APPLICATION OF PSEUDO RANDOM BINARY SEQUENCE (PRBS) SIGNAL IN SYSTEM IDENTIFICATION

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ABSTRACT

This project emphasized on both software and hardware analysis. Pseudo random binary sequence (PRBS) signal of 15 different maximum length sequences were developed using MATLAB software and were used as forcing function in simulated second order. There are four second order system responses that were examined; overdamped, underdamped, undamped and critically damped. For each response, traces of the output response of system forced by PRBS or without PRBS in the absence or presence of noise were analyzed. The autocorrelation function of the input signal and cross correlation function between input and output signal were performed using MATLAB software. From the correlograms of autocorrelation and cross correlation, the transfer function of the system was estimated. For verification of the simulation work, PRBS generator circuit was build using Transistor-transistor logic. The PRBS signal generated was analyzed using Dynamic Signal Analyzer. An experiment using PRBS as the forcing function to an unknown system was performed. The autocorrelation function of the input signal and cross correlation function between input and output signal were performed using Dynamic Signal Analyzer and the transfer function model of the unknown system was estimated. Results from this experiment were used to validate the simulation work previously.

ABSTRAK

Projek ini tertumpu kepada penganalisaan aturcara dan juga perkakasan. Isyarat Perduaan Jujukan Rawak (PRBS) sebanyak 15 panjang jujukan maksima dihasilkan menggunakan aturcara MATLAB dan ianya digunakan sebagai fungsi pemaksa di dalam pengujian sistem tertib kedua. Empat jenis sambutan sistem tertib kedua telah dianalisa; redaman lampau, teredam, sambutan tanpa redaman dan redaman genting. Untuk setiap jenis sambutan tertib kedua, analisis terhadap sambutan sistem yang dipaksa oleh PRBS atau yang tidak dipaksa oleh PRBS, dalam kehadiran gangguan atau tidak telah dilaksanakan. Fungsi sekaitan auto untuk isyarat masukan dan fungsi sekaitan silang antara isyarat masukan dan keluaran akan dilaksanakan menggunakan aturcara MATLAB. Dari graf sekaitan auto melawan masa lengah dan sekaitan silang melawan masa lengah, rangkap pindah untuk model sistem tersebut dikenalpasti. Untuk pembuktian keputusan analisa menggunakan aturcara MATLAB, penjana isyarat PRBS dibina menggunakan IC TTL. Isyarat PRBS yang dihasilkan dianalisis menggunakan Penganalisis Isyarat Dinamik. Satu ujikaji menggunakan isyarat PRBS sebagai fungsi pemaksa kepada satu sistem yang tidak diketahui telah dijalankan. Fungsi sekaitan auto bagi isyarat masukan dan fungsi sekaitan silang di antara isyarat masukan dan isyarat keluaran dilaksanakan menggunakan Penganalisis Isyarat Dinamik dan seterusnya rangkap pindah untuk model sistem yang tidak diketahui dikenalpasti. Keputusan ujikaji tersebut digunakan untuk membuktikan keputusan analisa menggunakan aturcara MATLAB yang sebelum ini.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Pseudo random signal has been widely used for system identification (A.H. Tan and K.R. Godfrey, 2002). Maximum length sequence (MLS) signals are the known class of pseudo random signals (N. Zierler, 1959); because it can be easily generated using feedback shift registers (A.H. Tan and K.R. Godfrey, 2002). There are several other classes of binary and near-binary signal but are less well known such as quadratic residue binary (QRB), Hall binary (HAB), Twin Prime binary (TPB) and quadratic residue ternary (QRT).

1.2 Rational, Significance and Need for the Study

In the 1960's and early 1970's, there was a fairly large amount of research into the design and application of pseudo random signals. Pseudo random binary signals based on maximum length sequences are easy to generate using simple shift register circuitry with appropriate feedback, and this has resulted in their incorporation as a routine facility in a number of signal generators and their use in a wide range of system dynamic testing (K.R. Godfrey, 1991).

It is important to study and generate PRBS because of the difficulty faced in generating a truly random sequence. A PRBS is not a truly random sequence but with long sequence lengths, it can show close resemblance to truly random signal

and furthermore it is sufficient for the test purposes. PRBS have well known properties and the most important point is its generation is rather simple. Moreover, knowing how a PRBS signal is generated make it is possible to predict the sequence. Outermost it makes error that might occur in the sequence is possible to register and count.

1.3 Research Objectives

There are four main objectives of this research, as stated below:

(i) To design and generate PRBS generator with different MLS using MATLAB,

(ii) To design PRBS generator using hardware (Transistor-transistor logic-TTL),

(iii) To analyze the characteristic of PRBS signal such as auto correlation function, cross correlation function, and power spectral density using MATLAB and dynamic signal analyzer,

(iv) To perform an experiment using real system where PRBS is the test input.

1.4 Scope of project

This project emphasized on both software and hardware analysis. PRBS generator with 15 different MLS (n=2, 3…, 16) were designed using MATLAB (SIMULINK) software. The signals obtained were used as forcing function in second order system. Four second order system responses were examined; overdamped, critically damped, undamped and critically damped. For each category, the response curves, autocorrelation function, cross correlation function and power spectral density are observed for three different conditions; system forced by PRBS signal in absence of noise, noisy system forced by PRBS signal and noisy system without PRBS signal as forcing function. The autocorrelation function of the input

signal and cross correlation function between input and output signal were used to estimate the transfer function model of the system.

Hardware analysis is done for the purpose of validation. PRBS generator was constructed using TTL. PRBS signal generated was tested using dynamic signal analyzer. An experiment using real second order system using PRBS as the test input was performed. The autocorrelation function of the input signal and cross correlation function between input and output signal were performed using Dynamic Signal Analyzer. The correlograms of these two functions were used to determine the transfer function model of the real second order system.

1.5 Project Outline

The preceding sections briefly summarized the contributions of the thesis. This section outlines the structure of the thesis and summarizes each of the chapters.

Chapter 2 describes the relevant literature and previous work regarding PRBS and its application in system identification. Overview of several classes of binary and near binary signals such as MLS, QRB, HAB, TPB and QRT will be explore, and characteristic of PRBS signal such as autocorrelation function, cross correlation function and power spectral density will be explained.

Chapter 3 introduces method or approach taken in order to achieve the four objectives set earlier in Chapter 1. This chapter describes the design for PRBS generator for both approaches, software simulation using MATLAB SIMULINK and hardware implementation using TTL.

Chapter 4 presents the results obtained from the simulation and experimental work done. Analyses were done on the results. Experimental results obtained validated the simulation result. Chapter 5 consists of conclusion and suggestions for future improvement.

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