Implementation of PID Controller for Temperature Process Using FPGA

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Abstract- *In this paper, the implementation of software module using 'VHDL' for Xilinx FPGA based PID controller for temperature process is presented. The tools used for building and testing the software modules are Xilinx ISE.Before verifying the design on FPGA the complete design is simulated using Modelsim Simulation tool. A test bench is written where, the set point can be changed for the process.The objective of our project was to implement PID controller on an FPGA for control application. We designed a controller to track and maintain a set point temperature of a heater. The motivation behind using FPGA to implement a PID controller rather than microcontrollers and DSPs is because it provides a good balance between performance and cost.*

I. INTRODUCTION

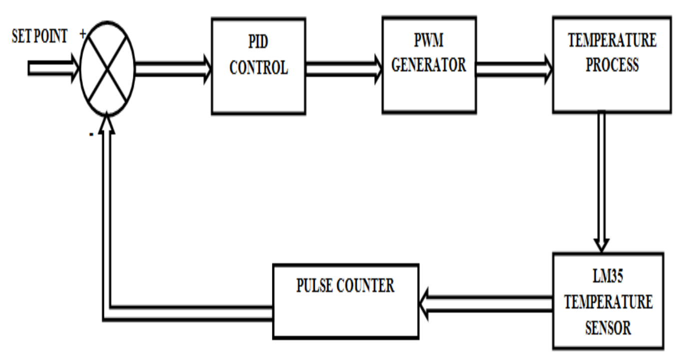
Hardware Description Languages (HDLs) are used to describe hardware for the purpose of Simulation, Modeling, Testing, Design, and Documentation of digital systems. The most popular HDLs are VHDL [(Very High Speed Integrated Circuit) Hardware Description Language], and Verilog. VHDL is used to describe hardware from the abstract to the concrete level. Many of the Electronic Design Automation (EDA) vendors are standardizing on VHDL as input and output from their tools. These tools include simulation tools, synthesis tools, layout tools and testing tools.

The Proportional-Integral-Derivative (PID) controllers have been widely used over the past five decades due to their simplicity, robustness, effectiveness and applicability for a broad class of systems. Despite the numerous control design approaches that have appeared in the literature, it is estimated that, now a day's PID controllers are still employed in more than 95% of industrial processes. For many decades, the digital PID controller has been used extensively in real time digital control. The PID is used extensively in the field of servo motor control, robotics, temperature control and power electronics. It has a long history of development and very mature tuning rules. overall, the PID is an important tool for the embedded real time digital control designer. They are usually implemented either in hardware using analog components or in software using computer-based system. The emergence of field programmable gate arrays and hardware description languages allows for added dimensions of digital PID controllers, Parallelism, Programmable bit widths and absolute determinism. Building PID controllers on Field Programmable Gate Arrays (FPGAs) improves speed, accuracy, power-efficiency, compactness and cost effectiveness.

In the past two years, Spartan II and III FPGA families from Xilinx have been successfully utilized in a variety of applications, which include inverters, communications, embedded processors, and image processing. The implementation of PID controllers using microprocessors and Digital Signal Processor (DSP) chips is old and well known , whereas very little work can be found in the literature on how to implement PID controllers using FPGAs.

II. METHODOLOGY

BLOCK DIAGRAM



III. PROJECT DESCRIPTION

PID CONTROLLER

The PID controller involves three separate parameters; the proportional, the integral and derivative values. The proportional value determines the reaction to the current error. The integral value determines the reaction based on the sum of recent errors. The derivative value determines the reaction based on the rate at which the error has been changing. The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve or the power supply of a heating element.

LM35

LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full 55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35 is rated to operate over a 55 to +150°C temperature range, while the LM35C is rated for a 40° to +110°C range (-10° with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package.

PWM GENERATOR

PWM is a very efficient way of providing intermediate amounts of electrical power between fully on and fully off. A simple power switch with a typical power source provides full power only, when switched on. PWM is a comparatively recent technique, made practical by modern electronic power switches The term duty cycle describes the proportion of on time to the regular interval or period of time; a low duty cycle corresponds to low power, because the power is off for most of the time. Duty cycle is expressed in percent, 100% being fully ON.PWM works well with digital controls, which, because of their on/off nature, can easily set the needed duty cycle.

