A FEEDBACK CONTROL SYSTEM FOR SUPPRESSING CRANE OSCILLATIONS WITH ON-OFF MOTORS

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This report is submitted in partial fulfillment of the requirement for the award of Bachelor of Electronic Engineering (Industrial Electronics) With Honours

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Special dedicated to my beloved parents, family and fellow friends, who had strongly encouraged and supported me in my entire journey of learning…

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ABSTRACT

Crane payloads frequently swing with large amplitude motion that will degrade safety and throughput. Open-loop methods have addressed this problem, but are not effective for disturbances. Closed-loop methods are also been used, but generally require the speed of the driving motors to be precisely controlled. In this project, a feedback control methods have been used for controlling motors to cancel the measured payload oscillations by intelligently timing the ensuing on and off motor commands. Generate commands for on-off motor is based on using measurement of payload swing to cancel the swing angle. This system is designed to control the swing angle and as well as the trolley position.

ABSTRAK

Beban kren yang selalunya berayun dengan amplitud pergerakan yang besar akan mengurangkan tahap keselamatan dan nilai output. Kaedah gelung terbuka telah menyelesaikan masalah ini tetapi tetapi tidak berapa berkesan untuk gangguan. Kaedah gelung tertutup juga telah digunakan untuk menyelesaikan masalah ini, tetapi secara keseluruhannya memerlukan ketepatan dalam mengawal kelajuan motor tersebut. Di dalam projek ini, kaedah suapan balik digunakan untuk mengawal motor untuk menghapuskan talaan beban oleh kadar masa yang tepat untuk menentukan arahan "on" dan "off" motor. Untuk menghasilkan arahan "on-off motor" adalah berpandukan ukuran sudut ayunan beban untuk menghapuskan ayunan beban itu sendiri. Sistem ini adalah bertujuan untuk mengawal sudut ayunan beban dan juga kedudukan troli.

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CHAPTER I

INTRODUCTION

1.1 Project Introduction

The fundamental motions of a gantry crane consist of travelling, load hoisting and load lowering. The significant characteristic of a gantry crane is that all motions are performed simultaneously at relatively high speed. When the crane is starting or stopping, it will induce the undesirable swinging of the suspended load. This oscillation can caused possibly damage to the load and workplace. This oscillation also produce safety hazards and can become dangerous to the people nearby. Until now, various type of control approaches have been used to addressed this problem. The approaches are the open-loop and closed-loop system.

One of the open-loop approach is input shaping. Input shaping is a feedforward control technique for improving the settling time and the positioning accuracy, while minimizing residual vibrations, of computer-controlled machines [1]. Another open-loop method is the optimal control which calculate a motion trajectory. This project is based on using measurement of payload swing to generate commands for on-off motors to cancel the payload swing.

1.2 Objective

The objective of this project is to design a gantry crane system with feedback control method that will drive the system from initial position into a target position without vibration and reducing swing angle with on-off motor commands.

1.3 Problem Statement

Cranes are used to transport heavy objects in a cluttered workspace. One inherent problem with cranes is that the payload can swing freely. These oscillations pose safety hazards and can damage the payload and other objects in the workplace. Crane travel and transverse motion especially when starting or stopping, induce undesirable swinging on the suspended load. This swinging could cause the suspension rope to leave its groove which could lead to overwrapping and possibly serious accident. Traditionally, an experienced operator is required to control the oscillations and make it safe. So, this project is applied to overcome the above problems.

1.4 Scope

Firstly, do some researches about a gantry crane system with a feedback control system for suppressing crane oscillations with on-off motors. After that, feasibility study and read up related technical knowledge such as:

a. non-linear feedback
b. on-off control

For the simulation part:

a. Derive the shaped input function from the specified output function, in this case is a third order exponential function.
b. Implement the input function into the closed loop system.
c. Develop the mathematical modelling using MATLAB and SIMULINK.

For the Hardware Part:

a. Finding and design the desired circuit.
b. Finding the suitable components that suitable for the project.
c. Mechanical drawing for the gantry crane
d. Build up the gantry crane, trolley, string, load and do the interfacing.

After finish build up the hardware, testing and troubleshooting should be done to check wheter the hardware is in good condition.

1.5 Methodology

In order to meet the objective of the project, the design of the system will consist of several parts. In the subsequent sections, each subsystem will be discussed in terms of criteria, calculations and selection of the project specifications. To achieve these, the following methods will be followed closely, if not entirely:

1. The initial stage of the project is basely solely on research about the basic concept of gantry crane whereby data and information are obtained through various medium, such as internet, books, journal, proceeding paper, broachers and more.
2. After the research about gantry crane had been done, research about on-off commands will be done. The research is about how to generate on-off commands and apply it to the gantry crane system.
3. Based on the above research, simulation using simulink in MATLAB had been done. Results are obtained and analyze whether the results meet the objectives of this project or otherwise. If the results obtained is not suitable or meet the objectives, the above research that is about on-off commands should be done again in order to obtain results that meet the objectives of this project.
4. After the good result is obtained is the hardware implementation. In this section, gantry crane model is built. The interfacing with MATLAB will be done after the gantry crane model is built.

