PID Control of Inverted Pendulum Using LabVIEW

S.Sharaenya[1], C.S.ManikadaBabu[2]

Student, M.E-VLSI (ECE Department), Sri Ramakrishna Engineering College, Coimbatore, India[1]

Assistant Professor (S.G), M.E-VLSI (ECE Department), Sri Ramakrishna Engineering College, Coimbatore, India[2]

Abstract: Today control theory over intelligent system is well developed to provide a sophisticated design technique for practical control systems. Moreover, computers are fast and powerful, as well as reliable and implementable software packages such as LabVIEW have considerably reduced the computational hindrances for designing, simulating and implementing sophisticated controllers. This paper presents the implementation of PID control of inverted pendulum using LabVIEW. LabVIEW is the reliable stand-alone hardware control processor and Windows independent software. The proposed algorithm shows high capabilities in learning. We show that this algorithm can be effectively applied to develop a LabVIEW VI to control the position of cart and pendulum & move it through a sequence of position as desired using the PID control algorithm. We can use the analog output to control the DC servo motor position to bring the pendulum to the reference zero position. In other words, we can bring the pendulum to the vertically erect position. For the feedback or the input device, we can use the encoder. The experimental implementation of the algorithm on the freestanding cart-mounted inverted pendulum evaluates the effectiveness and results of the proposed algorithm.

Keywords: Control systems, LabVIEW, PID, Inverted Pendulum.

I. INTRODUCTION

An inverted pendulum is a pendulum that has its center of mass above its pivot point. It is often implemented with the pivot point mounted on a cart that can move horizontally and may be called a cart and pole. Most applications limit the pendulum to 1 degree of freedom by affixing the pole to an axis of rotation. Whereas a normal pendulum is stable when hanging downwards, an inverted pendulum is inherently unstable, and must be actively balanced in order to remain upright; this can be done either by applying a torque at the pivot point, by moving the pivot point horizontally as part of a feedback system, changing the rate of rotation of a mass mounted on the pendulum on an axis parallel to the pivot axis and thereby generating a net torque on the pendulum, or by oscillating the pivot point vertically.

A simple demonstration of moving the pivot point in a feedback system is achieved by balancing an upturned broomstick on the end of one's finger. The inverted pendulum is a classic problem in dynamics and control theory and is used as a benchmark for testing control strategies. The inverted pendulum is a classic problem in dynamics and control theory and is widely used as a benchmark for testing control algorithms (PID controllers, state space representation, neural networks, fuzzy control, genetic algorithms, etc.). Variations on this problem include multiple links, allowing the motion of the cart to be commanded while maintaining the pendulum, and balancing the cart-pendulum system on a see-saw.

The inverted pendulum is related to rocket or missile guidance, where the center of gravity is located behind the center of drag causing aerodynamic instability.[2] The understanding of a similar problem can be shown by simple robotics in the form of a balancing cart. Balancing an upturned broomstick on the end of one's finger is a simple demonstration, and the problem is solved in the technology of the Segway PT, a self-balancing transportation device. Another way that an inverted pendulum may be stabilized, without any feedback or control mechanism, is by oscillating the support rapidly up and down. This is called Kapitza's pendulum. If the oscillation is sufficiently strong (in terms of its acceleration and amplitude) then the inverted pendulum can recover from perturbations in a strikingly counterintuitive manner. If the driving point moves in simple harmonic motion, the pendulum's motion is described by the mathematical equation.

II. SURVEY

Control of the inverted pendulum attached on the top plate of a mobile robot when the mobile robot is curvilinear motion, the stable control of the inverted pendulum is a challenging problem. The range of disturbance which can be overcome by the controller has been verified and utilized to control the pendulum [2].

A spherical inverted pendulum is a rod connected to a universal joint, which is attached to a horizontal movable base. An omni-directional mobile robot is a special type of wheeled mobile robot that can perform translational movement along any desired path combined with any rotational movement.

We consider the problems of balancing a spherical inverted pendulum that is driven by an omni-directional mobile robot [3].

