CHAPTER 1

INTRODUCTION

1.1 Historical Background

The correlation method for determining of the impulse response of a linear system using white noise input signal was first used by J.B. Wiesner and Y.W. Lee[1] in 1950. During 1961, J.D. Balcomb[6] had developed the crosscorrelation method using pseudorandom input signal to measure the impulse response of reactor system. Later, many authors[4,5,9,11] also used pseudorandom binary maximum-length sequence signal as an input signal for identification system. In 1964, K.R.Godfrey[8,9] first investigated and discussed the effect of input transducer errors in crosscorrelation method using pseudorandom binary signal . He also suggested a simple way to overcome these errors. His method may be extended to obtain the transducer errors in any particular time-shift.

1.2 Crosscorrelation Method for Determination of the Impulse Response

It is well-known that the output response y(t) of the linear system shown in figure 1.1 can be written in the form.

$$y(t) = \int_0^\infty h(u)x(t-u)\,du \qquad (1.1)$$

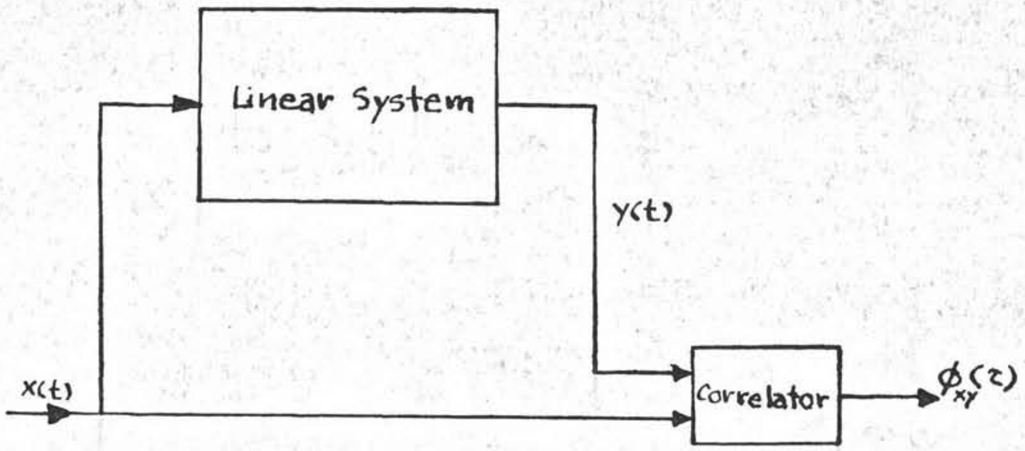

Figure 1.1

The crosscorrelation function of input signal x(t) and output signal y(t) where x(t) is an input signal

h(t) is a time-imvariant impulse response of the linear system without memory

$$h(t) = 0 \qquad , \text{for } t \leq 0$$

The cross-correlation between the imput signal x(t) and the output signal y(t) may be expressed as

$$\phi_{xy}(\tau) = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} x(t)\, y(t+\tau)\, dt \qquad (1.2)$$

from egn. (1.1) and eqn. (1.2), we have

$$\phi_{xy}(\tau) = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} x(t) \int_{0}^{\infty} h(u)\, x(t+\tau-u)\, du\, dt$$

$$= \int_{0}^{\infty} h(u) \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} x(t)\, x(t+\tau-u)\, dt\, du$$

Since $\lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} x(t)\, x(t+\tau-u)\, dt$ is the auto-correlation function of x(t), then

$$\phi_{xy}(\tau) = \int_{0}^{\infty} h(u)\, \phi_{xx}(\tau-u)\, du \qquad (1.3)$$

If the input signal x(t) is a white noise whose auto-correlation Function[7] $\phi_{xx}(\tau) = k\,\delta(\tau)$ From egn. (1.3) the impulse response function can be obtained directly,

$$h(\tau) = \frac{1}{k}\, \phi_{xy}(\tau) \qquad (1.4)$$

In practice, there are disadvantages[1,3] in using white noise input signal because it requires very long crosscorrelation time, theoretically it takes infinitely time, and other noise signals can also distort the wave form of the white noise. This distortion causes an error which is the major problem in the cross correlation method.

These problems may be overcome by using other types of input signals, such as pseudorandom sequence signals. These types of input signals have finite period and their auto-correlation function are similar to those of white noise[7,14]. In addition, their magnitudes may be parted into discrete levels so that the distortion error can be detected.

When the pseudorandom binary sequence is used as an input signal. From egn. (1.3) and expanding the impulse response function h(u) in Taylor series about $u=\tau$, we obtain.

$$\phi_{xy}(\tau) = C_0 h(\tau) + C_1 h'(\tau) + \ldots + C_r h^r(\tau) + \ldots \qquad (1.5)$$

where $C_r = \frac{1}{r!} \int_0^\infty (u-\tau)^r \phi_{xx}(\tau-u)\,du$

If all the derivative terms of the impulse response function h(u) is neglected. The approximate value of the impulse response can be determined directly, However, this causes some errors which will be discussed in more detail in chapter 5.

1.3 The Aim of this Research Work

The objective of this research is to investigate the effect of errors in linear system identification by crosscorrelation method. The cutline of the work can be summarized as follow:

(a) properties of m-sequence binary signal is presented in chapter 2.

(b) the effect of input transducer error is described in chapter 3.

(c) the effect of the external noise in the cross correlation method based on a white noise input and a time polynomial function input is also discussed in chapter 4.

(d) the accuracy in determination for impulse response is presented in chapter 5.