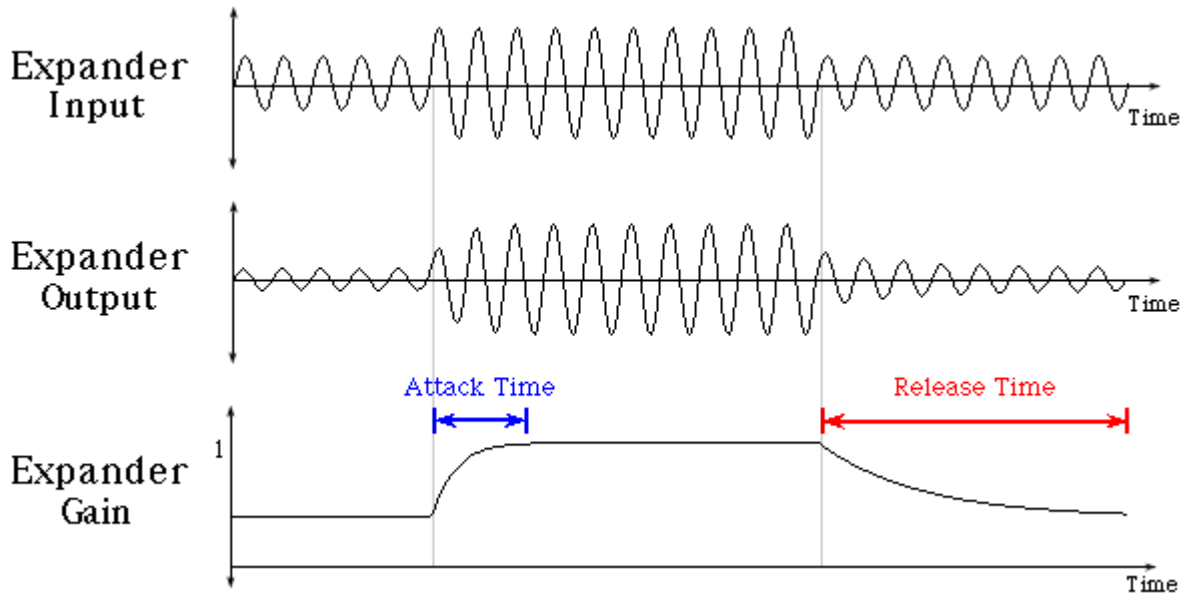



Compressor Input
Time
Compressor Output
Time
Attack Time
Release Time
Compressor Gain
1
Time

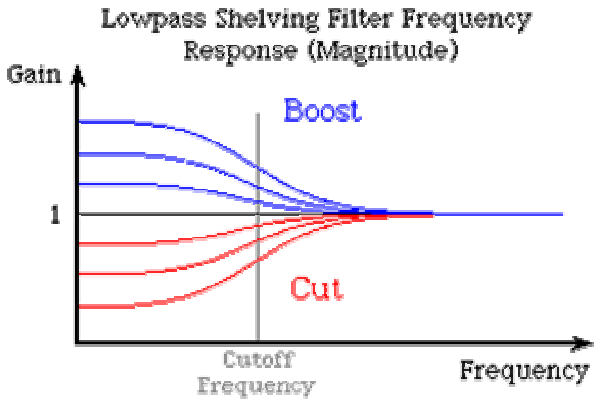
“Expander/noise-gating” effect

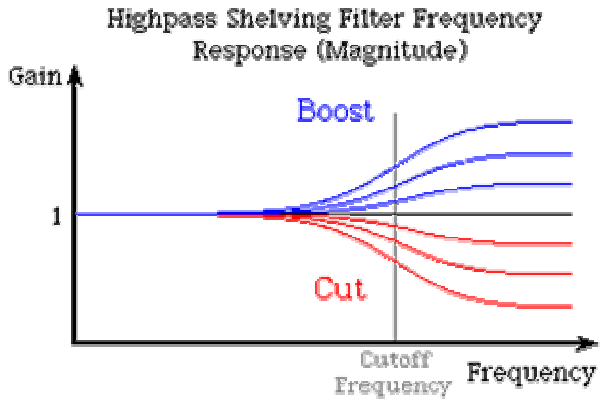


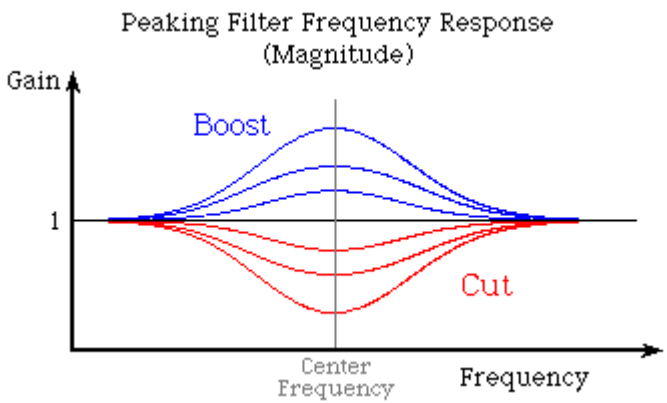


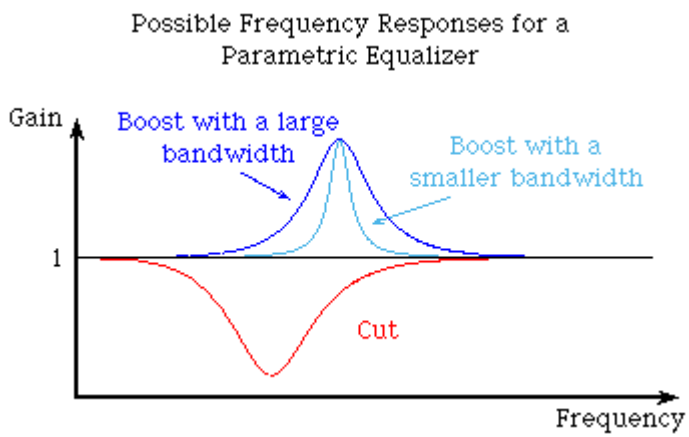

Expander Input
Time
Expander Output
Time
Attack Time
Release Time
Expander Gain
1
Time

