COMPUTER SYSTEM DEVELOPMENT AND INVESTIGATION OF A DIGITAL CONTROL TECHNIQUE

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To -

MY FAMILY

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SYNOPSIS

A control software system was developed for a mini-computer system. The system enables an operator to set up plant conditions, such as actuator settings, controlled by digital-to-analog converters and to monitor plant conditions, using analog-to-digital converters, while the plant is off-line. The operator can also establish parameters necessary for on-line control, and can generate reports on the present status of such parameters. Such activities would include selection of appropriate filtering for the sampled variables, and establishing controller characteristics for various control loops.

Multiple control loops may be catered for. In addition loops may be cascaded, a primary loop providing some relatively simple control function, the set point for this controller being provided in turn by a secondary control loop.

In order to achieve this, the system is interrupt driven, events being scheduled using the real-time clock.

The design of each control loop uses an algorithm developed by E.B. Dahlin and I.D. Higham. The method uses Z-transforms to provide a DDC scheme which is easy to implement and in particular has the ability to cater for process dead time and delays.

An investigation of the system was carried out on a "web process", where material in sheet form, such as a roll of paper, is passed over a system of rollers. The web system in

this case was an experimental one, the material being a continuous roll of towelling.

The control system provided lateral position control of the material on the rollers, position being detected by photocells, and a roller, pivoted on its main axis and pneumatically operated under control of an electrical signal from the computer, providing position actuation.

The operation of a primary loop was investigated using photocells close to the actuating roller, so that time delay was minimal.

A cascaded system, using results derived for the primary controller, was developed for photocells some distance from the actuating roller.

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1. INTRODUCTION

This thesis concerns the implementation of direct digital control, using a PDP/8F minicomputer. The project has been undertaken to gain a better understanding of certain aspects of the control theory used, and also the effective use of the minicomputer. The use of this system in the laboratory for the control of a typical system is described.

Direct digital control (DDC) is becoming increasingly important and is often replacing analog means using three-term controllers. Digital control is applied to a continuous process, which is sampled and processed as discrete time data. The z-transformation procedure is especially convenient and useful in the analysis of these systems.

The design method used has already been developed independently by E.B. Dahlin [7,8] and J.D. Higham [16,17]. This has been applied successfully in paper making and cement industries [9]. It has been chosen for its ease of implementation and ability to cater for process dead time, as well as its proven performance.

The objective is to establish an effective digital feedback control system utilizing the above design. Thus the variable feedback signal is compared with the desired set point value. The difference which is the error signal then passes to a digitized compensator which implements the desired control strategy and sends a signal to an actuator. This in turn controls the process element.

The above-mentioned design demonstrates the direct digital concept and is applied in a laboratory situation to the control of a web processing pilot plant. The objective of web process control is to establish an automatic guiding system to control the path of any material in sheet form with uniform width and straight edges running over a series of fixed rollers. This includes materials like paper, plastic, cloth or metal in sheet form. The pilot plant web material is a continuous roll of towel.

The automatic guiding system will thus incorporate the following basic components:-

(a) Sensing devices (photo cell) which detect the web edge position on the roller.

(b) A controller (minicomputer) which processes an error signal.

(c) The actuator which drives the pneumatic guiding equipment, moving an adjustable roller which has been pivoted about an axis perpendicular to and halfway along its length. The guiding equipment turns the roller about the axis deflecting the roller to the right or left and so changing web position.

The controller used is a 12-bit word-length, 8K PDP/8F minicomputer. A manufacturer-supplied floating point software package is used to assist in providing the basic multiplication and division operations. The entire Executive Program utilizes almost 4K of core storage and provides a real-time operating system. This includes an interactive system for setting process parameters and monitoring plant conditions

under interruptable procedures.

The performance and accuracy of the system is directly dependent on the quality of measurement of the controlled process variables. Therefore, the design of digital filtering is necessary to avoid excessive noise distortion of the signal which is transmitted over a distance. The digital filter is implemented in the software Executive Program of the PDP/8F system.

Two control schemes have been investigated. The first, when the web position is monitored by the photo cell which is mounted close to the adjustable roller (see Fig. 3.3). This controller has been proved to be simple and its application is very effective. The second scheme is more complex. Web position is monitored by a photo cell which is mounted further from the adjustable roller after having passed across an intermediate fixed roller. For this system, a two level control structure proves necessary in order to achieve satisfactory results.

Further details regarding hardware and software involved, application of DDC to the web mechanism and discussions of the experimental results are reviewed in later chapters.

The need to improve process efficiency and profitability has produced a demand for improved control over process operations and this in turn has led to the introduction and utilization of computers in the development of the control.

It is hoped that the mentioned design method [9] and its implementation will show that it is possible to achieve a satisfactory digital computer control suitable for application to industrial users since the project is being

directly related to such processes. Thus the constant requirements of certain industries for higher production rates, better quality control work and lower operating costs can hopefully be achieved.

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