5. The results from the interfacing with MATLAB are obtained and analyze. These results will be compared to the results that are obtained from the simulink.
6. Finally, the project would have been realized and ready for verification.

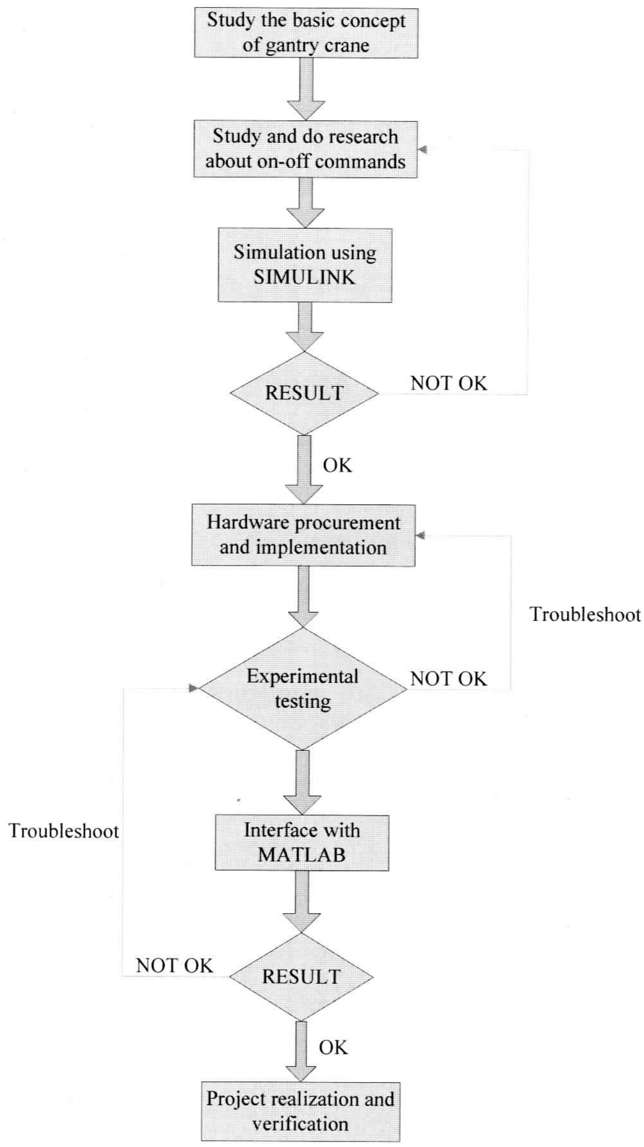

Figure 1.1 Flow chart of methodology.

1.6 Thesis Outlines

This thesis is represented by five chapters. The following chapters are the outline of a feedback control system for suppressing crane oscillations with on-off motors for gantry crane.

Chapter I discuss about the brief overview about the project such as introduction, objectives, problem statement and scope of the project.

Chapter II describes about the research and information about the project. Every facts and information, which found through journals, books and other references. This literature review and the construction of the software use an on-off motors command with the aid of MATLAB Simulink in this chapter.

Chapter III describes about the modelling of the gantry crane. In this chapter all the information and research about the gantry crane from journals will be included.

Chapter IV defines and illustrates the steps employed in the on-off motors command. Including detailed about methodology of hardware and software development in this project. All these methodology should be followed for a better performance.

Chapter V describes about hardware implementation. In this chapter, all the information about the hardware that is the gantry crane model including equipments, circuit and gantry crane specifications are been discussed.

Chapter VI describes about the discussion and project findings. The result is presented by figures. Also consist of how the components complete the tasks.

Chapter VII is about the conclusion of the project and the future recommendations.

CHAPTER II

BACKGROUND OF STUDY

This chapter discusses about literature discourse and review of on-off control method and gantry crane. In this chapter, all the information about gantry crane, the characteristic, requirement needed, on-off control method that suitable for the system are needed to ensure that this project will achieved its objectives.

2.1 Control System

A control system is a device or set of devices to manage, command, direct or regulate the behaviour of other devices or systems. There are two common classes of control systems, with many variations and combinations: logic or sequential controls, and feedback or linear controls. There is also fuzzy logic, which attempts to combine some of the design simplicity of logic with the utility of linear control. Some devices or systems are inherently not controllable.

The term "control system" may be applied to the essentially manual controls that allow an operator to, for example, close and open a hydraulic press, where the logic requires that it cannot be moved unless safety guards are in place.

