Digital transmission over bandlimited channels

EE 161

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Simplified communication system

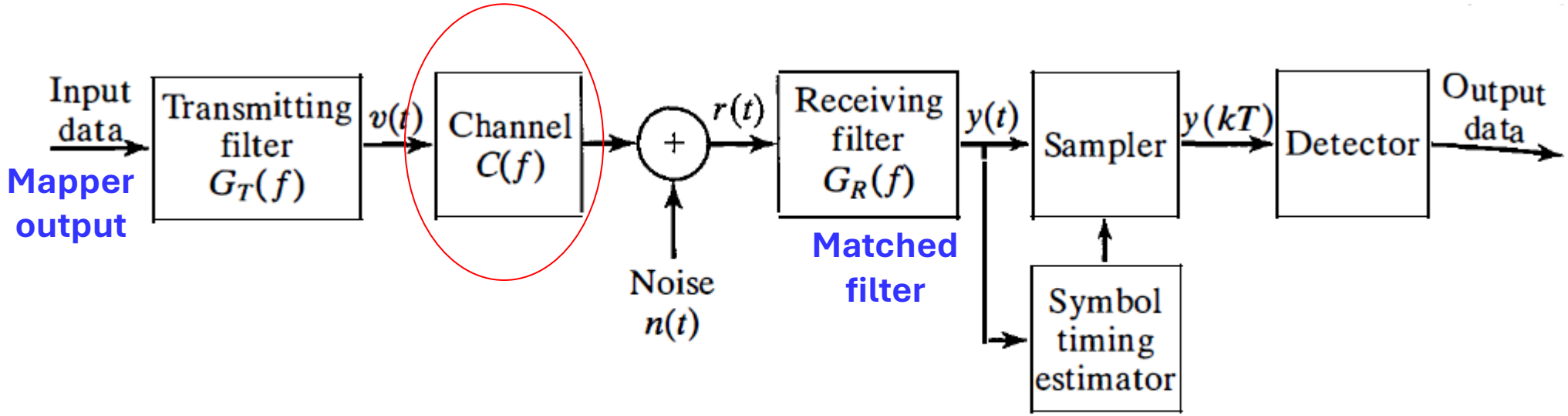


Figure 10.4 Block diagram of a digital PAM system.

- Notes:
  - We use s(t) as the transmitted signal
  - Channel is **bandlimited** and $C_o = 1$:

$$C(f) = \begin{cases} C_0 e^{-j2\pi f t_0}, & |f| \le W \\ 0, & |f| > W \end{cases},$$

Consequence of frequency band limitation

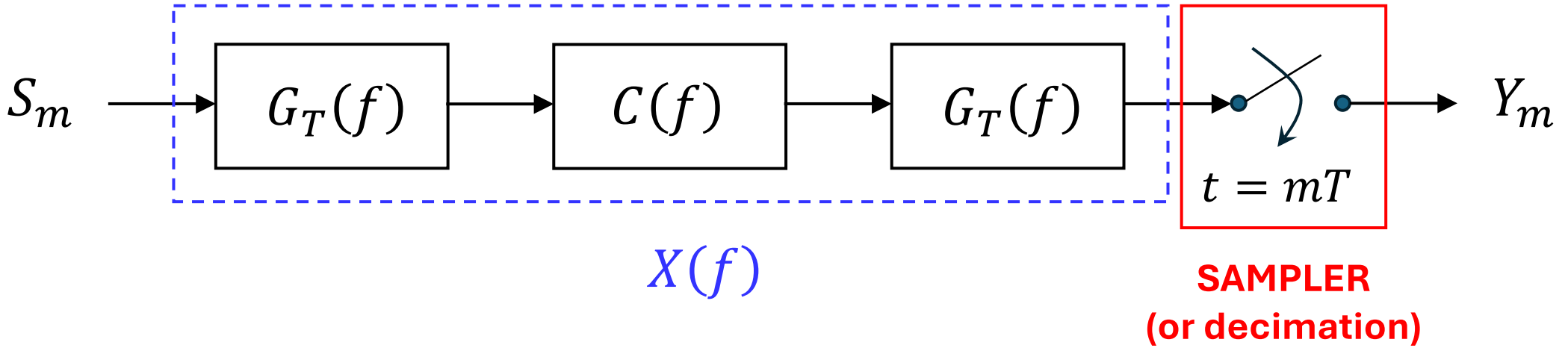
- An LTI system band-limited in the frequency domain has *infinite time duration* (time-unlimited)

- Example? Rectangular spectrum

$$C(f) = \frac{1}{2W}\Pi\left(\frac{f}{2W}\right) \quad \leftrightarrow \quad \mathrm{sinc}(2Wt)$$

Overall channel response

- Overall frequency domain response (without noise):



$$X(f) = G_T(f)C(f)G_R(f)$$

Nyquist criterion

- Intersymbol interference ($S_m = a_m$):

$$Y_m = y(mT) = x(0)a_m + \sum_{n \neq m} a_n x(mT - nT) + w(mT),$$

Intersymbol interference (ISI) term

- To remove interference, simply **make the ISI term equal to zero**.
- Using the **sampling theorem**, the Nyquist condition to remove ISI is for the *folded (sampled) spectrum* to satisfy

$$X_\delta(f) = \frac{1}{T} \sum_{n=-\infty}^{\infty} X\left(f - \frac{n}{T}\right) = 1 \qquad (*)$$

Nyquist criterion (cont.)

- Any overall channel spectrum $X(f)$ that satisfies Eq. (*) removes ISI
- Three examples (use whiteboard):
  1. Rectangular spectrum
  2. Triangular spectrum
  3. Raised-cosine (RC) spectrum

- **General overall spectrum conditions to remove ISI**
  - **Even symmetry about $f = 0$**
  - **Odd symmetry about $f = \pm\frac{1}{2T}$**