S.K.Suresh Babu, M.Saravanan / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 3, May-Jun 2012, pp.2650-2654

Multi-Controllers in a single chip for a DC-DC Converter and its Precious Application Using FPGA

S.K.Suresh Babu[1], M.Saravanan[2]
Department of ECE
S.N.S College of Technology
Coimbatore, Tamil Nadu, India.

Abstract:

In this paper, the Simulation, Comparison and Implementation of multi controllers in a chip will be compared with the separate individual controllers in a chip for a DC-DC converter and the precious application. The PID controller for DC-DC converter and PI controller for the actuator are used and discussed. The MATLAB/Simulink, Xilinx and Modelsim are the tools used for these analyses. These were tried with Spartan-3E FPGA.

Keywords:* *DC-DC converter, FPGA, Matlab/Simulink, Modelsim, PI, PID, SMA, Smart Actuator, Xilinx.

I. INTRODUCTION

A dc-dc converter is an active research topic in power control. Many controllers have been demonstrated [1,8]. Whilst the controllers differ in several aspects, the control strategies center on PD, PI, PID control; and compensation strategies. The designs incorporate both discrete-time emulation of an analog controller, and direct-digital design. In this paper, we apply an alternative controller design strategy to a boost converter. The closed-loop of this DC-DC converter is controlled with PID controller [4, 5]. This improves the gain of the system and obtain the necessary results and also with good settling time. Another system in this design is Actuator. It required another control system to control the action of actuator [5]. PI controller is used in this system. It’s a first order transfer function, thus Derivative term is not required. Only the proportional Integral (PI) controllers are used for better results. Multi Controllers in a single chip, here these two different controllers were been in-built in a single chip. Thus the controller of DC-DC Converter and the PI controller of Actuator are in built in a chip. The two different controllers were been in built to reduce the system size and also to improve the speed of operation too. Those results were been also discussed.

II. PROPOSED DESIGN

In general the two different IC’s are used to control the DC-DC converter and its precious application.

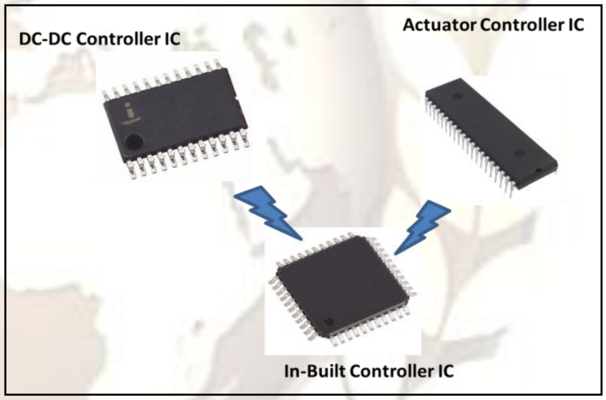

Fig.1. Proposed Design

This leads to increases the size of system and time. The proposed design will bring down the overall system size with improved data transfer. The model Fig. of this proposed design is shown below. FPGA is used here as the In-Built Controller IC [7].

III. BLOCK DIAGRAM AND ITS FUNCTION

The overall design block diagram is shown in Fig. 2. The three mail blocks are used in this design. 1. DC-DC converter, 2. Actuator and 3. Field Programmable Gate Array (FPGA).

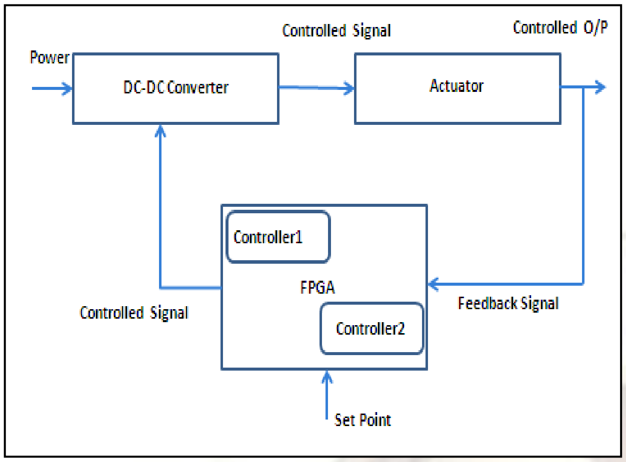

Fig. 2. Block diagram

DC-DC Converter block has the circuit of Boost converter.