DOI 10.17148/IJIREEICE.2016.45116

III. PID CONTROL

Achieving stability of an inverted pendulum has become a common engineering challenge for researchers. There are different variations of the inverted pendulum on a cart ranging from a rod on a cart to a multiple segmented inverted pendulum on a cart. Another variation places the inverted pendulum's rod or segmented rod on the end of a rotating assembly. In both, (the cart and rotating system) the inverted pendulum can only fall in a plane. There are many instances of the inverted pendulum model both man made and found in the natural world. Arguably the most prevalent example of an inverted pendulum is a human being. A person with an upright body needs to make adjustments constantly to maintain balance whether standing, walking, or running. Some simple examples include the metronome and balancing brooms or meter sticks by hand. The inverted pendulum has been employed in various devices and trying to balance an inverted pendulum presents a unique engineering problem. The inverted pendulum was a central component in the design of several early Seismometers due to its inherent instability resulting in a measurable response to any disturbance. The inverted pendulum model has been used in some forms of personal transportation devices. Two-wheeled wheel chairs and other two wheeled motorized vehicles can offer enhanced mobility for the driver.

A. PID Control

A Proportional Integral Derivative controller is a control loop feedback mechanism commonly used in industrial control systems. P -represents the present values of the error. I-represents the past values of the error. D-represents the possible future values of the error.

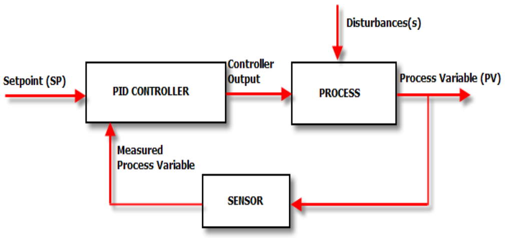

Fig. 1. PID control

To develop a LabVIEW VI that will control the position of pendulum and move it through a sequence of positions as fast as possible. Some position will require the pendulum to be inverted & other will require it to be hanging. Different control algorithms can be used in our model such as PID control and Fuzzy Logic. PID control algorithm is mainly focused. Using analog output we can control the servo motor position to get the pendulum to the reference zero position (i.e vertically erect).

Servo control addresses the disturbance rejection characteristics of the system. Disturbances can be anything from torque disturbances on the motor shaft to incorrect motor parameter estimations. The familiar "P.I.D." (Proportional Integral and Derivative position loop) control are used to combat these types of problems.

B. Circuit Diagram

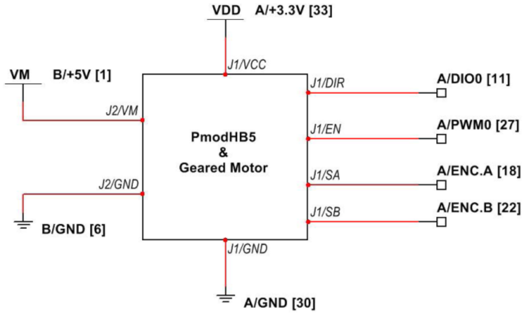

Fig. 1. Circuit diagram of PmodHB5 and Gear Motor

C. Energy Calculation: Potential Energy

Ep=Mp*g*Lp(1-cos Alpha) (1)

Ep is potential energy, Mp is the mass of the pendulum,g=9.81,
Lp is the length of the pendulum.

D. Kinetic Energy

Ek=1/2*Jp*(Alpha_dot)^2 (2)

Ek is kinetic energy,Jp is moment of inertia.

E. Total Energy

E=Ep+Ek (3)
E=Mp*g*Lp(1-cos Alpha)+1/2*Jp*(Alpha_dot)^2 (4)
E_dot=Mp*u*Lp*Alpha_dot*cos(Alpha) (5)
u= (Er-E)*Alpha_dot*cos(Alpha) (6)

