Design and Analysis of Digital PID Controller A Review

Bhakti Khandalkar, Prof. Amit Lamba , Prof. Vipin Bhure

Electronics and Communication Engineering
GHRAET, RTMN University Nagpur, India

***Abstract*— The digital Proportional-Integral-Derivative (PID) controller is the feedback controller which is most wildly used in automation industries.PID controller play an important role in industry because of its excellent properties like simplicity, robustness, good noise tolerance and maintenance requirement. This project is concerned with design and analysis of structure of a digital Proportional – Integral – Derivative (PID) controller. In order to design digital PID controller, multipliers and adders are the basic blocks hence in our project we will design PID controller using high speed optimized adders and high speed optimized multiplier which improves the area and speed.**

***Keywords*— *Digital PID controller, High speed adder and multiplier*.**

I. Introduction

The digital PID controller is the feedback controller .It is divided into two parts main part PID controller and closed loop system. A system in which the control action is somehow depending on the output is called closed loop system. Closed loop system consist of reference input r(t),Feedback signal y(t),Error signal e(t),Control o/p u(t),Plant/Process. The PID algorithm consists of three basic modes, Proportional, Integral and Derivative modes. While utilizing this algorithm it is necessary to decide which modes are to be used (P, I or D) and then specify the parameters (or settings) for each mode used. Generally, three basic algorithms are used P, PI or PID [1].

The PID controller minimizes the error by changing the controller output, which is given as an input to the system. Proportional is related with present error, Integral on the past one and Derivative means prediction about the future errors. Sum of the each term, multiplying with respective gain gives the output of PID controller [2].

The general PID equation is given as,

$$u(t) = K\left(e(t) + \frac{1}{T_i}\int_0^t e(t)\,dt + T_d \frac{d}{dt} e(t)\right) \quad \ldots\ldots\ldots\ldots \ (1)$$

Where,

e(t) is error signal, u(t) is output of controller, K is gain or proportion gain, Ti is Integration time or rise time, Td is Derivative time[3,6].

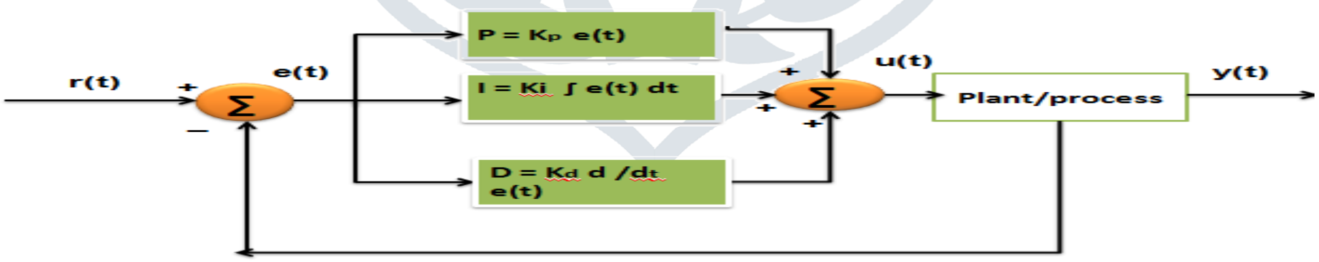

Fig 1.Generic system controlled by PID controller

The function of the digital PID controller is to generate an output that drives the system at the plant so that the output matches a reference signal. The target is to get the error as close to zero as possible.

Simplicity, robustness, effectiveness are some properties of the Proportional-Integral-Derivative (PID) controllers due to which it have been widely used over the past five decades[4]..Despite the numerous control design approaches, now a day's PID controllers are still employed in more than 95% of industrial processes. Proportional integral-derivative (PID) controllers are the most adopted controllers in industrial settings because of the advantageous cost/benefit ratio they are able to provide. The area in which PID controller are use such as process control, aerospace, robotics, automation, manufacturing, and transportation system[4].

Related Work Done

Kaustubh etal "Implementation of PID Architecture in FPGA for DC Motor Speed Control".

The customized Proportional-Integral-Derivative (PID) architecture was designed using FPGA for the speed control of permanent magnet DC motor. This architecture is design using Verilog to implement speed control loop. Closed loop system is simulated using MATLAB Simulink. To test the valid proposed design, an experimental set up has been developed for DC motor speed control. Mainly due to large computational requirement and resource requirement of floating point arithmetic, they proposed fixed point PID architecture which gives the comparable results. The output of the controller is assigned to on-time of PWM signal through PWM Generation module. PWM module generate enable signal for control loop. But the PWM block provides disconnection of modulator and brakes of motor which increases power consumption. The performance of motor is tested and studied parameters like frequency, speed. It is found that the design PID controller is able to control the speed as per the requirement with accuracy [2].

Rajesh Nema, etal "Design &Implementation of FPGA Based on PID Controller with Motor & Sensor"
In this paper author proposed PID controller and it is implemented in a dedicated FPGA with PWM modulator.

