APPLICATION OF VIRTUAL INSTRUMENTATION IN POSITION CONTROL SYSTEM USING DIRECT DIGITAL CONTROL VIA PID AND FUZZY LOGIC CONTROLLER

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To my beloved mother and father

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ABSTRACT

The objective is to design and developed a GUI software using Microsoft Visual Basic 6.0 to ease students in performing position control system experiment, expose students on position control system theoretically and practically and to developed controller using software for position control system. The scope of the project is to apply direct digital control (DDC) in position control system. PID controller and a fuzzy logic controller will be use to control the output response. An interactive software will be developed to help the student to visualize and analyze the system. This project can be divided into two parts namely hardware and software. Hardware parts involve more in interfacing MS150 Modular servo System and Data Acquisition System with a personal computer. While the software part include programming real-time software using Microsoft Visual Basic 6.0. In the earlier stage, literature review and experiment are performed manually to understand the concept of the controller. An interactive software will be designed using Microsoft Visual Basic 6.0. The software will be equipped with a set of graphic instructions to ease any mistake when performing experiment. Finally, the software will be integrated with hardware to produce a GUI position control system.

ABSTRAK

Satu perisian komputer akan di reka dengan menggunakan Microsoft Visual Basic 6.0. Tujuan perisian ini di reka adalah untuk pembelajaran dan pemahaman pelajar semasa menjalankan ujikaji mengawal kedudukan sistem motor servo. Selain itu, tujuan perisian ini adalah untuk mereka sistem kawalan menggunakan Visual Basic 6.0 yang dapat mengawal kedudukan motor servo. Skop projek ini adalah untuk mengadaptasikan modul kawalan terus digital dalam mengawal kedudukan motor servo. Pengawal PID dan pengawal "fuzzy logic" akan digunakan bagi mengawal keluaran motor servo. Satu perisian yang interaktif akan di reka agar dapat membantu pelajar menganalisis sistem motor servo tersebut. Projek ini terbahagi kepada dua bahagian iaitu perkakasan dan perisian. Perkakasan terdiri daripada membuat hubungan antaramuka antara modal MS150 Modular servo sistem dengan DAQ cad dan computer peribadi. Manakala, perisian adalah lebih kepada mereka bentuk perisian yakni mereka bentuk pengawal PID dan pengawal "fuzzy logic" menggunakan Microsoft Visual Basic 6.0 bagi mengawal sistem motor servo.

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LIST OF SYMBOLS

VI	-	Virtual Instrument
PC	-	Personal Computer
DAQ	-	Data Acquisition
DSP	-	Digital Signal Processing
GUI	-	Graphical User Interface
DDC	-	Direct Digital Control
ITL	-	Interactive Teaching and Learning
PID	-	Proportional Integral Derivative Controller
I&C	-	Instrumentation and Control
DC	-	Direct Current
ADC	-	Analogue to Digital Converter
DAC	-	Digital to Analogue Converter
FCE	-	Final Control Element
$\theta_i(t)$	-	Input shaft angle
$\theta_o(t)$	-	Output shaft angle
R_a	-	Armature resistance
L_a	-	Armature inductance
$I(t)$	-	Armature current
F	-	Magnetic field force
1	-	Length of conductor
β	-	Magnetic field strength
$v(t)$	-	Velocity of conductor normal to the magnetic force

$v_b(t)$	-	Back electromotive force
K_b	-	Motor dependant constant
$\tau(t)$	-	Torque
J	-	Total moment inertia
B	-	Total viscous friction
K_T	-	Motor torque constant
$e(t)$	-	Error signal
K_g	-	Gain
ζ	-	Damping ratio
w_n	-	Natural frequency
T_p	-	Peak time
T_r	-	Rise time
$\%OS$	-	Percent overshoot
M_p	-	Peak value of time response
f_v	-	Final value
T_s	-	Settling time
CV	-	Control variable
SP	-	Set point
$y(t)$	-	Output position signal
$r(t)$	-	Reference signal
$V(t)$	-	Controller output
K_p	-	Proportional gain
K_i	-	Integral gain
K_d	-	Derivative gain
DMA	-	direct Memory Access
I/O	-	Input / output
RTDs	-	Resistance temperature detectors
IC	-	Integrated circuit
AI	-	Analogue input

