transmission

\[ \int (y - \hat{y})^2 d\mu \leq \int (y - \hat{y}) d\mu \]
3.4.2 The Shannon Channel Capacity

The Shannon channel capacity is the limit of how much information can be transmitted over a channel with noise. It is given by the formula:

\[ C = W \log_2 \left( 1 + \frac{P}{N_0} \right) \]

where:
- \( C \) is the channel capacity in bits per second
- \( W \) is the bandwidth in Hertz
- \( P \) is the power in watts
- \( N_0 \) is the power spectral density of the noise in watts per hertz

This formula shows that the channel capacity increases with the bandwidth and decreases with the noise power. The channel capacity is finite and is limited by the noise in the channel.

In this section, we will explore the concept of channel capacity and how it relates to the design of communication systems. We will also discuss the implications of channel capacity on practical communication systems.
Given parameters, the maximum possible transmission rate is given by the following formula:

\[ C = \log_{10} (SNR + 1) \text{ bits/second} \]

This formula represents the maximum achievable bit rate under the condition of Gaussian noise, which is a common assumption in communication systems. The capacity is directly proportional to the signal-to-noise ratio (SNR), meaning that higher SNR values allow for higher transmission rates.

The expression on the right-hand side is derived using integral calculus and involves the use of a specific probability density function associated with the Gaussian distribution.

\[ \int_{-\infty}^{\infty} \frac{1}{\sqrt{2\pi} \sigma^2} e^{-\frac{(x-\mu)^2}{2\sigma^2}} dx = \int_{-\infty}^{\infty} \frac{e^{-x^2}}{\sqrt{2\pi}} dx = 1 \]

The maximum rate of transmission is achieved when the signal-to-noise ratio is maximized, which typically corresponds to a noise-free environment.

For a detailed analysis and further explanations, refer to the textbook sections on communication fundamentals and capacity theorems.