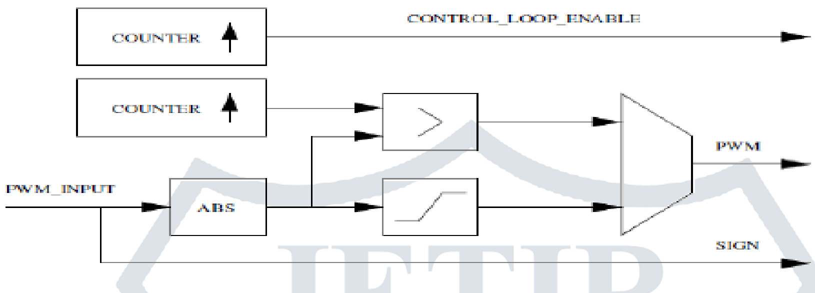

Fig.2. Block diagram of the PWM modulator

The PWM module also generates the enable signal for the control loop. The PWM modulator admits a two's complement input and transforms it into a PWM signal. The module has two outputs, one the modulated PWM and the other one the sign of the modulation .The PWM block also has an on/off input, allowing the disconnection of the modulator and the brake of the motor. Author is proposing a sensor by eliminating PWM Modulator and A/D Convertor, which can reduce the power consumption and overall Delay for system [3].

Michal Kocur, etal "Design and implementation of FPGA-digital based PID controller."

This paper proposed an effective realization of digital PID control algorithms using FPGA technology. In this case the parallel design of the digital based PID algorithm with register, summer and multiplier is used. The overall control system is composed of five components as we as we can see in the Fig. Clock divider provides the sample rate and the CLK signal for the other components. DAC an ADC interfaces transmit or receive data from convertors.

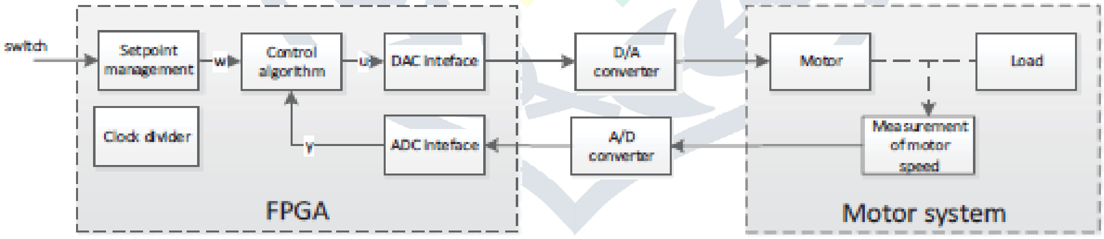

Fig.3 Block scheme of control loop

There are two approaches for implementing of control systems using software which implies a memory-processor interaction and in hardware approach controlled motor system consist of two DC motors linked by a common shaft with the incremental encoder. Communication between FPGA and motor system provides A/D and D/A converters. The ADC has width of 12-bit and the DAC has width of 8-bit. The results of the hardware implementation are very similar with Matlab obtained by simulation only the high noise is making differences [4].

Somsubhra Ghosh etal "An FPGA Based Implementation of a Flexible Digital PID Controller for a Motion Control System".
In this paper author presents a novel technique for implementation of an efficient FPGA based digital Proportional-Integral-Derivative (PID) controller for the motion control of a permanent magnet DC motor. The controller is used in a speed control loop. The controller has been designed with a trapezoidal integral and filter algorithm. The average connection delay for the design is 15.194ns. In this paper author compare the experimental results with the Matlab based simulation which shows the effectiveness of the proposed method [5].

CONCLUSION

From the above summary of paper it is observed that the constancy of speed with a varying load is better with the closed loop system than with the open loop. This shows controller is robust and able to handle load disturbances as well as uncertainties. Second paper presents, a PID controller for FPGA implementation providing an efficient technique which require less power and achieve high speed as well as better performance. While in the next one, present the basic principle to realize PID control algorithm. In the last paper, the design shows improvement over the present way of implementing digital controllers in microcontroller unit.

REFERENCES

[1] Abdesselem etal "PID Control Implementation using FPGA Technology".

[2] Kaustubh etal "Implementation of PID Architecture in FPGA for DC Motor Speed Control." Circuit Controls and communication (CCUBE), 2013 International Conference on 27-28 Dec. 2013 IEEE.

[3] Rajesh Nema, etal "Design &Implementation of FPGA Based On PID Controller with Motor & Sensor". International Journal of Emerging Science and Engineering (IJESE) ISSN: 2319–6378, Volume-1, Issue-3, January 2013

[4] Michal Kocur, Stefan Kozak, Branislav Dvorscak "Design and implementation of FPGA-digital based PID controller." 978-1-4799-3528-4/14/$31.00 ©2014 IEEE.

[5] Somsubhra Ghosh et al "An FPGA Based Implementation of a Flexible Digital PID Controller for a Motion Control System."(*ICCCI*- 2013) Jan04–06 2013, Coimbatore INDIA ©2013IEEE.

[6] Hammad Khan et al "Comparative Analysis and Design of Diverse Realizations for FPGA Based Digital PID Controller Using Xilinx SysGen" International Journal of Computer and Electrical Engineering, Vol. 4, No. 6, December 2012

[7] Prof. Vikas Gupta, et al "Efficient FPGA Design and Implementation of Digital PID Controllers in Simulink." International Journal of Recent Trends in Engineering Vol 2, No. 6, November 2009(ACEEE)