FPGA

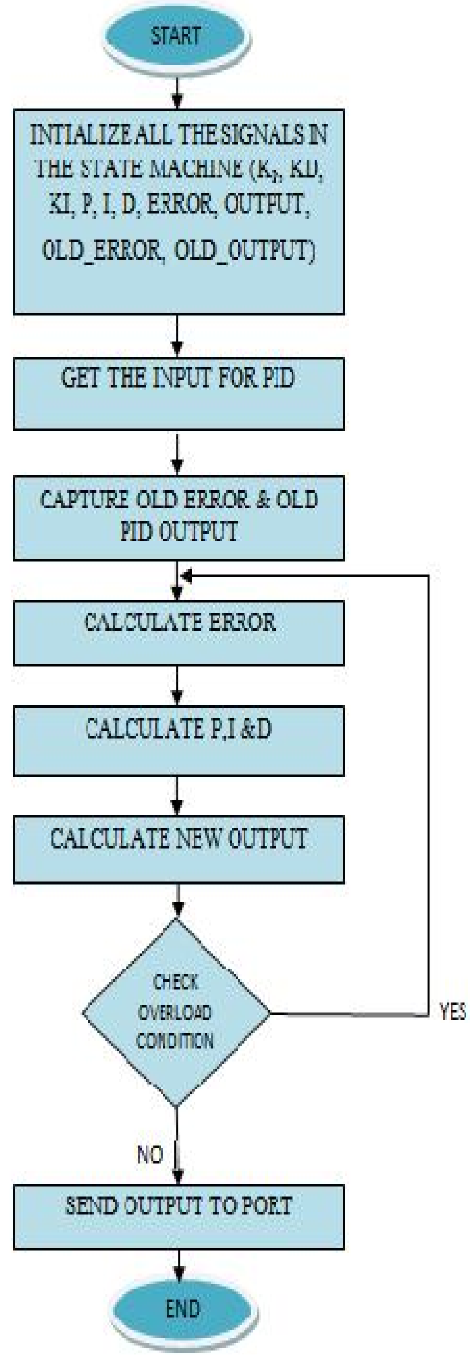
The FPGA is an integrated circuit that contains many (64 to of 10,000) identical logic cells that can be viewed as standard components. Each logic cell can independently take on any one of a limited set of personalities Based on the principle of functional Completeness FPGA: Functionally complete elements (Logic Blocks) placed in an interconnect framework Interconnection framework comprises of wire segments and switches.

In an FPGA logic blocks are implemented using multiple level low fan-in gates, which gives it a more compact design compared to an implementation with two-level AND-OR logic. FPGA provides its user a way to configure:

1. The intersection between the logic blocks and
2. The function of each logic block.

IV. STATE FLOW DIAGRAM

The state flow diagrams are so drawn that, they are self explanatory and gives the complete idea of software development for FPGA based PID controller for temperature control process. This flow diagram is explain the function of PID controller in Field Programmable Gate Array.



V. CONCLUSION

FPGA-Based PID Controller Implementation involves Proportional-Integral-Derivative (PID) controllers are widely used in automation systems. It is usually implemented either in hardware using analog components or in software using computer-based systems.It is also implemented using Application Specific Integrated Circuits (ASICs). The paper outlines several modules necessary for building PID controllers on Field Programmable Gate Arrays (FPGAs) which improve speed, accuracy, power, compactness, and cost effectiveness. Two PID controllers for speed and position utilizing these modules are implemented and used as experimental platforms to illustrate and test the designed modules.

In order to meet the requirements such as high precision, small overshoot, fast response in Polymerase Chain Reaction(PCR). The design of genetic algorithm PID controller is realized by FPGA. And in the MATLAB environment, the simulation is conducted using genetic algorithm PID control. The simulation results show that genetic algorithm PID controller which is realized by FPGA can well track the input signal, and the control effect is better.

Logic simulation in FPGA design environment plays a very vital role in verifying the functionality of the designs. Simulation is a powerful way to test the system on a computer, before it is turned into hardware. Simulators let designer to check the values of signals inside the system. Finally, we design the FPGA kit design programming as per the temperature set point of the heater.

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