AO	-	Analogue output
DI	-	Digital input
DO	-	Digital output
Hz	-	Hertz
LSB	-	Least significant bit
TTL	-	Transistor-transistor logic
PA150C	-	Preamplifier unit
OA150A	-	Operational amplifier unit
IP150H	-	Input potentiometer
OP150K	-	Output potentiometer
AU150B	-	Attenuator unit
DCMl50F	-	DC motor
GT150X	-	Reduction gear tacho unit
PS150E	-	Power supply
Ω	-	Ohm
RAD	-	Rapid Application Development
HTML	-	Hypertext Markup Language
VB6	-	Visual Basic Version 6.0
COM	-	Component Object Model
IIS	-	Internet Information Server
ASP	-	Active Server Pages
DLL	-	Dynamic. Link Libraries
API	-	Application Programming Interface
IDE	-	Integrated Development Environment
OLE DB	-	Object Link Embedded Database
MTS	-	Microsoft Transaction Server
Ne	-	negative error
Pe	-	positive error
Ze	-	zero error
Nde	-	negative de
Pde	-	positive de

Zde	-	zero de
No	-	negative output
Po	-	positive output
Zo	-	zero output

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CHAPTER 1

INTRODUCTION

1.1 Virtual instrumentation

Virtual instrument have become the catchword in measurement technology. Virtual instrumentation easily can be connected with the term “test engineer”. When attempting to interpret the meaning of “test engineer”, almost everyone ties a different idea or concept to this catchword. For many, it represents a control instrument based on standard personal computers to store, evaluate, and represent test data. According to this notion, data is acquired through special measuring devices attached to a personal computer over a serial or parallel cable. Some thinks that it means a computer equipped with application and driver software and a built in transmitter as sort of low-cost alternative to relatively expensive standard alone measuring devices. Both ideas are correct, but only up to a certain point. They cover only part of this concept. Before discussing the exact definition, we will describe the principle types of computer-assisted test data acquisition [13].

Test data can be acquired in a computer in a different ways. It is important to understand the underlying architecture of a measuring device. A traditional measuring device always consists of three components, shown in figure 1.1, which perform the following tasks [13]:

- Acquire the measurement parameters (data acquisition)
- Adapt and process the measured signal (analysis)
- Output the measured value (presentation)

