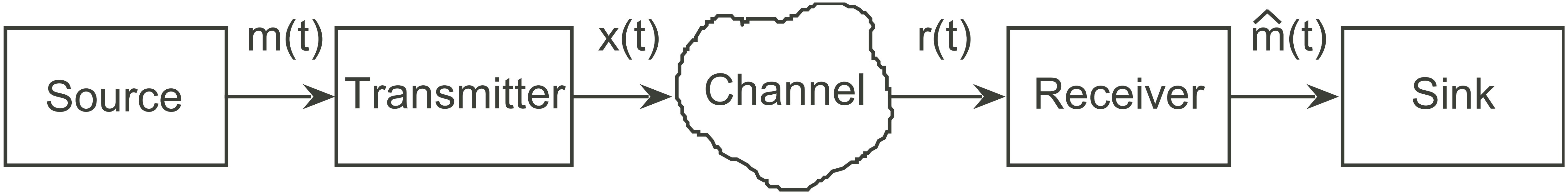
Fundamentals of Electrical Engineering

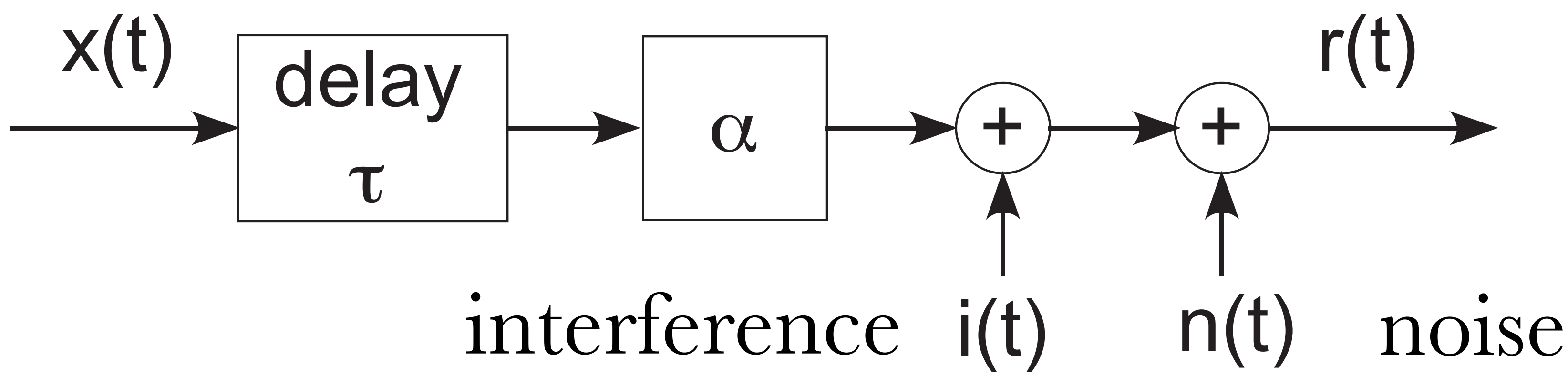
Interference and Noise in Channels

- Basic channel model
- Interference
- Noise
- Baseband communication

RICE

Basic Channel Model





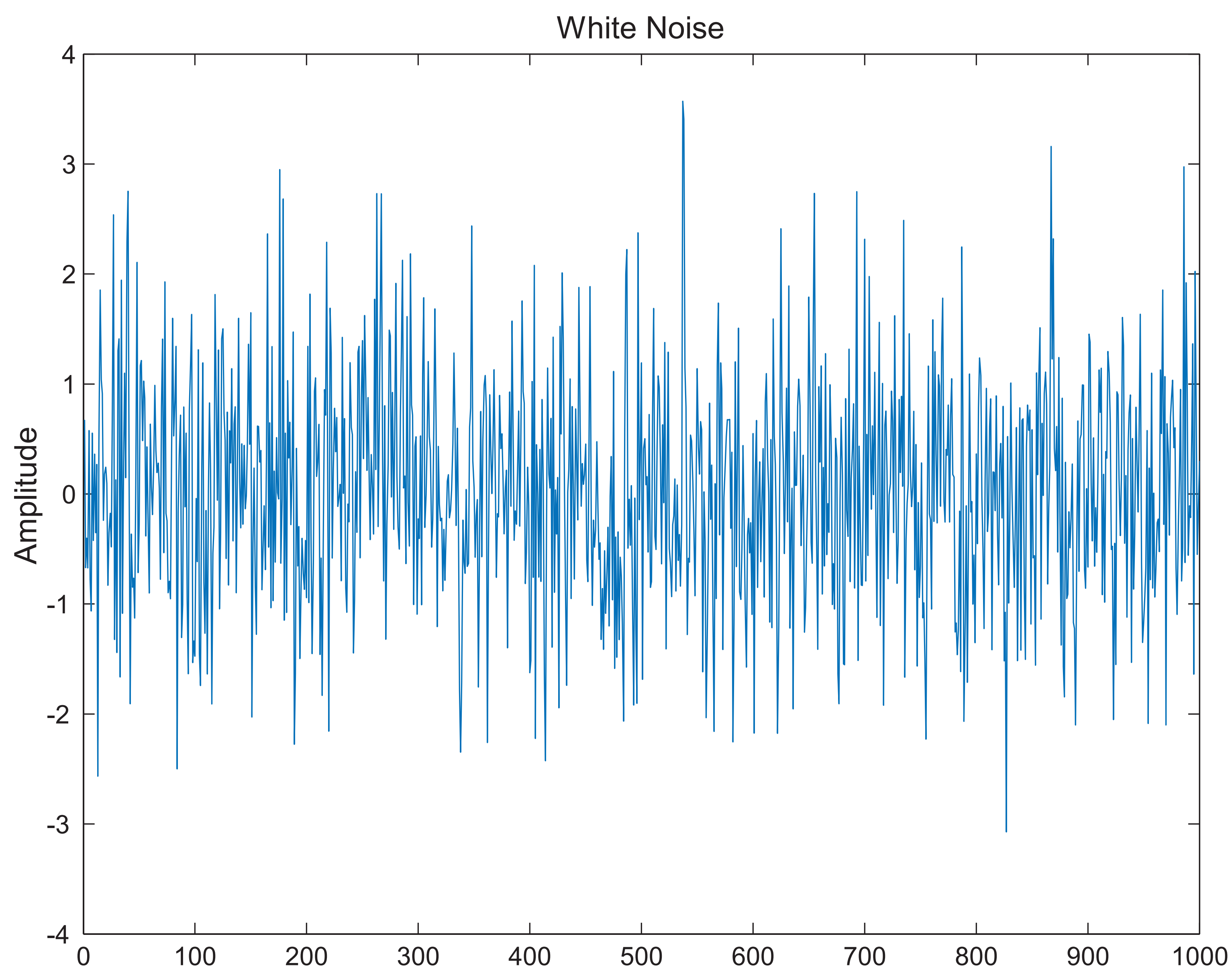
$$r(t) = \alpha x(t - \tau) + i(t) + n(t)$$

Wireline: $\tau = \dfrac{D}{c},\ \alpha = 1,\ i(t) \approx 0,\ n(t) \approx 0$

Wireless: $\tau = \dfrac{D}{c},\ \alpha = \dfrac{k}{D},\ i(t) = ?,\ n(t) = ?$

White Noise

