Swing Up Control of Quanser Qube Servo

G.Vinaykumar[1], B.Abhilash[2], Mr. P. Ganesh[3] and Dr. M. Lakshmi Swarupa[4]

[1, 2]UG Students, Department of Electrical and Electronics Engineering, Malla Reddy Engineering College (A), India
[3]Assistant Professor, Department of Electrical and Electronics Engineering, Malla Reddy Engineering College (A), India.
[4]Professor, Department of Electrical and Electronics Engineering, Malla Reddy Engineering College (A), India.
E-Mail: ganeshp5891@gmail.com

Abstract - An inverted pendulum is a popular mechatronic application that exists in different forms. There are two interesting cases available in roational and arm driven systems. These use a link rotating about an axis to balance a pendulum link which rotates freely in the vertical plane. The arm driven vertical uses a driven link rotating in a vertical plane to balance the pendulum link which also rotates on the vertical plane. The horizontal and vertical configurations can be switched by simply replacing the links and setting the base on its side. Inverted pendulum is a non linear unstable control problem alike a flexible broom on a moving cart. Control of an inverted pendulum is a control engineering problem based on flight simulation of rocket or missile during initial stages of flight. The aim is to stabilize the inverted pendulum such that the position of the carriage on the track is controlled quickly and accurately so that the pendulum is always erected in its inverted position during such movements. The main objective of this project is to balance a link on one end of the control system using a feedback control in LABVIEW. In the proposed system the reference energy has changed from 90mJ to 120 mJ and observed the stability of the pendulum. In addition, to this the values of swing up control gain and acceleration also observed and the plots have drawn.

Keywords - LABVIEW, pendulum, control, stability, acceleration, control gain

I. INTRODUCTION

Laboratory Virtual Instrument Engineering Workbench (LabVIEW) is a system-design platform and development environment for a visual programming language from National Instruments .The graphical language is named "G" not to be confused with G-code. Originally released for the Apple Macintosh in 1986, LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of operating systems (OSs), including Microsoft Windows, various versions of Unix, Linux, and macOS. LabVIEW programs are called virtual instruments, or VIs, because their appearance and operation imitate physical instruments, such as oscilloscopes and multimeters. LabVIEW contains a comprehensive set of tools for acquiring, analyzing, displaying, and storing data, as well as tools to help you troubleshoot code you write. In LabVIEW, you build a user interface, or front panel, with controls and indicators. Controls are knobs, push buttons, dials, and other input mechanisms. Indicators are graphs, LEDs, and other output displays. After you build the front panel, you add code using VIs and structures to control the front panel objects. The block diagram contains this code.

You can use LabVIEW to communicate with hardware such as data acquisition, vision, and motion control devices, as well as GPIB, PXI, VXI, RS232, and RS485 instruments

In the following exercises, you will build a VI that generates a signal and displays that signal in a graph. After you complete the exercises, the front panel of the VI will look similar to the front panel as shown in figure

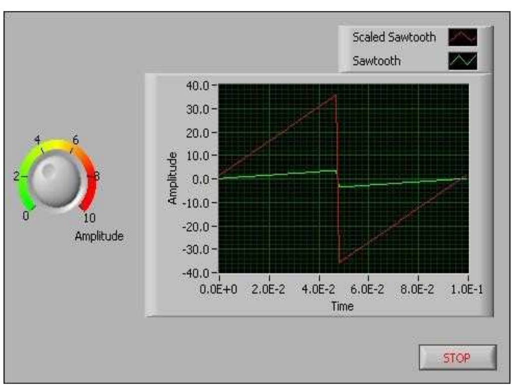

Fig. 1. Front Panel of the Acquiring a Signal VI

II. Acquiring Data & Communicating with Instruments (Windows)

An instrument driver is a set of software routines that control a programmable instrument. Each routine corresponds to a programmatic operation such as configuring, reading from, writing to, and triggering the instrument. Instrument drivers simplify instrument control and reduce test program development time by eliminating the need to learn the programming protocol for each instrument. Use an instrument driver for instrument control when possible. National Instruments provides thousands of instrument drivers for a wide variety of instruments. In the following exercises, you will use instrument drivers and the Instrument I/O Assistant to communicate with an instrument. You must have an instrument installed to fully complete the following exercises.

