BALL AND BEAM BALANCER CONTROL USING MICROCONTROLLER

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This project report is dedicated to

Dad, En. Ismail Bin Che Mat,
Mum, Pn. Siti Ishah Bt Ali,
also Brother and Sisters, Waznati, Nur Hidayah
and Muhammad Hakim
Who always been very supportive and
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ABSTRACT

Ball and beam balancer system is the most popular laboratory model used in control system due to its simple modeling and low in cost. However this system is an open loop of unstable. Due to this problem, controllers need to be designed to stabilize the system. A ball will roll on the top of long beam with an acceleration that is proportional to the angle of the beam. The important objective of the system is to regulate the position of the ball along the beam to its reference position which is to center of the beam. This project will be implemented in hardware using PIC18F452 microcontroller. Controller that will be used in this project is PID controller which has been verify before using MATLAB. The PID controller will be programmed using Mikroelektronika software and then will be embedded into microcontroller. Programmer will be used to interface between the software and hardware.

ABSTRAK

Sistem bola dan pelantar seimbang sering digunakan di dalam makmal bagi tujuan pembelajaran terutamanya mengenai sistem kawalan. Sistem ini menjadi pilihan disebabkan mudah untuk dimodelkan dan memerlukan kos yang rendah dari segi reka bentuknya. Walaubagaimanapun, sistem ini tidak stabil kerana merupakan sistem gelung buka. Pengawal diperlukan untuk menjadikan system ini lebih stabil. Sebiji bola akan bergerak di atas pelantar di mana pecutan bola adalah berkadar terus dengan sudut pelantar. Objektif utama projek ini adalah untuk memastikan kedudukan bola sentiasa berada di kedudukan rujukan iaitu di tengah-tengah pelantar. Projek ini akan dilaksanakan menggunakan mikropengawal, PIC18F452. PID adalah pengawal yang akan digunakan bagi sistem ini, di mana telah dipastikan menggunakan MATLAB. Pengawal PID akan diprogram menggunakan perisisan Mikroelektronika. Program ini kemudiannya akan dibenamkan di dalam mikropengawal di mana menggunakan pengaturcara untuk menghubungkan antara perisisan dan perkakasan.

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P	-	Proportional
I	-	Integral
D	-	Derivative
PWM	-	Pulse Width Modulation
RAM	-	Random Access Memory
DAQ	-	Data Aquistion
ADC	-	Analog to digital Converter

LIST OF SYMBOLS

F	-	Force
m	-	Mass
x	-	Distance
θ	-	Angle
$\propto$	-	Angular displacement
a	-	Radius
J	-	Moment of inertia
τ	-	Torque
k_t	-	Motor toque constant

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CHAPTER 1

INTRODUCTION

1.1 General Introduction

Control systems are an integral part of modern society and numerous applications around us use control system. One example of system that use control theory is ball and beam balancer system. It is the most important model used to explain and teaching control systems engineering and use in learning about applying control to stabilize an unstable system.

A ball and beam balancer system is very simple to understand, and yet the control techniques that can be studied cover many important and classical design methods. This system is a common classical closed loop feedback system project, due to it ease in construction.

There are three main advantages by using this ball and beam balancer system as a model to learn control theory. First, it can be used for demonstrating PID controllers in action. Second, this system has all elements that needed in control loop system such as actuator, sensor, signal conditioning circuit, comparator and control method. Finally, this system is inexpensive and mechanically simple for construction.

From Figure 1.1 it shows the set up for ball and beam balancer model system.

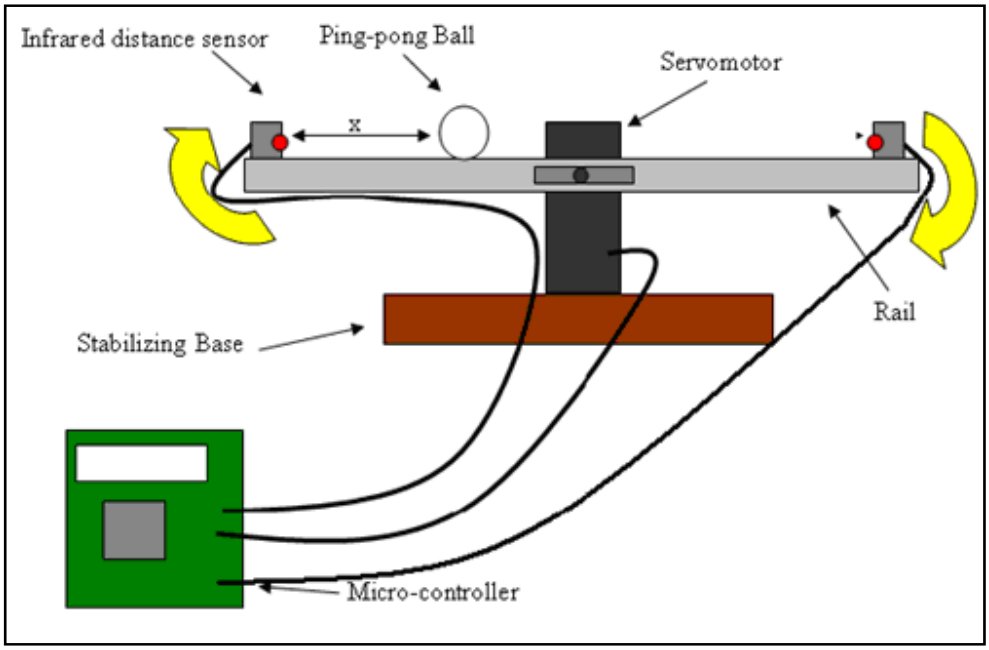

Figure 1.1: Ball and Beam Balancer System Model

1.2 Problem Statement

Ball and beam balancer system consist of a long beam that attach with a motor in the middle of the beam. A ball is placed on the top center of the beam. By applying an electrical control signal to the motor, the beam can tilt about it centre axis with certain angle. Movement of the beam will cause the ball rolling along the beam with an acceleration that is proportional to the angle of the beam.

However, this system is an open loop unstable system because the system output which is ball position will increase without limit for a fixed input which is the beam

angle. The problem is to maintain the position of the ball at the center of the beam on which the ball rolls along freely.

The control task is to automatically regulate the position of the ball on the beam by changing the angle of the beam. The beam angle will control acceleration of the ball and not position. However, by controlling the acceleration of the ball, its position can be control as well.

1.3 Objectives of study

There are three main objectives for this project which are:

1) To design a ball and beam balancer system model with a simple, low cost and easy to assemble construction
2) To design a controller such as P, PI, PD and PID using microcontroller to regulate the position of the ball to the center of the beam.
3) To test stability of the designed system.

1.4 Scope of work

The scopes of this project are as follows:

1. Understand the principle of work of a ball and beam balancer system.
2. Design the hardware model of the system.

3. Understand the theory and principle of all instruments that being used in this project.
4. Design a suitable controller such as P, PI, PD and PID using microcontroller.

1.5 Significant of project

The ball and beam balancer system is a classic example of control theory that is studied by advanced undergraduate students. By build this model, lecturers can make demonstrations in classrooms how a control system with feedback works. Besides that, with this model, for the future research, students only require to design their own controller that will give a better control performance and make some improvement to the plant and sensor.