- Constant power at all frequencies
- Random phase and amplitude
- When adding noise signals, *powers* add, not amplitudes



Power Spectrum

Definition: A signal's *power spectrum* equals the magnitude-squared value of the signal's spectrum

$$P_s(f) \equiv |S(f)|^2$$

The power spectrum of a filter's output is

$$P_y(f) = |H(f)|^2 P_x(f)$$

Because of Parseval's Theorem,

$$\text{power}[s] = 2\int_0^{\infty} P_s(f)\,df$$

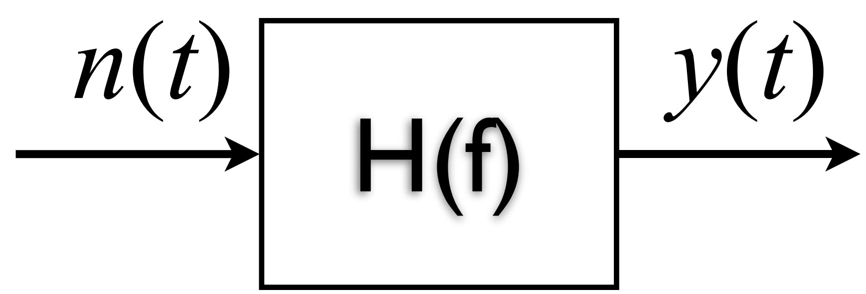
$$\text{power}[s] \text{ in } [f_1, f_2] = 2\int_{f_1}^{f_2} P_s(f)\,df$$