An automatic sequential control system may trigger a series of mechanical actuators in the correct sequence to perform a task. For example various electric and pneumatic transducers may fold and glue a cardboard box, fill it with product and then seal it in an automatic packaging machine.

In the case of linear feedback systems, a control loop, including sensors, control algorithms and actuators, is arranged in such a fashion as to try to regulate a variable at a setpoint or reference value. An example of this may increase the fuel supply to a furnace when a measured temperature drops. PID controllers are common and effective in cases such as this . Control systems that include some sensing of the results they are trying to achieve are making use of feedback and so can, to some extent, adapt to varying circumstances. Open-loop control systems do not directly make use of feedback, but run only in pre-arranged ways.

2.1.1 Logic Control

Pure logic controls were historically implemented by electricians with networks of relays, and designed with a notation called ladder logic. Nowadays, most such systems are constructed with programmable logic controllers.

Logic controllers may respond to switches, light sensors, pressure switches etc and cause the machinery to perform some operation. Logic systems are used to sequence mechanical operations in many applications. Examples include elevators, washing machines and other systems with interrelated stop-go operations.

Logic systems are quite easy to design, and can handle very complex operations. Some aspects of logic system design make use of Boolean logic.

2.1.2 On-Off Control

William Earl Singhose in his paper called "Command Generation For Flexible System" said that, the time-optimum and minimum-time-multi-switch bang-bang commands are a subset of a larger class of commands referred to as on-off control. On-off commands are a constant positive value, zero, or a constant negative value. The minimum-time commands are a subset that do not contain periods when the actuator effort is zero.

For example, a thermostat is a simple negative-feedback control: when the temperature (the 'measured variable' or MV) goes below a set point (SP), the heater is switched on. Another example could be a pressure-switch on an air compressor: when the pressure (MV) drops below the threshold (SP), the pump is powered. Refrigerators and vacuum pumps contain similar mechanisms operating in reverse, but still providing negative feedback to correct errors.

Simple on-off feedback control systems like these are cheap and effective. In some cases, like the simple compressor example, they may represent a good design choice.

In most applications of on-off feedback control, some consideration needs to be given to other costs, such as wear and tear of control valves and maybe other start-up costs when power is reapplied each time the MV drops. Therefore, practical on-off control systems are designed to include hysteresis, usually in the form of a deadband, a region around the setpoint value in which no control action occurs. The width of deadband may be adjustable or programmable.

2.2 Feedback control method

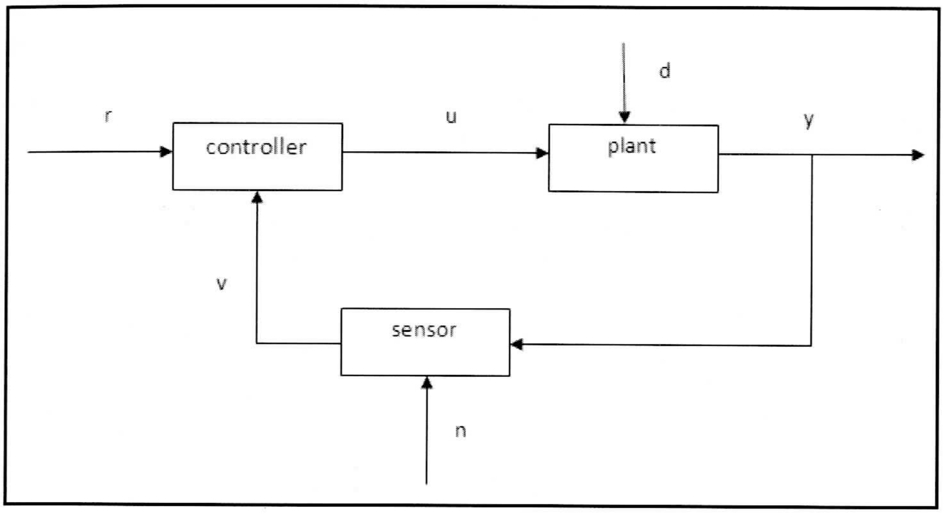

Figure 2.1 Elementary control system.

The most elementary feedback control has three components: plant (the object to be controlled, in this project it is a gantry crane), a sensor to measure the output from the plant, and a controller to generate the plant's input. The controller is always correcting the output until the desirable output is got. From figure 2.1, has two inputs, one internal to the system and one coming from outside, and one output. These signals have the following interpretations:

r = reference or command input

v = sensor output

u = actuating signal, plant input

d = external disturbance

y = plant output and measured signal

n = sensor noise

The three signals coming from outside—r, d, and n—are called exogenous inputs. In what follows we shall consider a variety of performance objectives, but they can be summarized by saying that y should approximate some prespecified function of r, and it should do so in the presence of the disturbance d, sensor noise n, with uncertainty in the plant. We may also want to limit the size of u. Frequently, it makes more sense to