III. QUBE-SERVO

The Quanser QUBE-Servo 2, pictured in Figure 6.1, is a compact rotary servo system that can be used to perform a variety of classic servo control and inverted pendulum based experiments. The QUBE-Servo 2 can be configured with either the QFLEX 2 USB or QFLEX 2 Embedded interface modules. The QFLEX 2 USB allows control by a computer via USB connection. The QFLEX 2 Embedded allows for control by a microcontroller device such as an Arduino via a 4-wire SPI interface. For all versions, the system is driven using a direct-drive 18V brushed DC motor. The motor is powered by a built-in PWM amplifier with integrated current sense. Two add-on modules are supplied with the system: an Inertia disc and a Rotary pendulum. The modules can be easily attached or interchanged using magnets mounted on the QUBE Servo module connector. Single-ended rotary encoders are used to measure the angular position of the DC motor and pendulum, and the angular velocity of the motor can also be measured using an integrated software-based tachometer.

The QUBE-Servo 2 can be configured with one of two different I/O interfaces: the QFLEX 2 USB, and the QFLEX 2 Embedded. The QFLEX 2 USB provides a USB interface for use with a computer. The QFLEX 2 Embedded provides a 4-wire SPI interface for use with an external microcontroller board.

The interaction between the different system components on the QUBE- Servo 2 is illustrated in Figure 6.2. On the data acquisition (DAQ) device block, the motor and pendulum encoders are connected to the Encoder Input (EI) channels #0 and #1. The Analog Output (AO) channel is connected to the power amplifier command, which then drives the DC motor. The DAQ Analog Input (AI) channel is connected to the PWM amplifier current sense circuitry. The DAQ also controls the integrated tri-color LEDs via an internal serial data bus. The DAQ can be interfaced to the PC or laptop via USB link in the QFLEX 2 USB, or to an external microcontroller via SPI in the QFLEX 2 Embedded.

One of the most compelling reasons to attain stability is to remove the damping oscillations and vibrations from the system. Now a days there are lot of research works going on to attain the stability and to control the systems. This project has tested the Qube servo inverted pendulum by visualization software platform and swing up controller, the physical model in LabVIEW has been designed and tested the swing up control, stability by using proportional derivative (PD) controller and feedback controller. It is observed that the pendulum becomes stable according to the input parameters like reference energy, swing up control gain, and acceleration.

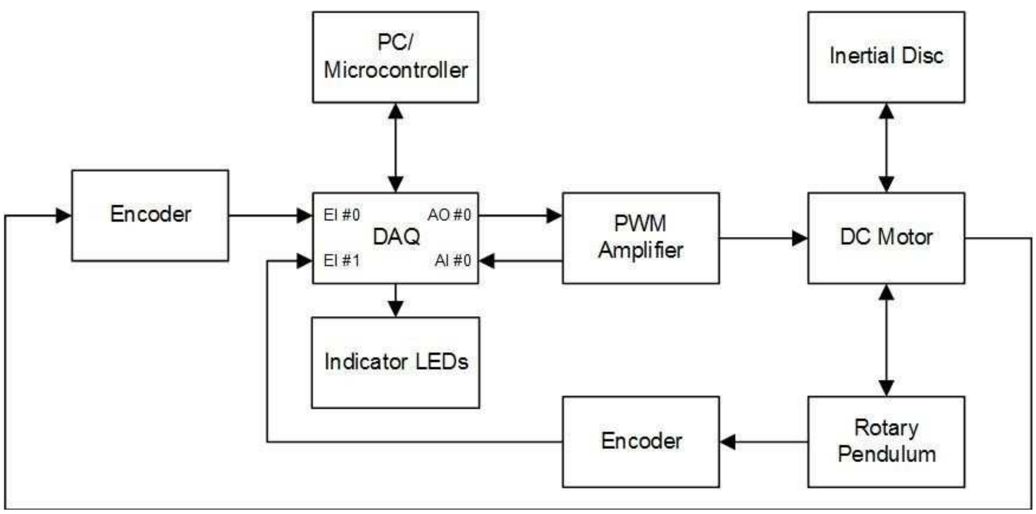

Fig. 2. Interaction between QUBE-Servo 2 components

IV. Conclusion

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V. Future Scope

However the stability and the control of the system is still under development. Further work can be done by designing a stable system for the applications of inverted pendulum like active suspension, magnetic levitation, cranes, and coupled tanks in real time. Qube servo inverted pendulum by visualization software platform and swing up controller, the physical model in LabVIEW may be designed.

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