White Noise

White noise signals have a constant power spectrum

$$P_n(f) = \frac{N_0}{2}$$

$$\text{power}[n] \text{ in } [f_1, f_2] = N_0(f_2 - f_1)$$



$$P_y(f) = \frac{N_0}{2}|H(f)|^2$$

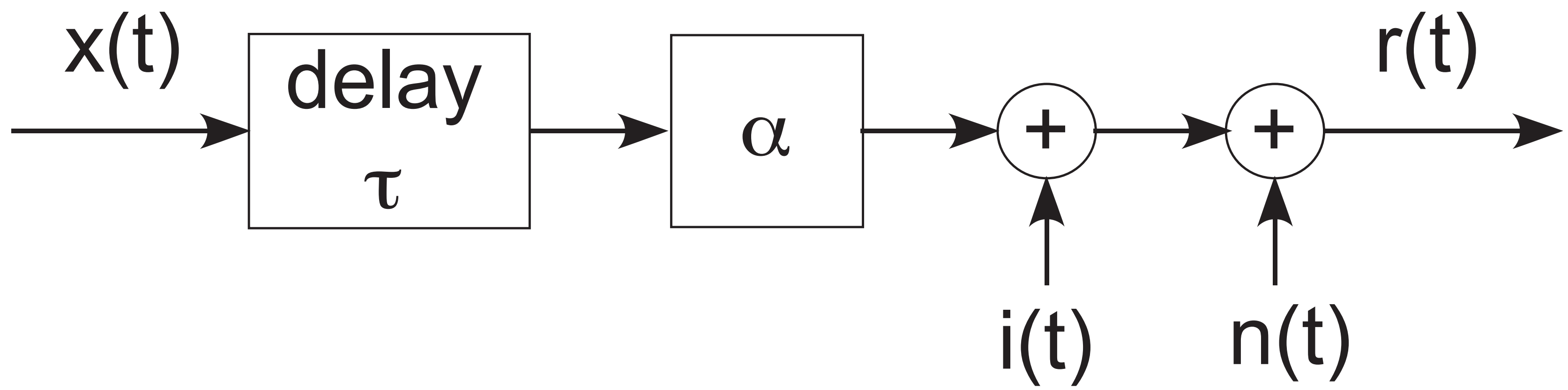
Signal-to-Noise Ratio

$$\mathrm{SNR} = \frac{\mathrm{power}[\mathrm{signal}]}{\mathrm{power}[\mathrm{noise}]}$$