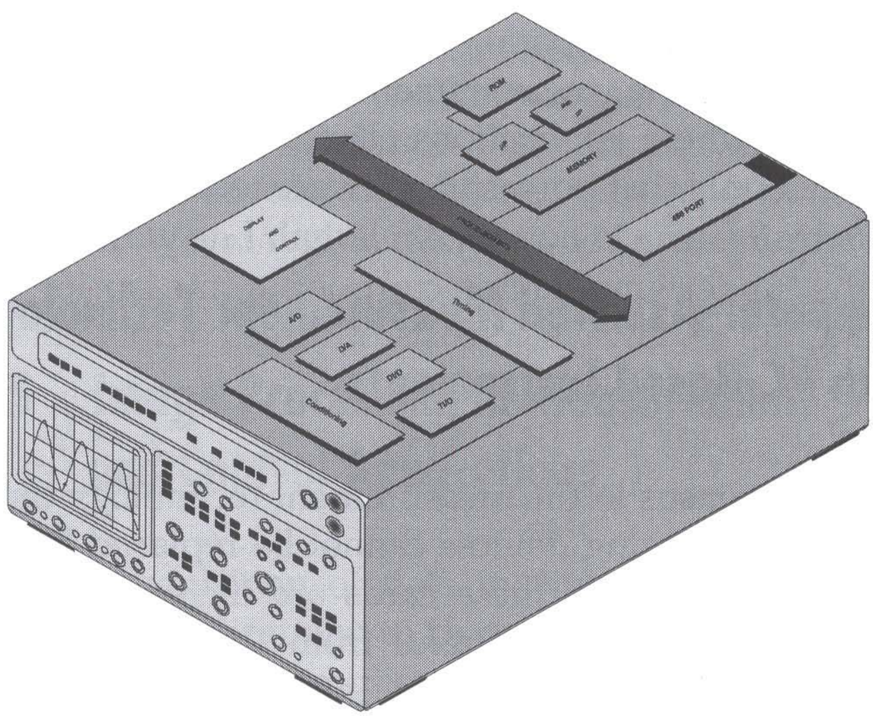

Figure 1.1: Structure of a measuring device.

Such measuring devices generally have fixed functions defined by the manufacturer, and they are characterized by a manufacturer-specific architecture and an inflexible user interface. Consequently, they cannot be adapted easily to changing needs.

Both the operation and the documentation are entirely manual. To add long measuring sequences that require constant changes of settings, a large amount of time is used to set the measuring devices and to document the measured values.

1.2 Virtual Instruments

Based on this background information, we are now able to define the term "virtual instrument" in a more accurate way. We speak about a virtual instrument when we create measuring systems composed of a standard personal computer, suitable software, and appropriate measuring hardware tailored to the measuring task, which is normally available only in specifically designed stand-alone measuring devices. Virtual instruments represent a visualization and centralization of complex measurement systems on a standard personal computer in the form of a virtual user interface [13]. The user sees a uniform, comprehensive single system, i.e., a complete application, consisting of many individual measuring components. This fundamental concept is the quantum leap from the conventional measuring device over computer-assisted measurement technologies to adaptable virtual measuring systems. This represents a shift from manufacturer-defined measuring devices to user-defined measuring systems. The main benefits of this concept are:

- A virtual instrument can contain any combination of industry standard hardware to acquire or output data: IEEE-488.2, RS-232 devices, VXI/MXI systems, field buses (CAN, Interbus-S, Profibus, Foundation Fieldbus, Axiom etc.), multifunction plug-in cards, DAQ instruments, image processing components, external black-box systems, or motion control. figure 1.2 illustrates the hardware architecture.

- The capabilities to analyze and represent measured data reach far beyond the boundaries of conventional measurement technology.
- A powerful software development environment and a set of hardware components allow creation of a number of virtual instruments to cover a wide range of test functions and applications.