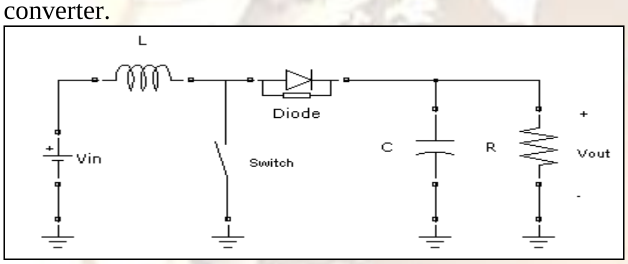

Fig. 3. DC/DC Boost converter

It used to amplify or boost the fixed input level signal to Actuator required variable level. Fig.3 shows the general circuit of DC/DC Boost Converter. It has 3 main components: Inductor, Capacitor, Diode and Switch (MOSFET). This MOSFET switch is digital controlled by the PWM generator circuit blocks [2]. Input fixed Voltage: 3V, Inductor: 1e-5, Capacitor: 4.7e-5 and Diode Resistor: 0.001. The generation of the control pulse Vcon through the PWM method is illustrated in the Fig. 4. The triangular wave form with 250 KHz.

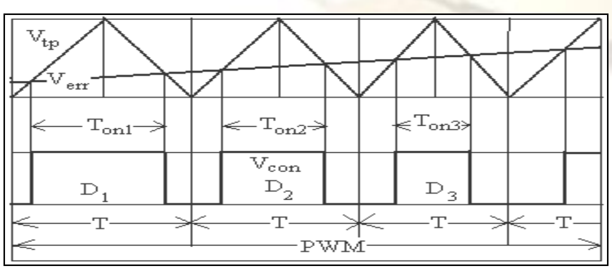

Fig. 4. Generation of PWM Control Signal

In this Fig.4. a triangular signal, Vtp, and an error voltage, Verr, are used to generate the control pulse [3, 4]. The error voltage (Verr) is calculated as the difference between the output voltage (Vout) and a reference voltage (Vref). As can be seen, the control pulse (Vcon) is high when Vtp>Verr and low when Vtp<Verr. The generated control pulses have constant switching frequency (1/T) and variable duty cycle [10]. In this Fig., the triangular pulses are generated with the maximum value Vlim.

Duty Cycle: Dc= Ton/ Ton+Toff

These pulses are compared with the Verr to generate the control pulse (Vcon1) to control the switch in the DC-DC converter [6]. The Actuator transfer function is 0.105/(s+0.13) [9]. Since it is a first order transfer function and to avoid overshoot and steady state error the proportional integral (PI) controller is used to control the actuation. The controller parameters proportional and integral gains Kp and Ki are found for the obtained transfer functions. The closed loop controller based on PI controller decides the current flow in Actuator and enables the accurate required positioning [9].

Field Programmable Gate Array (FPGA) will hold these two different controllers of PID and PI controller for both DC-DC converter and Actuator respectively in a single chip [11, 12]. Thus the whole control actions of multi controllers are in-built in a single chip.

IV. MATLAB/SIMULINK ENVIRONMENT

This system is simulated in MATLAB/Simulink; here complete design of system is simulated. The both DC-DC converter with the Actuator is designed. It's shown in Fig.

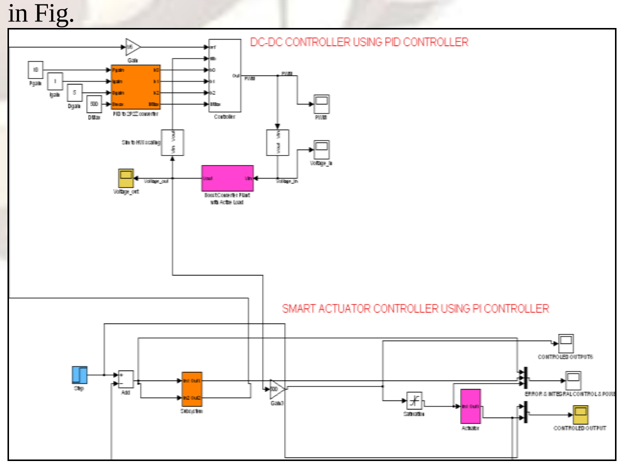

Fig. 5. Simulink model of Complete System (DC-DC Converter with Smart Actuator)

This above Fig. 5 shows the complete system of DC-DC Converter and Actuator control systems simulation blocks. The main blocks are PID controller and Boost Converter plant In DC-DC Converter and PI controller and Actuator System block in Actuator Controller.