$$= \frac{2\int_0^\infty P_s(f)\,df}{2\int_0^\infty P_n(f)\,df}$$

RICE

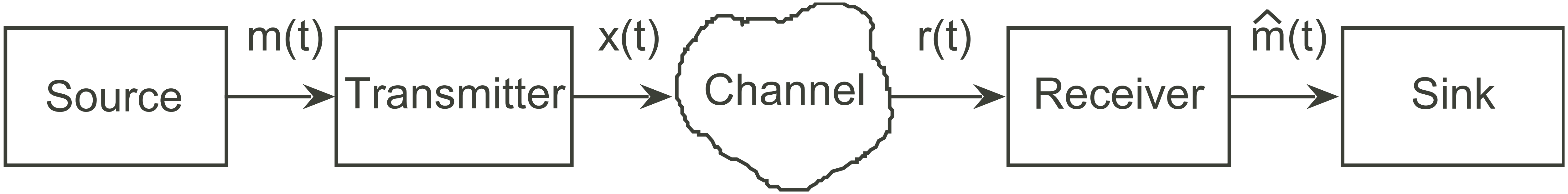
Power and the Channel Model



$$r(t) = \alpha x(t - \tau) + i(t) + n(t)$$

$$\text{SNR}_r = \frac{2\alpha^2 \int_0^\infty P_x(f)\, df}{N_0(f_u - f_l)}$$

Baseband Communication

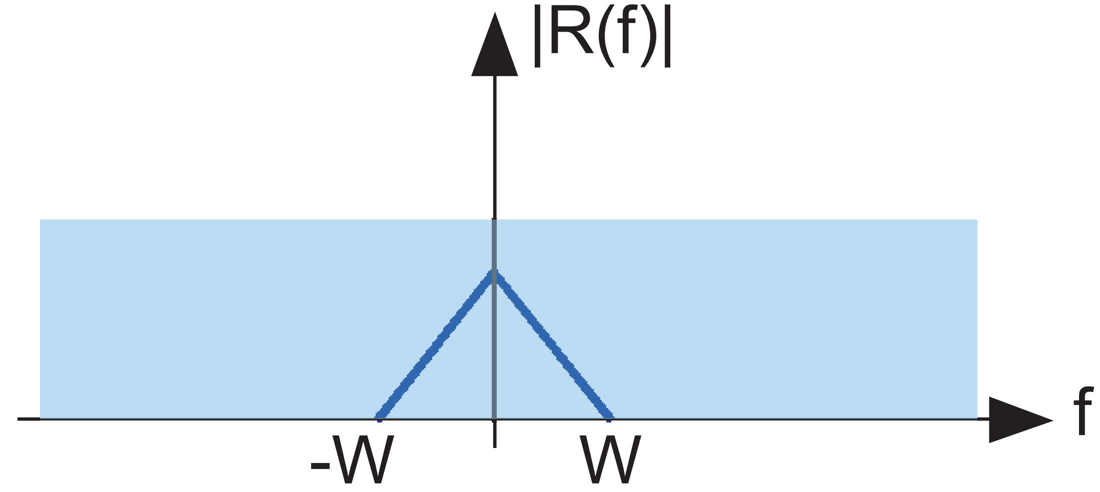


- Communication mode defined by the transmitter
- For baseband communication,

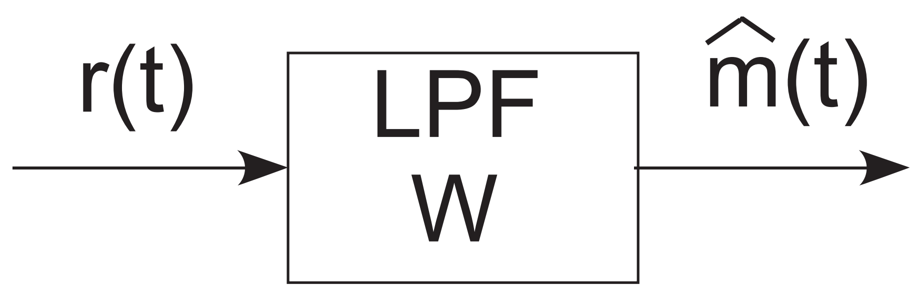
$$x(t) = G \cdot m(t)$$

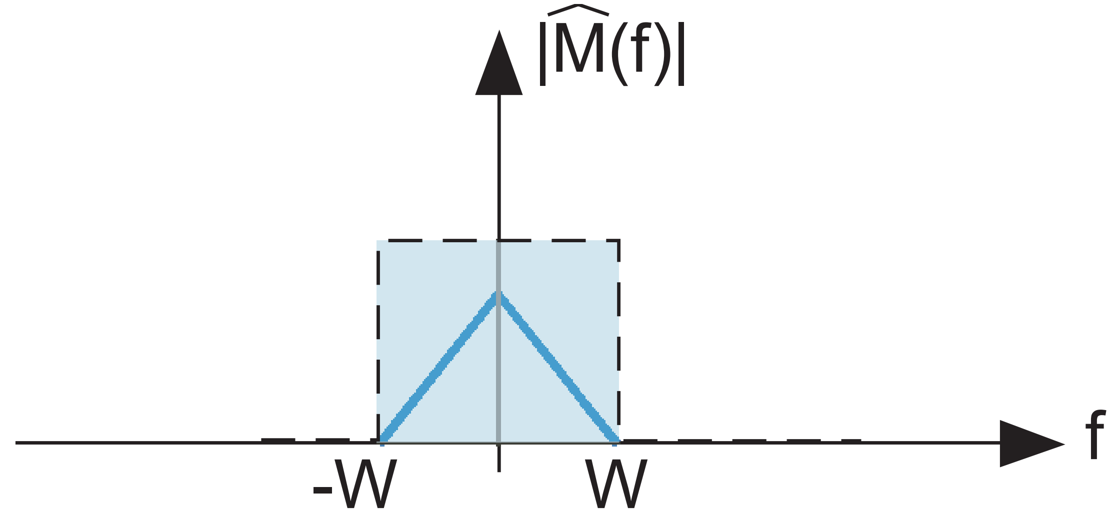
- Most message signals have a lowpass spectrum
- Baseband does not work well for wireless channels

