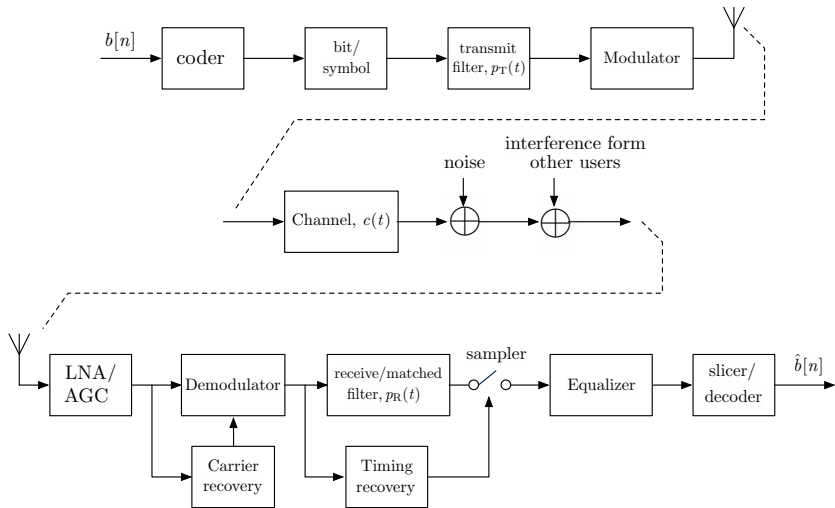


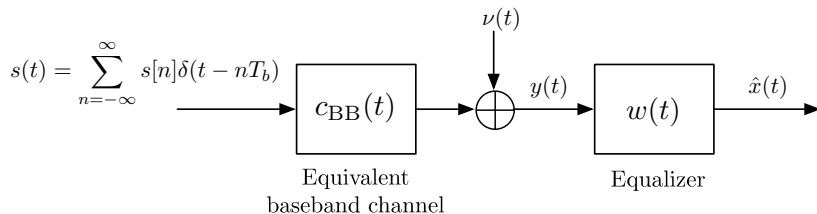
Chapter 11

Channel Equalization

March 26, 2008

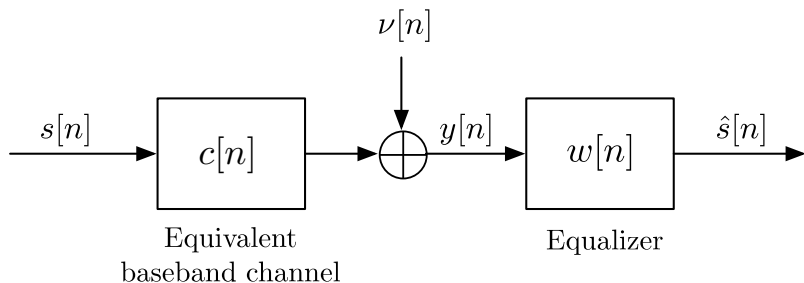


11.1 Continuous-Time Channel Model

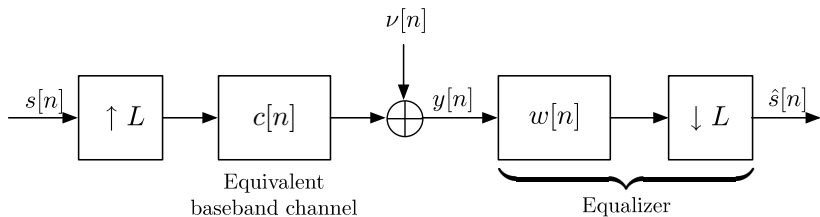


11.1 Discrete-Time Channel Model

11.2.1 Symbol-spaced equalizer

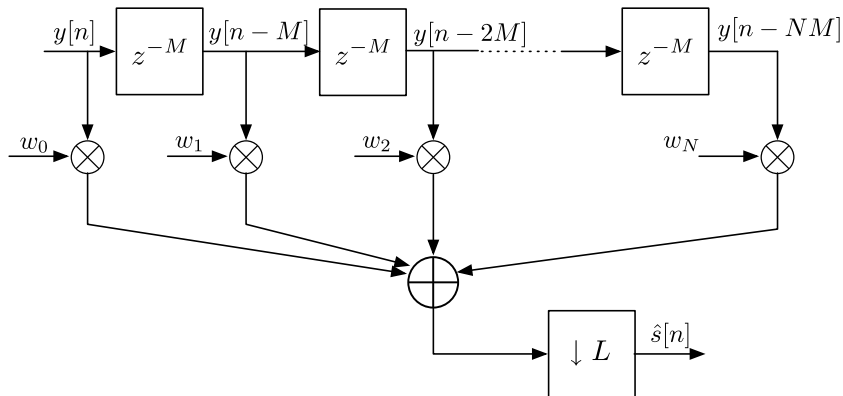


11.2.2 Fractionally-spaced equalizer



11.2.2 Fractionally-spaced equalizer (continued)

Details of a fractionally-spaced equalizer with tap-spacing $(M/L)T_b$



11.2.3 Symbol-spaced versus fractionally-spaced equalizer

A fractionally -spaced equalizer has the following advantages over its symbol-spaced counterpart:

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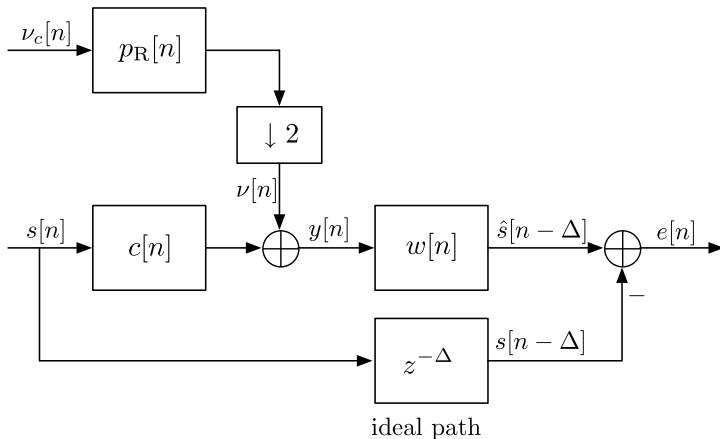
Symbol-spaced equalizers, on the other hand, may offer lower complexity, in some cases (NOT ALWAYS!).

11.3 Performance Study of Equalizers

This section presents a detailed derivation of equations that may be used to evaluate the optimum coefficients of symbol-spaced and fractionally-spaced equalizers and the respective minimum mean-square errors (MMSEs).

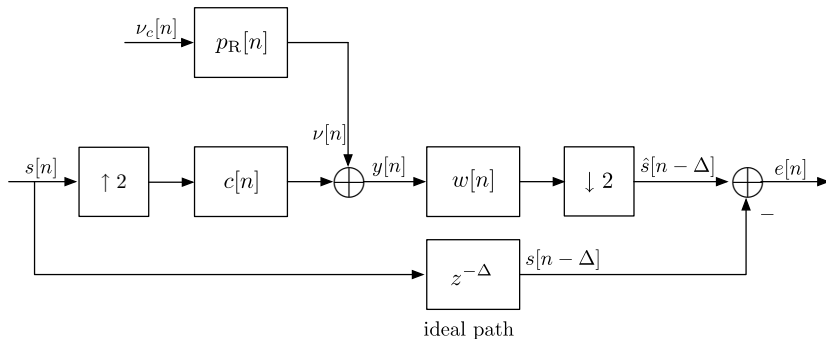
11.3 Performance Study of Equalizers (continued)

System set-up for study of a symbol-spaced equalizer:



11.3 Performance Study of Equalizers (continued)

System set-up for study of a half symbol-spaced equalizer:



11.3.2 Numerical examples

Simulated channels:

$$c = c_1 = [1 \text{ zeros}(1, 91) 0.4];$$

$$c = c_2 = [0.5 \text{ zeros}(1, 60) 1 \text{ zeros}(1, 123) 0.25];$$

$$c = c_3 = [1 \text{ zeros}(1, 67) 0.75 \text{ zeros}(1, 145) 0.4];$$

$$c = c_4 = [1 \text{ zeros}(1, 75) 0.6 \text{ zeros}(1, 103) 0.2];$$

11.3.2 Numerical examples

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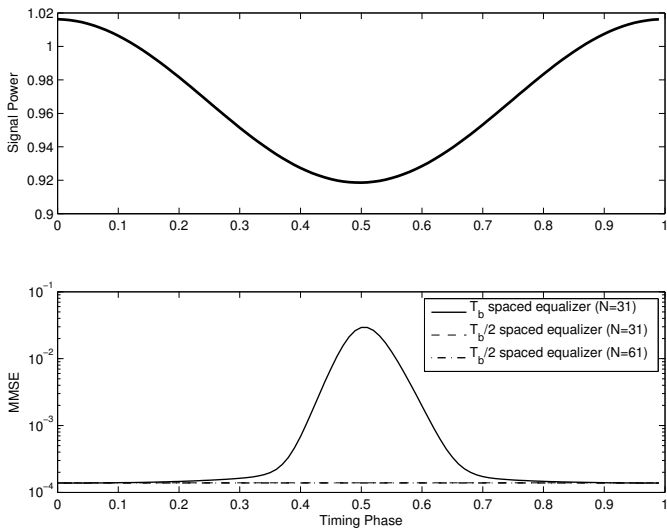
$$c = c_4 = [1 \text{ zeros}(1, 75) 0.6 \text{ zeros}(1, 103) 0.2];$$

A good choice of Δ :