Fig. 6 shows the running condition of the proposed system. The both DC-DC Converter performed better with another system as Smart Actuator with two different controllers.

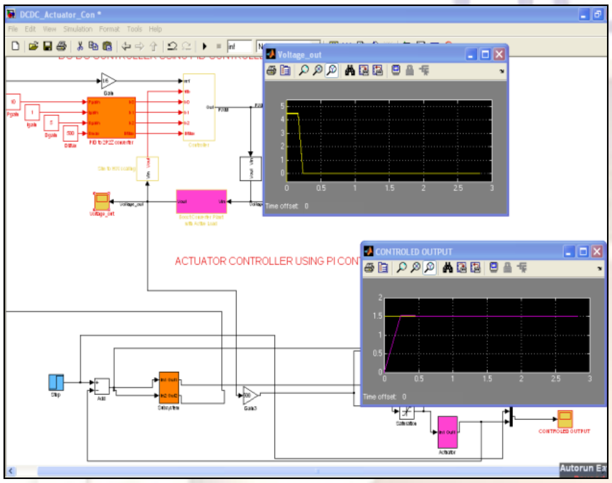

Fig. 6. Simulink model of Complete System in running condition

The “Voltage_out” shows the response voltage of DC-DC converter. The “CONTROLLED OUTPUT” scope model shows the Actuator response for the Set Point (SP) = 1.5mm.

V. XILINX ENVIRONMENT

The Xilinx environment the PI Controller for the Actuator is designed and its Technology schematic view show in the Fig. 7.

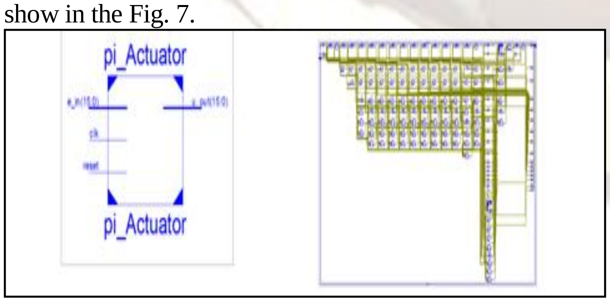

Fig. 7. Technology Schematic view of PI controller for Actuator

The PID Controller for the DC-DC Converter is designed and its Technology schematic view show in the Fig. 8.

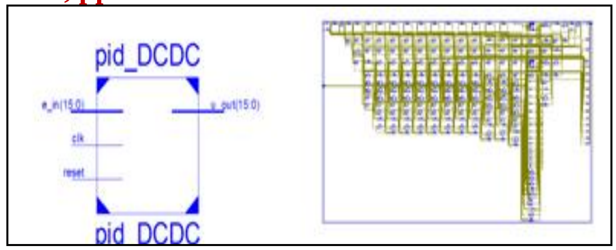

Fig. 8. Technology Schematic view of PID controller for DC-DC Converter

The Multi-Controller in Single Chip is designed. PI Controller for the Smart Actuator and the PID

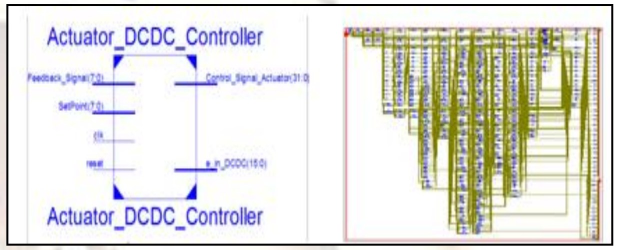

Fig. 9. Technology Schematic view of Multi-Controller in Single Chip

Controller of DC-DC Converter is designed and its Technology schematic view show in the Fig. 9.