F. myRIO Connections with motor

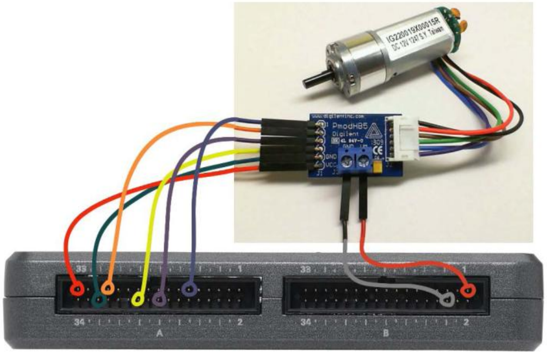

Fig. 2. myRIO connections with Motor

IV. INTERFACE THEORY

Determine the number of shaft encoder counts for one revolution of the gearbox shaft output and then add block diagram code to display the gearbox output shaft angle in degrees. Add a display to show the gearbox output shaft RPS (revolutions per second).The block diagram has been intentionally designed to make it easy for us to add a PID (proportional/integral/derivative) controller to implement a closed-loop speed control system Place the PID controller located in the Real-Time Function Blocks Control sub palette in this space. Create front-panel controls for the proportional gain, integral time, and derivative time values. Right-click on the PWM duty control and select "Change to indicator," Connect the PID output to the PWM duty indicator Create a control for the PID set point input Keep the Reset Counter switch active or change it to a true-valued constant.

V. LABVIEW INTRODUCTION

LabVIEW (short for **Lab**oratory **V**irtual **I**nstrumentation **E**ngineering **W**orkbench) is a platform and development environment for a visual programming language from National Instruments. The graphical language is named "G". Originally released for the Apple Macintosh in 1986, LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms including Microsoft Windows, various flavors of Linux, and Mac OS X. The code files have the extension ".vi", which is an abbreviation for "Virtual Instrument". LabVIEW offers lots of additional Add-Ons and Toolkits.

G. Dataflow Programming

The programming language used in LabVIEW, also referred to as G, is a dataflow programming language. Execution is determined by the structure of a graphical block diagram (the LV-source code) on which the programmer connects different function-nodes by drawing wires. These wires propagate variables and any node can execute as soon as all its input data become available. Since this might be the case for multiple nodes simultaneously, G is inherently capable of parallel execution. Multi-processing and multi-threading hardware is automatically exploited by the built-in scheduler, which multiplexes multiple OS threads over the nodes ready for execution.

H. Graphical Programming

LabVIEW ties the creation of user interfaces (called front panels) into the development cycle. LabVIEW programs/subroutines are called virtual instruments (VIs). Each VI has three components: a block diagram, a front panel, and a connector panel. The last is used to represent the VI in the block diagrams of other, calling VIs. Controls and indicators on the front panel allow an operator to input data into or extract data from a running virtual instrument. However, the front panel can also serve as a programmatic interface.

Thus a virtual instrument can either be run as a program, with the front panel serving as a user interface, or, when dropped as a node onto the block diagram, the front panel defines the inputs and outputs for the given node through the connector pane. This implies each VI can be easily tested before being embedded as a subroutine into a larger program. The graphical approach also allows non-programmers to build programs simply by dragging and dropping virtual representations of lab equipment with which they are already familiar. The LabVIEW programming environment, with the included examples and the documentation, makes it simple to create small applications. This is a benefit on one side, but there is also a certain danger of underestimating the expertise needed for good quality "G" programming. For complex algorithms or large-scale code, it is important that the programmer possess an extensive knowledge of the special LabVIEW syntax and the topology of its memory management. The most advanced LabVIEW development systems offer the possibility of building stand-alone applications. Furthermore, it is possible to create distributed applications, which communicate by a client/server scheme, and are therefore easier to implement due to the inherently parallel nature of G-code.