Equalization

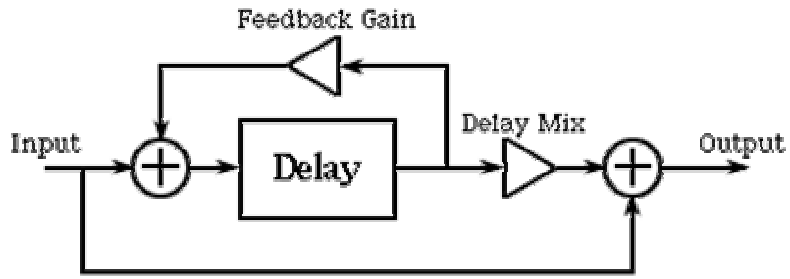




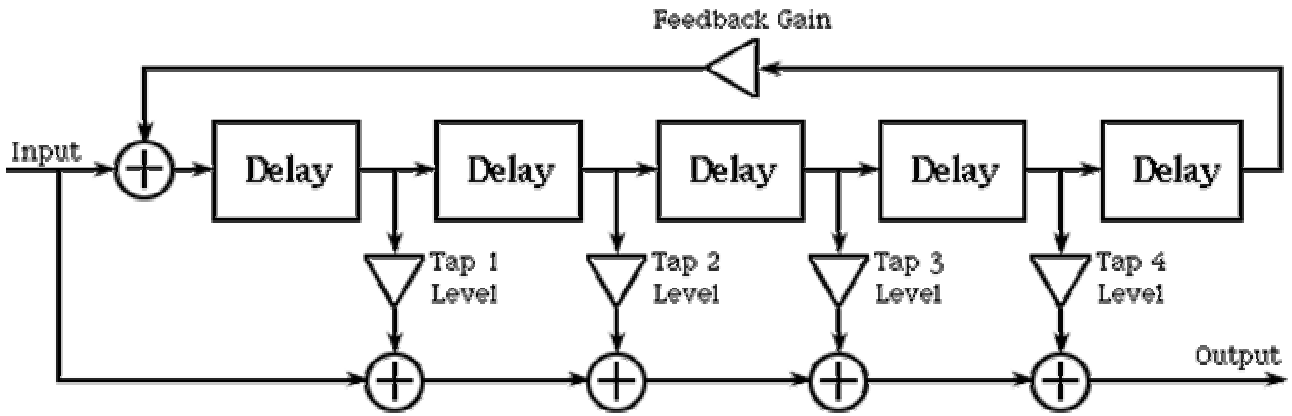




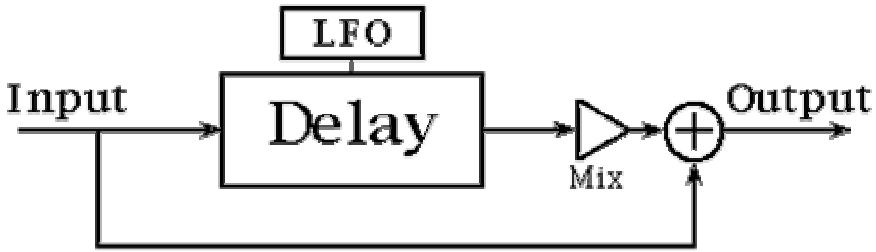
“Delay” effect

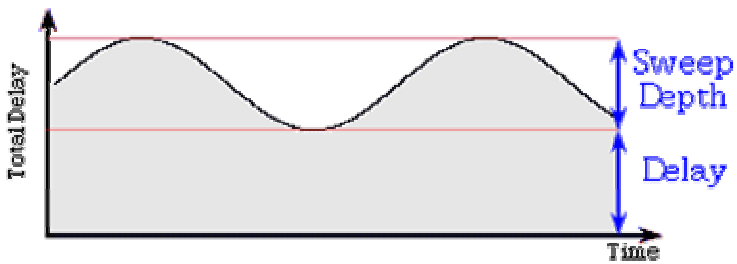


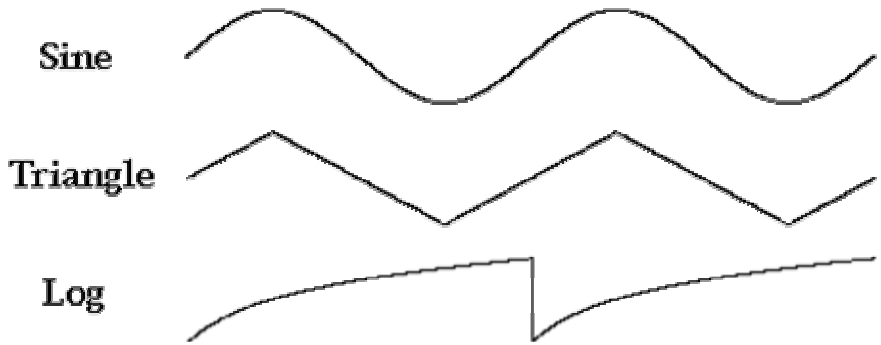
- Increasing delay and feedback gain
- 40-ms delay
- 1.5-s delay



“Chorus” effect







“Phaser/flanger” effect