VI. COMPARISON IN XILINX ENVIRONMENT

In Xilinx environment the hardware analysis were been carried out and charted below. The three main parameters are carried out like Number of Slices of Flip Flops, Number of 4 I/O LUTs and Number of Occupied Slices in FPGA. Here it were been analyzed with separated controllers for designed system is compared with Multi-Controllers in a Single chip. Actuator controlling Controller (PID) occupied in FPGA, DC-DC Controlling Controller (PI) occupied in FPGA, Multi- Controllers (PID-PI) in FPGA and the existing design i.e. without Multi-Controlled in Single Chip.

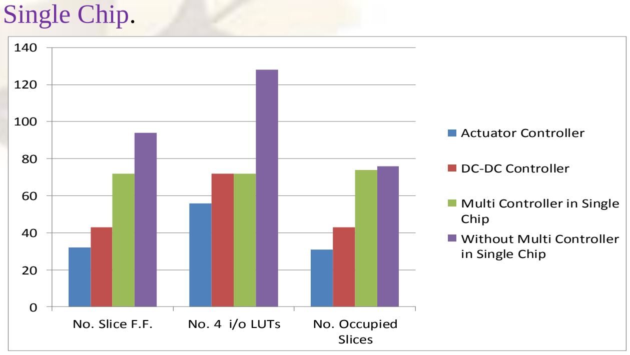

Fig. 10. Comparison Chart

These Cleary shows in Fig. 10 that, the Multi-Controllers in a Single chip is occupied less hardware's compare to the existing system of without Multi-Controllers in Single Chip.

VII MODELSIM ENVIRONMENT

The Multi-Controllers in a Single Chip is designed and simulated in ModelSim as Shown in Fig. 11.

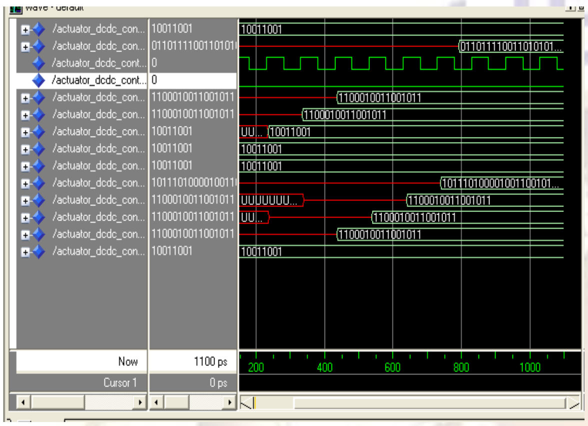

Fig. 11. Multi-Controllers in Single Chip with Delay

It shows the controller with clear view of process with added delay to know the sequential processing in a system. This process done at Reset as Zero.

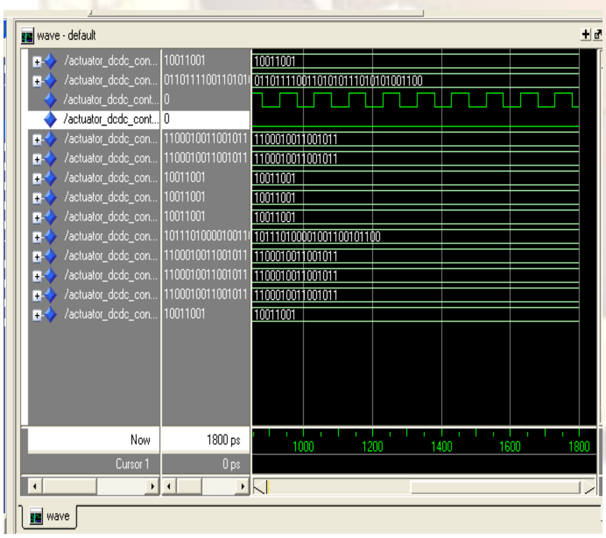

Fig. 12. Multi-Controllers in Single Chip completed process after sequential processing

The Multi-Controllers in a Single Chip is designed and simulated in ModelSim as Shown in Fig. 12. It shows the completed process after sequential processing of a system. This process when Reset at Zero.