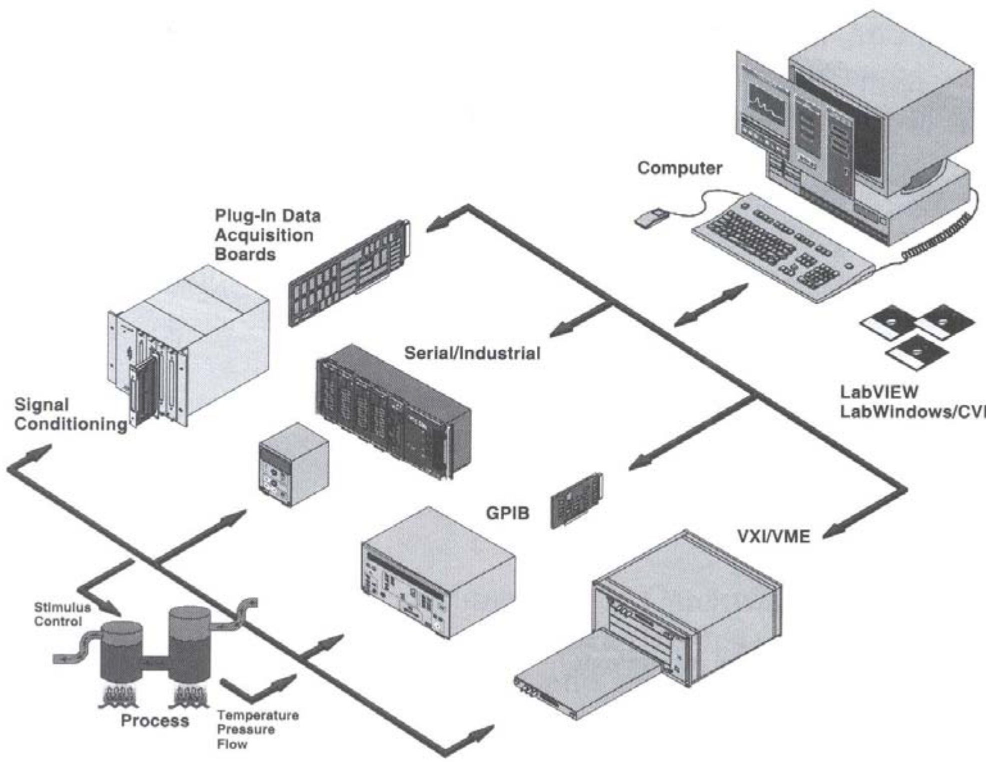

Figure 1.2: Hardware architecture of virtual instruments.

The spectrum of virtual instruments used in practice includes classical laboratory automation, process visualization and control, automotive and aviation industries, medical applications, manufacturing industry, and research and science.

1.3 Project Objectives

The main objective of this project is to develop software with Graphical User Interface (GUI) capabilities using Microsoft Visual Basic version 6.0 in performing their position control system experiment. The GUI will be developed with the following goals:

1) To developed controller using software for position control system.
2) To ease students in performing position control system experiment.
3) Expose students on position control system theoretically and practically.
4) Enable students to understand more on application that is based on position control.
5) Teaching electrical engineering students real-world data acquisition and analysis.
6) Allowing students manipulate the information with their graphics and word processing packages to generate professional quality lab reports.
7) Empowering students to acquire experimental data in this laboratory experiment directly from the software.
8) Permits students to meaningfully experiment with physical relationship in a readily interpretable, graphics format.

Besides that, the objectives of each experiment that have to be performed by student are basically divided into 4 classical control experiments listed as below:

(i) Experiment 1 – Closed-loop Position Control System.
Objective: To demonstrate a simple motor-driven closed-loop position control system.

(ii) Experiment 2 – Effect of Gain Changes On Deadband.

Objective: To study on the deadband of a position control system and the effect of gain changes upon the Deadband.

(iii) Experiment 3 – Unit Step Response To Gain Changes.

Objective: Visual study of step response to gain changes upon position control system.

(iv) Experiment 4 – Velocity Feedback.

Objective: Study on the effect of velocity feedback in a position control system.

Besides these experiments, an additional experiment using Direct Digital Control (DDC) techniques will be implementing in this software to allow student to observe system response behaviour upon changes on the proportional gain, integral gain and derivative gain. The objective of these experiments is to enable student to differentiate between Direct Digital Control and Classical Control. Hence, this will allow student to control the position of the control system in real-time with a PC-based system and aware them of the important role, played by personal computers in engineering nowadays.

Based on the above experiment, it also allow student to differentiate between Supervisory Control and Direct Digital Control where in Supervisory Control, computers are used for monitoring purpose only but in Direct Digital Control, control loop is replaced by computers to interface with process measurement and control some of the physical process parameters.

1.4 Project Scope

The scope of the project is listed below:

i. To apply direct digital control (DDC) in position control system.

ii. To develop a PID and a fuzzy logic controller which will be use to control the output response.

iii. To make comparison of the performance between PID controller and fuzzy logic controller.

iv. To developed Graphical User Interface to help the student to visualize and analyze the system. Besides, it also covers the method on enhancing the original experiment for student so that they can finish their experiment on time and in the mean time, they can grab more understanding through visual presentation.