Baseband Receiver



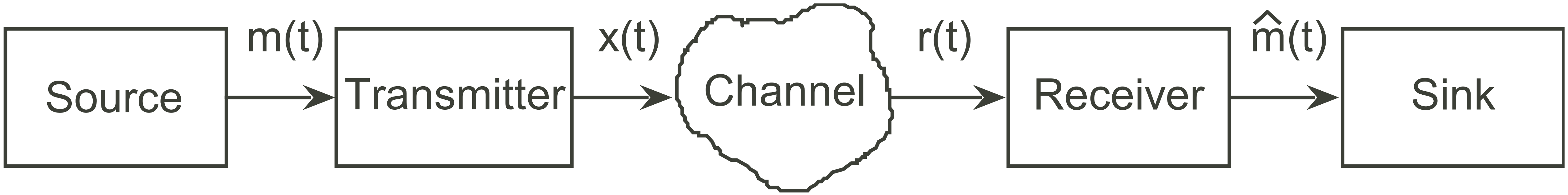
Need to remove "out-of-band" noise

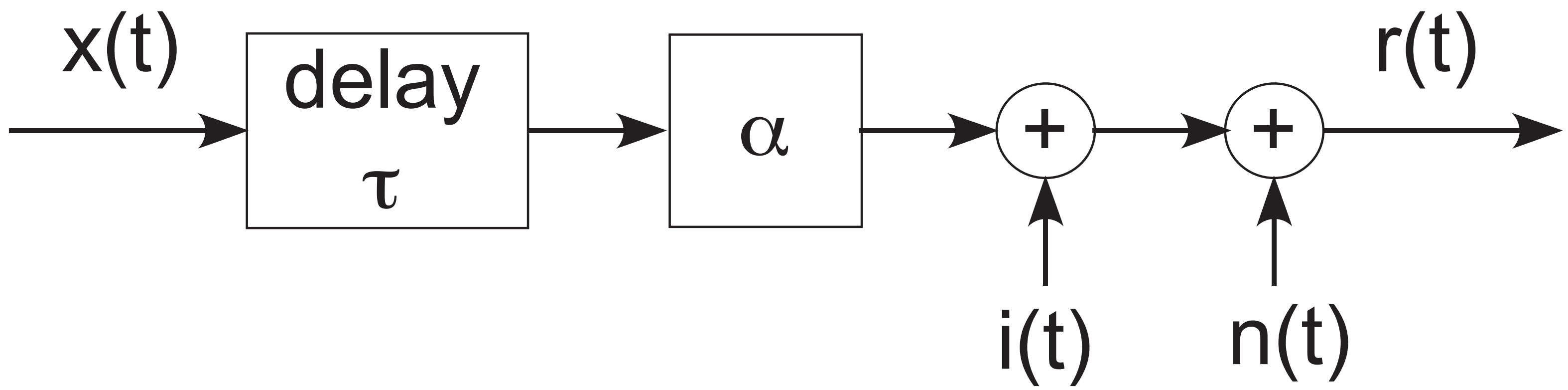




$$\mathrm{SNR}_{\mathrm{baseband}} = \frac{\alpha^2 G^2 \mathrm{power}[m]}{N_0 W}$$

Basic Communications





$$r(t) = \alpha x(t - \tau) + i(t) + n(t)$$

Wireline: $\tau = \frac{D}{c}, \ \alpha = 1, \ i(t) \approx 0, \ n(t) \approx 0$

Wireless: $\tau = \frac{D}{c}, \ \alpha = \frac{k}{D}, \ i(t) = ?, \ n(t) = ?$

Most wireless receivers consist of a front-end filter to remove out-of-band noise and out-of-band interference