1 Digital Modulation Techniques

1.1 Introduction

TODO Something Here maybe

1.2 Basic Maths and Concepts

1.2.1 Quick Intro to the Chapter and Section

Digital modulation techniques are fundamental in modern communication systems, enabling the transmission of digital information over analog channels. Several key mathematical concepts and equations are essential to understanding and implementing digital modulation techniques. In this Section we shall present some of the most basic modulation techniques, concepts, and specifications, keep in mind though that specific modulation schemes may have variations and additional considerations depending on factors like channel characteristics and system requirements.

1.2.2

1.3 Baseband Representation of Digital Signals

Digital signals are typically represented in baseband using pulse waveforms. A simple rectangular pulse can be represented with the equation:

$$x(t) = \sum_{n=-\infty}^{\infty} A_n p(t - nT) \tag{1}$$

Where:

- A_n is the amplitude of the n^{th} pulse.
- p_t is the basic pulse shape (often a rectangular pulse, but it can be other shapes).
- T is the pulse duration or the time between the start of successive pulses.

Equation 1.3 above essentially states that the digital signal is composed of a series of pulses, each shifted by multiples of T seconds. The amplitudes A_n determine the information content of each pulse.
For a rectangular pulse $p(t)$ is defined as:

$$p(t) = \text{rect}\left(\frac{t}{T}\right) = \begin{cases} 1, & \text{if } |t| < \frac{T}{2} \\ 0, & \text{otherwise} \end{cases}$$

To be clear, in equation 1.3, $rect$ is the rectangular function, and T is the duration of the pulse.
This representation is foundational for understanding how digital signals are formed and transmitted. It forms the basis for various modulation techniques, where the information is encoded in the characteristics of these pulses.

1.3.1 Amplitude Modulation

Amplitude Modulation is a modulation technique where the amplitude of a carrier signal is varied in proportion to the instantaneous amplitude of a modulating signal (message signal, $m(t)$). The modulated signal $s(t)$ in the time domain is given by:

$$s(t) = A_c[1 + m \cdot x(t)] \cdot \cos(2\pi f_c t), \tag{2}$$

Where:

- A_c is the amplitude of the carrier signal,
- m is the modulation index, representing the extent of modulation,
- $x(t)$ is the baseband message signal (modulating signal),
- f_c is the frequency of the carrier signal.

In equation 1.3.1, $A_c[1 + m \cdot x(t)]$ represents the instantaneous amplitude of the modulated signal, and $cos(2\pi f_c t)$ is the carrier signal. The modulation index, m, determines the depth of modulation. If $m = 0$, there is no modulation, and the output is just the carrier signal. As m increases, the amplitude of the carrier signal varies more with the message signal.