$$\Delta = \frac{1}{2}(\text{length of channel} + \text{length of equalizer})$$

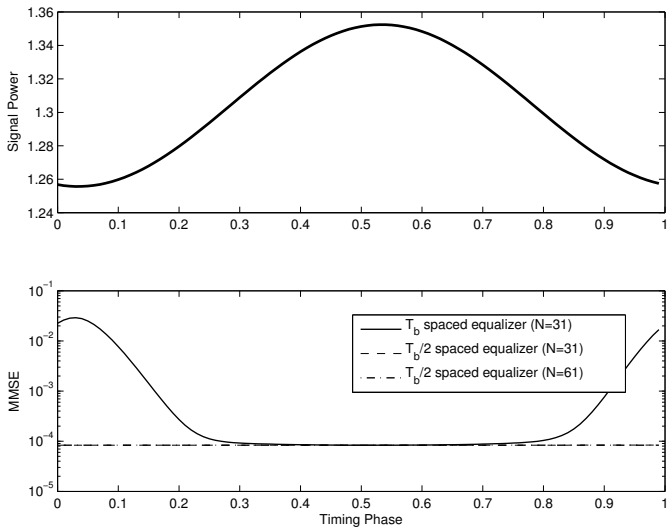
11.3.2 Numerical examples

$$c_1 = [1 \text{ zeros}(1, 91) 0.4];$$



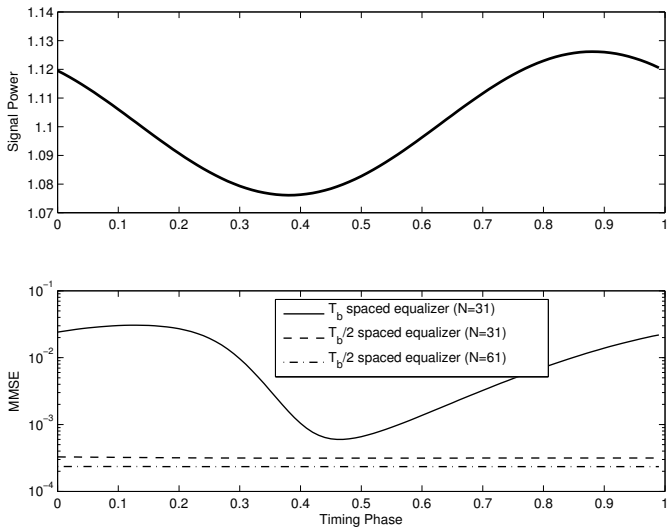
11.3.2 Numerical examples

$$c_2 = [0.5 \text{ zeros}(1, 60) \ 1 \ \text{zeros}(1, 123) \ 0.25];$$



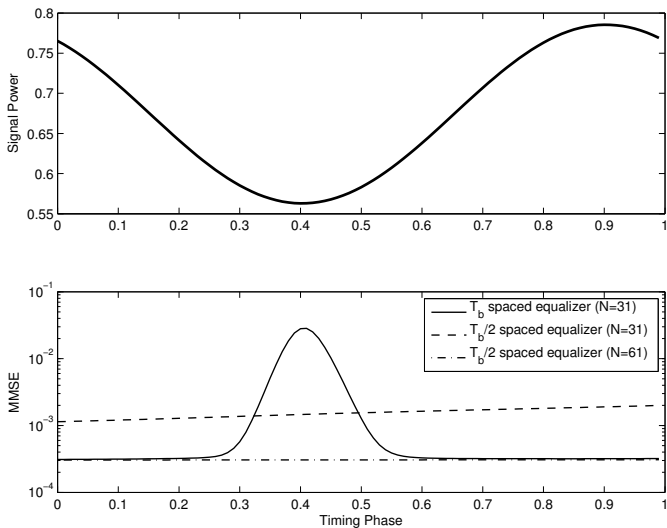
11.3.2 Numerical examples

$$c_3 = [1 \text{ zeros}(1, 67) 0.75 \text{ zeros}(1, 145) 0.4];$$



11.3.2 Numerical examples

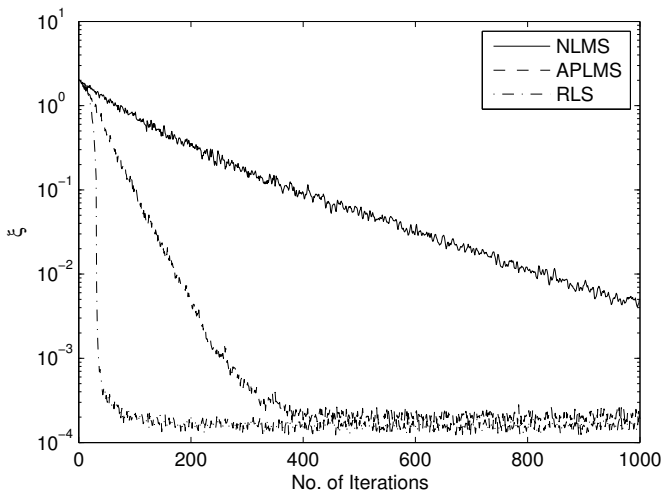
$$\mathbf{c}_4 = [1 \text{ zeros}(1, 75) 0.6 \text{ zeros}(1, 103) 0.2];$$



11.4 Adaptation Algorithms

Symbol-spaced equalizer:

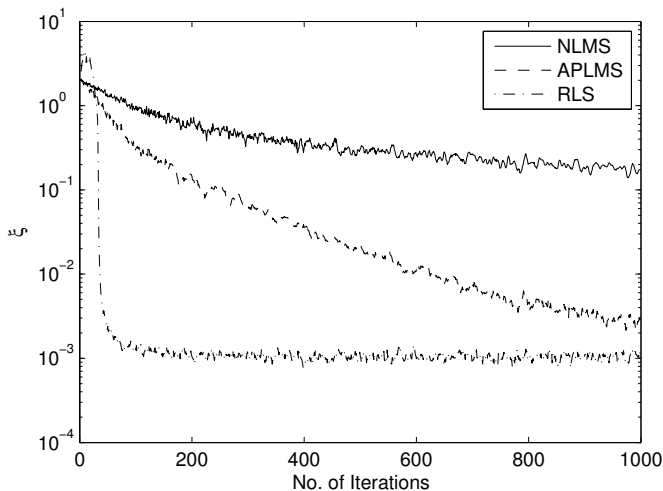
$$c_1 = [1 \text{ zeros}(1, 67) 0.75 \text{ zeros}(1, 145) 0.4];$$



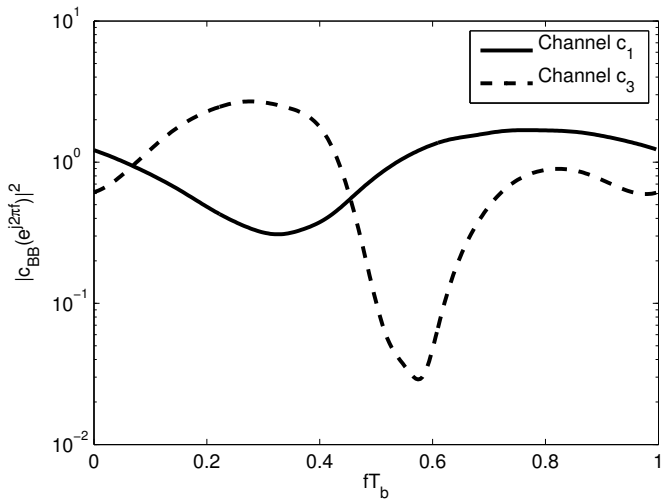
11.4 Adaptation Algorithms

Symbol-spaced equalizer:

$$c_3 = [1 \text{ zeros}(1, 67) 0.75 \text{ zeros}(1, 145) 0.4];$$



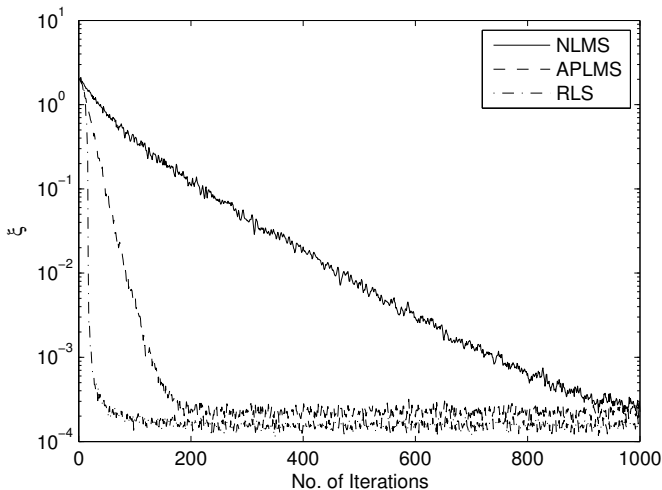
11.4 Adaptation Algorithms



11.4 Adaptation Algorithms

Fractionally-spaced equalizer:

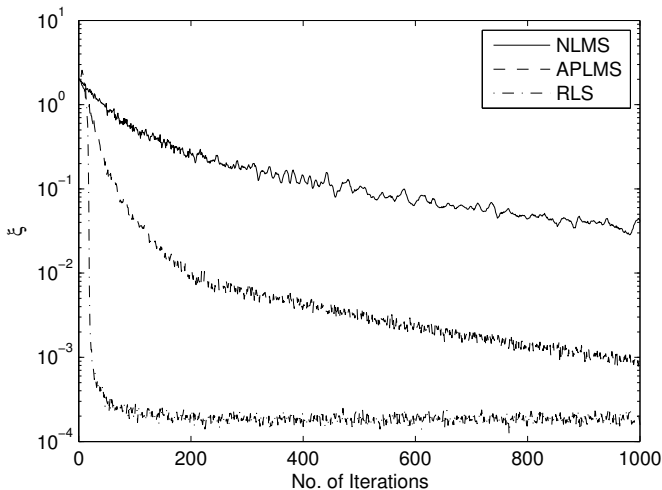
$$c_1 = [1 \text{ zeros}(1, 67) 0.75 \text{ zeros}(1, 145) 0.4];$$



11.4 Adaptation Algorithms

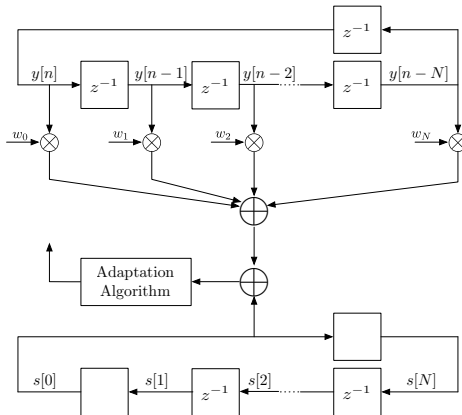
Fractionally-spaced equalizer:

$$\mathbf{c}_3 = [1 \text{ zeros}(1, 67) 0.75 \text{ zeros}(1, 145) 0.4];$$



11.5 Cyclic Equalization

Symbol-spaced equalizer:



for $i = 0, 1, 2, \dots$

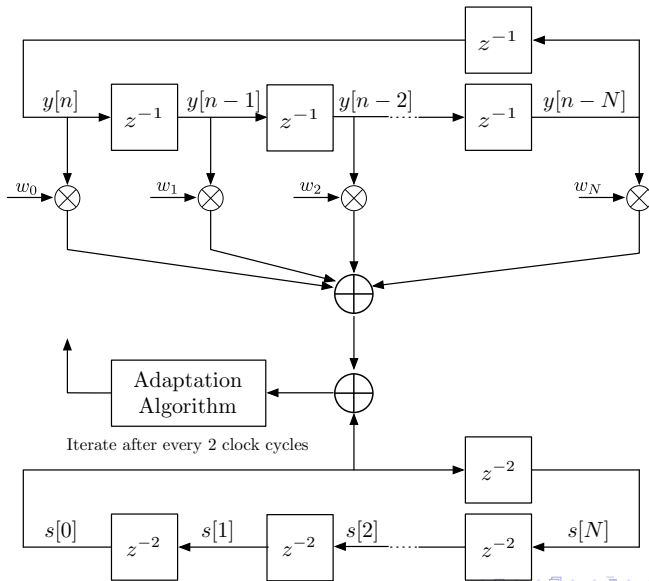
$$e[i] = s[i \bmod N + 1] - \mathbf{w}^H[i] \mathbf{y}_i$$

$$\mathbf{w}[i + 1] = \mathbf{w}[i] + 2\mu e^*[i] \mathbf{y}_i$$

end

11.5 Cyclic Equalization

Fractionally-spaced equalizer:



Pilot Symbols

$$s[n] = \begin{cases} e^{j\pi n^2/(N+1)}, & \text{for } N+1 \text{ even} \\ e^{j\pi n(n+1)/(N+1)}, & \text{for } N+1 \text{ odd.} \end{cases}$$

Comparisons (symbol-spaced)

Table: Performance comparison of the cyclic equalizers for direct and indirect setting.

Channel	MMSE	Average MSE of Cyclic Equalizer	
		Direct	Indirect
c_1	0.000138	0.00380	0.000240
c_2	0.000085	0.00241	0.000151
c_3	0.000644	0.00547	0.000750
c_4	0.000311	0.01832	0.000676