VI. RESULTS

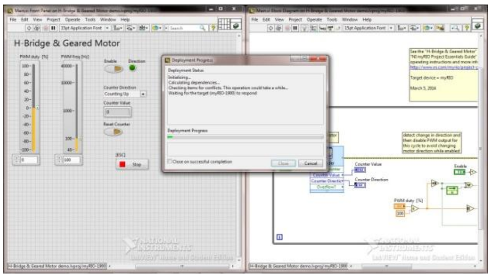

Fig. 4. H-Bridge & Geared Motor

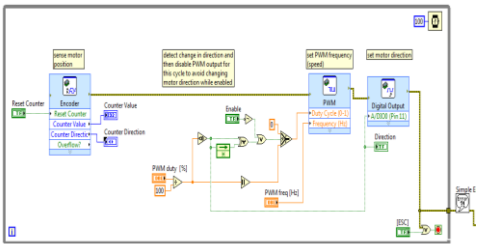

Fig.5.Block Diagram of H-Bridge & Geared Motor

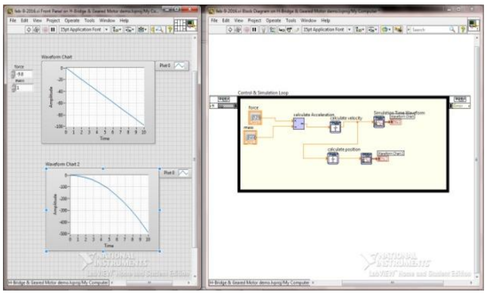

Fig.6. PID Control Logic

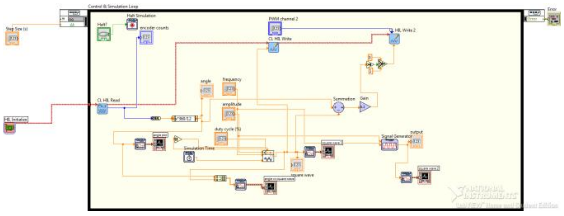

Fig.7. Swinging of Pendulum using LabVIEW

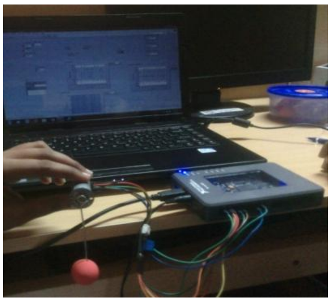

Fig. 8. Swinging of Pendulum using myRIO

DOI 10.17148/IJIREEICE.2016.45116

VII. CONCLUSION

Finally the interfacing of PID is done in order to design the inverted pendulum and the angle & energy calculation is done. The inverted pendulum find multiple applications and its widely used in humanoid robot, iBOT etc.,

ACKNOWLEDGMENT

I express my profound gratitude to my supervisor **C.S.Manikandababu, M.E.,(Ph.D)** Assistant Professor (S.G), Department of Electronics and Communication Engineering, Sri Ramakrishna Engineering College for guiding me in the right direction towards the successful completion of my project.

REFERENCES

[1]. S. M. Metev and V. P. Veiko, Laser Assisted Microtechnology, 2nd ed., R. M. Osgood, Jr., Ed. Berlin, Germany: Springer-Verlag, 1998.
[2]. Howon Lee and Jangmyung Lee, “Driving Control of Mobile Inverted Pendulum”, The 9th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI 2012), Nov. 26-28, 2012 in Daejeon Convention Center(DCC), Daejeon, Korea.
[3]. Sho-Tsung Kao, Wan-Jung Chiou; Ming-Tzu Ho, “Balancing of a spherical inverted pendulum with an omni-directional mobile robot”,IEEE transactions on Control Applications, vol. 28, pp. 760-765, Aug 2013
[4]. Vikas Kumar and Rana.K.P.S, “Real time comparative study of the performance of FPGA based PID and fuzzy controllers for a rectilinear plant” , IEEE Transaction on Power Electronics, vol.12,pp.1-7, Jan 2011.
[5]. Zhao Junpeng, Liu Xinfu “Research on PID controller for hydraulic servo system based on LabVIEW” IEEE Transactions on Fluid Power and Mechtronics (FPM), vol.18,pp.1195-1198,Aug 2015.

BIOGRAPHIES

Prof. C.S. Manikandababu, B.E., ME., (Ph.D),Assistant Professor(SI.G), Sri Ramakrishna Engineering College, Coimbatore has completed his M.E., (VLSI Design) at Anna University Regional Centre, Coimbatore in the year 2009, and B.E., (ECE) at VLB Janakiammal College of Engineering & Technology, Coimbatore, Bharathiyar University, Coimbatore in the year 2001. He has 10 years of teaching experience in addition to his portfolio in the technical industry for 03 years. His research area lies in Image processing & VLSI Design.

He has published 17 technical papers in various peer-reviewed National & International Journals, 26 technical papers in the proceedings of various National & International Conferences.

He has organized and coordinated around 22 programmes including Guest lectures, Technical Symposiums, Workshop, National & International Conference. His industrial interaction laid path for signing Memorandum of Understanding, Career & Internship for students. He is a life member of the International Association of Engineers (IAENG) and Indian Society for Technical Education (ISTE).

S.Sharaenya, Student M.E-VLSI Design, Sri Ramakrishna Engineering College, Coimbatore, completed her B.Tech (ECE) at Bharathiyar College of Engineering and Technology.

DOI 10.17148/IJIREEICE.2016.45116