VIII. CONCLUSION

Multi-Controllers in a Single Chip system is better than individual control system, it's proven in application based system (DC-DC Converter with Actuator Control).From MATLAB Simulation, the PID controller for DC-DC converter and PI controller for Smart Actuator are performed, the complete analysis of this overall system is proven. In Xilinx environment, these controllers were been designed and compared with Multi Controllers in a Single Chip; Multi-Controllers designed occupied less cells than the individual control system; those results are also analyzed from comparison chart. In ModelSim, the Designed Multi-controllers in a Single Chip are simulated, analyzed and discussed. From all these result gives, A Multi-Controller in Single Chip is better than of using in separate control system in a chip.

IX. FUTURE WORK

This work can be carrying out with the Adaptive controllers for the both DC-DC converter and for an Actuator. This Adaptive controller will improve the overall performance of the system. It can be carrying out with parallel processing control system for the complex systems.

REFERENCES

[1] Ferdinand Sluijs, Kees Hart, Frans Schoofs, Prof. Holstlaan, (2010) "Design flow for Digital Integrated DC/DC Converter", IEEE Traction, Vol. 34, No.1, pp.232-236 .
[2] Hwu, Tamkang (2010), "Forward Converter with FPGA-Based Self-Tuning PID Controller", Journal of Science and Engineering, Vol. 13, No. 2, pp. 173-180.
[3] M. Lazar, R. De Keyser, (2008) "Non-linear predictive control of a DC-to-DC converter", IEEE vol.6, pp.342-347.
[4] Kun Wang, Nabeel Rahman, Zdravko Lukic, and Aleksandar Prodic,(2010) "All-Digital DPWM/DPFM Controller for Low-Power DC-DC Converters" , IEEE, vol.4, pp.453-458.
[5] Kyoung Kwan Ahn and Bao Kha Nguyen, (2006), "Position Control of Shape Memory Alloy Actuators Using Self Tuning Fuzzy PID Controller." International Journal of Control,

Automation, and Systems, vol. 4, no. 6, pp. 756-762.

[6] Nandan Kumar Sinha, Mamta Jangid, and N Ananthkrishnan, (2005) "Automated Gain Scheduling Using Continuation Techniques", IEEE, vol.6, pp.342-350.

[7] Prashant Agnihotri, Hossein Salehfar, (2009) "FPGA-Based Combined PWM-PFM Technique to Control DC-DC Converters", IEEE, vol.54, pp.213-219.

[8] Rosario Mita and Gaetano Palumbo, (2010) "Vhdl-Based Modeling of "A Dc-Dc Boost Converter", IEEE, vol.45. Pp.243-250.

[9] P.Senthilkumar, S.Jayasankar, Satisha, (2011) "Development and Wind Tunnel Evaluation of an SMA Based Trim Tab Actuator for A Civil Aircraft." Symposium on Applied Aerodynamics and Design of Aerospace Vehicle (SAROD), pp.16-18.

[10] Wilmar hernandez, (2008) "Robust Control Applied to Improve the Performance of a Buck-Boost Converter", WSEAS TRANSACTIONS on CIRCUITS AND SYSTEMS, Issue 6, Volume 7, pp.125-131.

[11] Zurita-Bustamantey, Linares-Floresz, Guzm´an-Ram´ırezz, and Sira-Ram´ırezyy, (2011), "A comparison between the GPI and the PID controllers for the stabilization of a DC-DC "buck" converter: A Field Programmable Gate array implementation,"IEEE Transactions, vol.23, pp.212-220.

[12] Zumel, Fernandez, Lazaro, Barrado, (2006), "Digital compensator design for DC-DC converters based on FPGA: an educational approach"IEEE, vol. 12, pp.413-421.

S.K.SureshBabu, Pursuing final year M.E.VLSI Design from S.N.S College of Technology, Coimbatore. He also worked in National Aerospace Laboratories (R&D Lab), CSIR, Bangalore for more than 2 years as a Project Graduate Trainee and Project Engineer as well. He obtained his B.E. in E.C.E from Bannari Amman Institute of Technology, Coimbatore in 2007. He has published various papers in both National and International conferences.

M. Saravanan working as Assistant Professor in S.N.S College of Technology, Coimbatore. He has completed his M.E. in VLSI Design from Anna University of Technology, Coimbatore. B.E. degree from Coimbatore Institute of Technology in 2006. He has more than 3 years of teaching and 3 years of Industrial experiences. He has published various papers in both National & International journals and conferences.