2.3. Noiseless Channels

// 1 2 3 4 5 6 7

// 2.3.1.

In a 3kHz wide channel with a 2-level signal:

a) What is the maximum transmission capacity?

b) What is the max. transmission capacity if we use 2-bit symbols (4 levels)?

a) $C = 2B\log_2 L = 2 \cdot 3\text{kHz} \log_2 2 =$ 6 kbps

b) $C = 2B\log_2 L = 2 \cdot 3\text{kHz} \log_2 4 =$ 12 kbps

// 2.3.2.

A noiseless 4kHz channel is sampled every 1ms

a) What is the max. data rate?

b) What is the max. data rate if the channel is noisy with SNR = 30dB?

a) If there is no noise, we may use as many levels as we need and make the data rate infinitely large. ($L \to \infty \Rightarrow 2B\log_2 L \to \infty$)

b) $C \leq B\log_2(1+10^{\frac{SNR}{10}}) = 4\text{kHz} \cdot \log_2(1+10^{\frac{30}{10}}) =$ 39.87 kbps

*(2.3.3: next page)

2.3.4.

The Shannon theorem limits the capacity of a channel: $R \leq B\log_2(1+\frac{S}{N})$. Hartley's law sets the capacity according to the used signal levels M and bandwidth B: $R = 2B\log_2(M)$. Given an SNR of 10db:

a) What is the max recommendable M?

b) What if the SNR is 24dB?

a) $R \leq B\log_2(1+\frac{S}{N}) = B\log_2(1+10^{\frac{10}{10}}) = B\log_2(11)$

$R = 2B\log_2(M) \Rightarrow 2B\log_2(M) \leq B\log_2(11) \Rightarrow M^2 \leq 11 \Rightarrow M \leq \sqrt{11} = 3.317 \Rightarrow$ M = 3

$M = 2^{\frac{8}{23}}$

b) $M^2 \leq 1+10^{\frac{24}{10}} \Rightarrow M \leq \sqrt{252.19} = 15.88 \Rightarrow$ M = 15