Supporting Document for Comments Against Draft 1.3

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Description of Comments

- Comment row #6:
  - Page 757, after Section 178A.1.7.5
  - Add a new sub-section “178A.1.7.6 Quantization noise”

178A.1.7.6 Quantization noise

The power spectral density of the quantization noise at the input of the quantized time receiver equalizer is defined by Equation (178A-X0).

$$S_{qn}(\theta) = \sigma_q^2 / f_b \qquad (178\text{A} - \text{X0})$$

where σ_q^2 is the power of the quantization noise at the output of the quantizer defined by Equation (178A-X1).

$$\sigma_q^2 = LSB^2/12 \qquad (178\text{A} - \text{X1})$$

where LSB is the quantization step size defined by Equation (178A-X2).

$$LSB = 2\ CL/\left(2^{N_{qb}} - 1\right) \qquad (178\text{A} - \text{X2})$$

Description of Comments

where CL is the quantization clip level defined by Equation (178A-X3).

$$CL = -P^{-1}(P_{qc}/2) \qquad (178A - X3)$$

where P is the cumulative distribution function of the signal prior to quantization defined by Equation (178A-X4).

$$P(y) = \int_{-\infty}^{y} p(u)du \qquad (178A - X4)$$

where p is the probability density function of the signal prior to quantization defined by Equation (178A-X5).

$$p(y) = p_{sig}(y) * p_{noise}(y) \qquad (178A - X5)$$

where

p_{sig} is the probability density function of the noiseless signal prior to quantization obtained by following the procedure defined in 93A.1.7.1 with pulse response $h(n)$ replaced by the pulse response from the input of the transmitter FFE to the input of the quantizer.

Description of Comments

p_{noise} is the probability density function of the noise prior to quantization estimated by a Gaussian distribution* defined by Equation (178A-X6).

$$p_{noise}(y) = \frac{1}{\sqrt{2\pi}} e^{-\frac{y^2}{2\sigma_{noise}^2}} \qquad (178A-X6)$$

where σ_{noise}^2 is the power of the noise prior to quantization defined by Equation (178A-X7).

$$\sigma_{noise}^2 = \sigma_{rn}^2 + \sum_{k=1}^{K-1} {\sigma_{xn}^{(k)}}^2 + \sigma_{tn}^2 + \sigma_{jn}^2 + \sigma_{in}^2 \qquad (178A-X7)$$

where each of the terms in the Equation (178A-X7) is calculated from the general Equation (178A-X8) using their corresponding power spectral densities obtained from sections 178A.1.7.1 to 178A.1.7.5.

$$\sigma^2 = \int_{-\pi}^{\pi} S(\theta)d\theta \qquad (178A-X8)$$

* The actual noise probability distribution is not necessarily Gaussian. However, for the purpose of equalizer optimization a Gaussian assumption helps optimization algorithm run time by avoiding to calculate the noise PDF every time. The final COM will be based on the actual noise PDF.

Description of Comments

- Comment row #7:
  - ❖ Page 754, Section 178A.1.7, Figure 178A-7
  - ❖ Add quantization noise to the figure

