In this chapter, the following topics may be covered:

- The matched filter
- Calculation of the bit error rate due to the presence of channel noise
- Inter symbol interference
- Nyquist’s criteria for distortion less base band data transmission
- Correlative level coding
Base band pulse transmission

- Equalization
- The eye pattern
Introduction

When digital data are transmitted through the communication channel it will be disturbed by two different noise types

1. Inter-Symbol interference (ISI) which results due to the overlap between the adjacent pulses (treated by equalization)

2. The additive white Gaussian noise which can be treated by the use of the matched filter at the receiver input
The matched filter is the first element in the base band receiver.

The matched filter is a linear time invariant system used to maximize the signal to noise energy of the received signal sample.
Impulse response of the optimum matched filter

The impulse response of the filter, is a time-reversed and delayed version of the input signal ie $h_{opt}(t) = kg(T - t)$

This means that the filter is matched to the input signal

The maximum peak pulse signal to noise ratio at the sampling instant $t = T_b$ is given by $\eta_{max} = \frac{2E_b}{N_0}$
Example 4.1 Matched filter for rectangular pulse

Consider the rectangular pulse $g(t)$ shown below:

1. find the matched filter output
2. Show that the filter can be implemented by using an integrator followed by a sampling switch

![Diagram of a rectangular pulse with energy $A^2T$.]
Solution

The output signal is obtained by the convolution sum between $g(t)$ and $h(t)$.

The resulting filter output $g_o(t)$ is shown below.
solution

The peak value of $g_o(t)$ can be obtained when $t = T$ which can be obtained by passing the rectangular pulse $g(t)$ through an integrator, then sample the integrator output at $t = T$.
Consider the signal $s(t)$ shown in Figure P4.1.
(a) Determine the impulse response of a filter matched to this signal and sketch it as a function of time.
(b) Plot the matched filter output as a function of time.
(c) What is the peak value of the output?
Problem 4.1

(a) The impulse response of the matched filter is

\[ h(t) = s(T-t) \]

The \( s(t) \) and \( h(t) \) are shown below:
(b) The corresponding output of the matched filter is obtained by convolving \( h(t) \) with \( s(t) \). The result is shown below:

![Graph showing the matched filter output with labels for \( s_o(t) \), \( A^2T/4 \), \( T/2 \), \( T \), \( 3T/4 \), and \( 2T \).]

(c) The peak value of the filter output is equal to \( A^2T/4 \), occurring at \( t=T \).