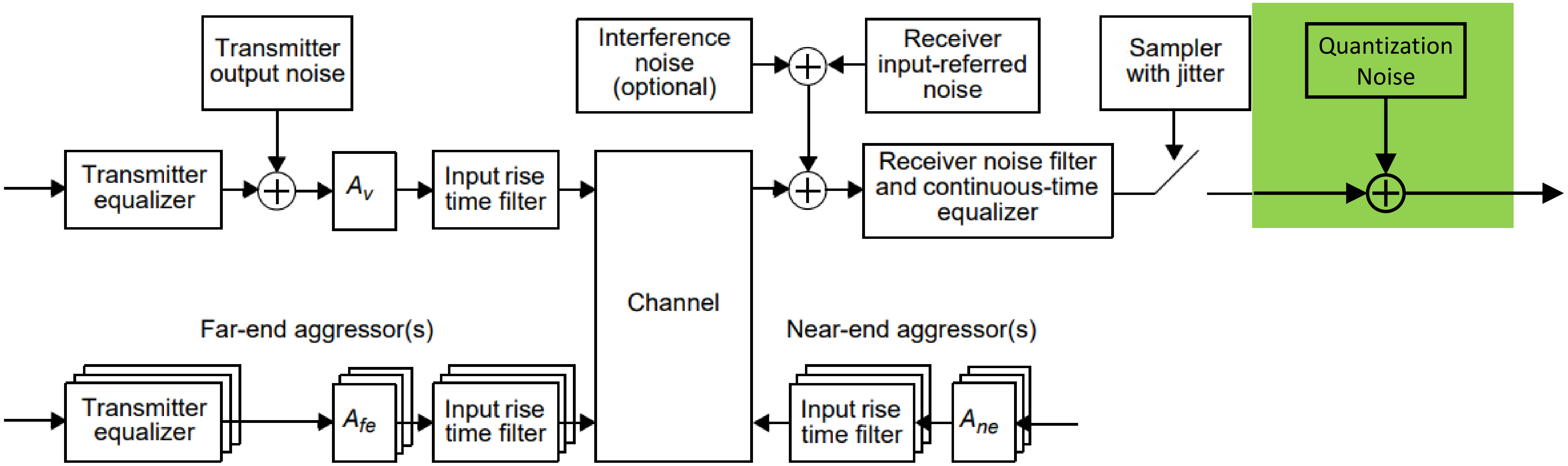

Figure 178A–7—Sources of noise considered in calculation of COM

Description of Comments

- Comment row #8:
  - Page 755, Section 178A.1.7, Table 178A-9
  - Add number of quantization bits and clipping rate to the table

Table 178A–9—Summary of noise parameters

Parameter	Symbol	Units
Number of signal levels	L	—
One-sided noise spectral density at receiver input	η_0	V^2/GHz
Transmitter signal-to-noise ratio	SNR_{TX}	dB
Random jitter, RMS	σ_{RJ}	UI
Dual-Dirac jitter, peak	A_{DD}	UI
Number of quantization bits	N_{qb}	–
Quantization clip rate	P_{qc}	–

Description of Comments

- Comment row #9:
  - Page 755, Section 178A.1.7, Equation (178A-14)
  - Add Quantization Noise PSD

$$S_n(\theta) = S_{rn}(\theta) + \sum_{k=1}^{K-1} S_{xn}^{(k)}(\theta) + S_{tn}(\theta) + S_{jn}(\theta) + S_{in}(\theta) + S_{qn}(\theta) \quad (178A\text{–}14)$$

where

θ	is normalized frequency in the range $[-\pi, \pi)$ where $\pi = f_b / 2$
$S_{rn}(\theta)$	is the receiver input-referred noise power spectral density defined in 178A.1.7.1
$S_{xn}^{(k)}(\theta)$	is the crosstalk power spectral density for signal path k defined in 178A.1.7.2
$S_{tn}(\theta)$	is the transmitter output noise power spectral density defined in 178A.1.7.3
$S_{jn}(\theta)$	is the power spectral density of the noise due to jitter defined in 178A.1.7.4
$S_{in}(\theta)$	is the interference noise power spectral density defined in 178A.1.7.5
$S_{qn}(\theta)$	is the quantization noise power spectral density defined in 178A.1.7.6

Description of Comments

- Comment row #13:
  - Page 758, Section 178A.1.8.1, Figure 178A-9
  - Add quantization noise after sampler

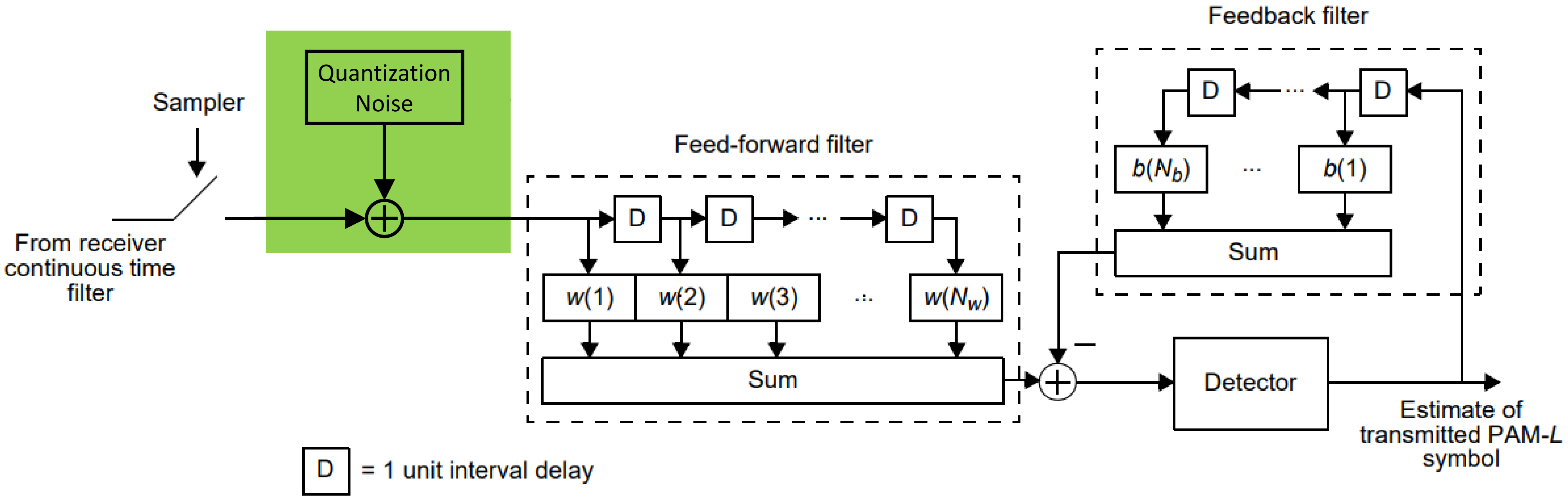

Figure 178A–9—Receiver discrete-time equalizer

Description of Comments

- Comment row #14:
  - Page 761, Section 178A.1.9, Equation (178A-34)
  - Add Quantization Noise PSD

$$\sigma_G^2 = f_b \int_{-\pi}^{\pi} [S_{tn}(\theta) + S_{jn}^{(RJ)}(\theta) + S_{rn}(\theta) + S_{in}(\theta) + S_{qn}(\theta)] |H_{rxffe}(\theta)|^2 d\theta \quad (178A\text{–}34)$$

Description of Comments

- Comment row #15:
  - Page 761, Section 178A.1.10.2, Line 51
  - Add the following before the last sentence

178A.1.9. The corresponding cumulative distribution function is defined by Equation (178A–38).

Add quantization noise by convolving the resulting probability density function with the quantization noise probability distribution function defined by evaluating Equation (178A-X9) sequentially for integer values $j = 1$ to $j = N_w$ with p_{qn} initialized to a Dirac delta function.

$$p_{qn}(y) = p_{qn}(y) * \frac{1}{w_{lim}(j)} p_{qi}\left(\frac{y}{w_{lim}(j)}\right) \quad (178A - X9)$$

where

N_w is the total number of taps in the feed-forward filter of the receiver equalizer defined in 178A.1.8.1.

w_{lim} is the optimized vector of taps in the feed-forward filter of the receiver equalizer defined in 178A.1.8.1.

Description of Comments

p_{qi} is the probability density function of the quantization noise at its injection point defined by Equation (178A-X10).

$$p_{qi}(y) = \begin{cases} 1/LSB & -LSB/2 \leq y < LSB/2 \\ 0 & Otherwise \end{cases} \qquad (178\text{A} - \text{X}10)$$

where LSB is defined by Equation (178A-X2) with replacing p_{noise} with the actual probability density function of the noise prior to quantization and after optimization during execution of the equation.

Description of Comments

- Comment row #16:
  - Page 762, Section 178A.1.11, Figure 178A-10
  - Add quantization noise after sampler

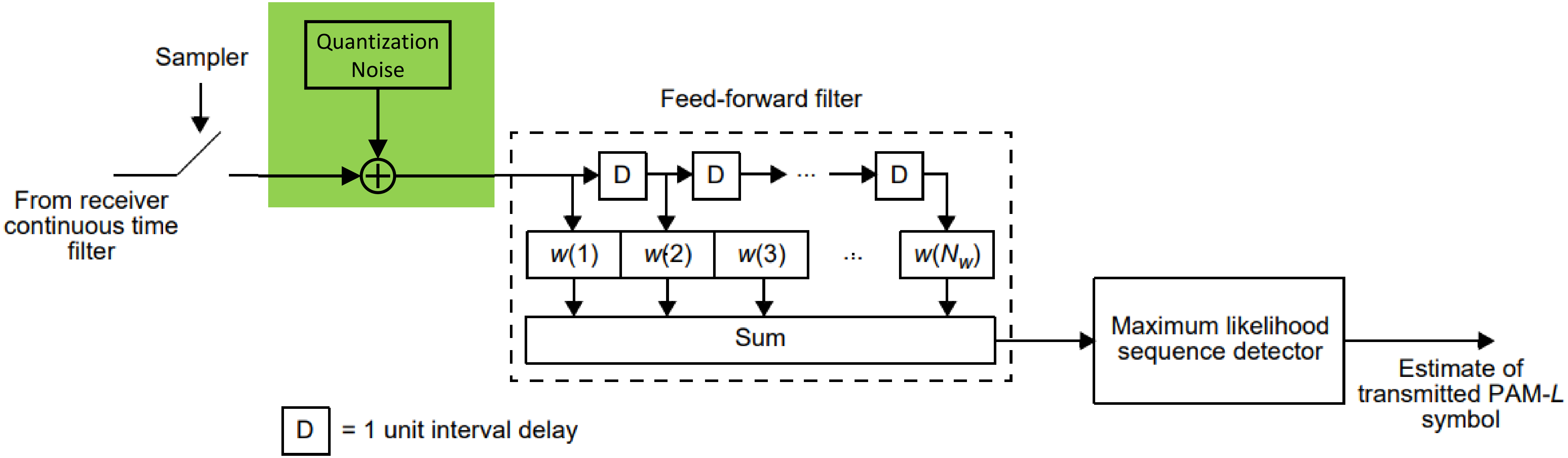

Figure 178A–10—Receiver discrete-time equalizer with MLSD

Thank You ☺

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