A Review on Reconfigurable PLC Development, Synthesis & Implementation for Industrial Application

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Abstract— Although PLCs are widely used in industrial applications, their performance does not always meet the requirements of today's complex industrial applications. With FPGA technology, it is easier to implement PLC control programs into FPGAs for higher performance in terms of speed and accuracy. Implementation of PLC on FPGA leads to miniaturization of space required to install control circuitry on machine. Reconfigurable nature of FPGA allows designer to change, modify or add a PLC control program as many times as required. PLCs based on FPGA technology can fulfill the requirements of today's industrial applications.

Key words: PLC, FPGA, HDL

I. Introduction

A Programmable Logic Controller (PLC) is a digital computer used for automation of industrial electromechanical processes like factory assembly line, packaging industries etc. It can implement control functions like sequencing, timing, counting, arithmetic, data manipulation and communication. PLC gets information from input interface which is connected to inputs like pushbuttons, sensors and limit switches etc. PLC controls devices through output interface connected to controllable devices like relays, lamps etc. PLCs are designed to survive into electrically noisy environment of industries.

II. PLC Architecture

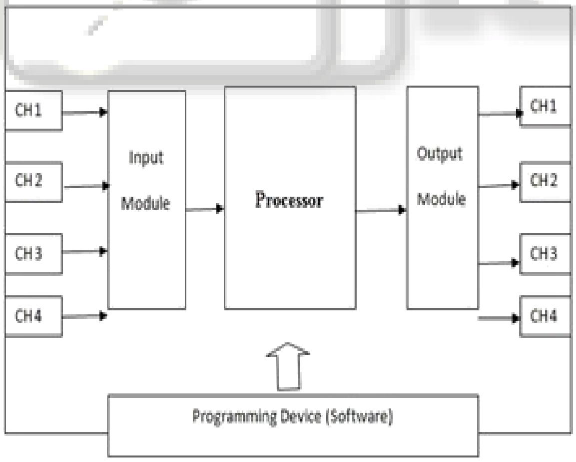

Fig. 1: PLC Architecture

A Field Programmable Gate Array (FPGA), first introduced into market in 1985 by Xilinx Company. FPGA technologies are adapted significantly and reduced the early digital development process. FPGAs are pre-fabricated CLBs that can be programmed in the field to realize almost any kind of digital system. FPGA consists of Programmable logic blocks which can implement any logic function, Programmable routing that connects these CLBs and I/O blocks.

III. Overview of FPGA Architecture

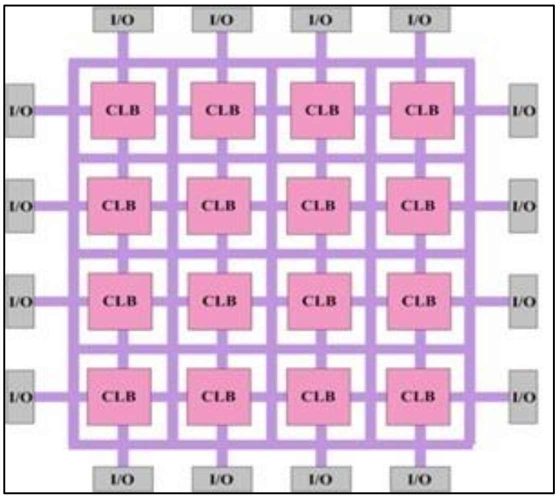

Fig. 2: Overview of FPGA Architecture

A. *Advantages of PLC designed using FPGA:*

1) Short Product Development Cycle:
With the use of standard HDLs, Design engineers can try out different types of implementations on FPGAs, which has drastically reduced product development time.

2) Reconfigurable:
Since FPGAs are reconfigurable, design engineer can change, modify or add any feature or instruction of the control programs easily to the existing design.

3) High Speed Performance:
PLCs designed using FPGA can perform all tasks in parallel, so execution of control programs is very fast as compared to conventional PLCs which perform operations in sequence.

4) Cost Effective:
Functionality to this FPGA based PLC can be added easily for better performance and future requirements without changing the product. So the cost of purchasing new PLC is saved.

5) Compactness:
With the FPGA technology we can implement large systems on single FPGA, which greatly saves space required to implement designs.

B. *Ladder Diagram*

Ladder diagram is the most widely used graphical method to represent PLC programs. A ladder diagram consists of one or more rungs. Rung consists of condition part and processing part as shown in fig.

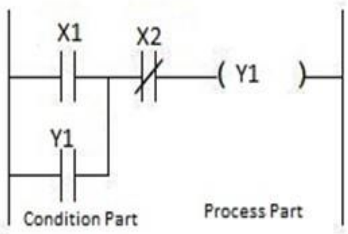

Fig. 3: Overview of Ladder Diagram

C. Execution Sequence of ladder diagrams

1) Self-test:
Testing of its own hardware and software for faults.

2) Input scan:
PLC copies all its inputs and their values into memory.

3) Logic solve:
Using the inputs and their values from memory, ladder logic program is solved and output is updated into memory

4) Output scan:
Output ports are updates by their corresponding values in the memory.

This execution sequence repeats again and again, called cyclic scan. By reducing cyclic scan time we can improve the PLC performance.

IV. Translation of Rung

In fig., Switch X1 is start switch and X2 is stop switch. The slash on X2 denotes off switch. If X1 is ON and X2 is OFF, the output coil Y1 is turned ON; this also bypass the X1 and Y1 holds when X2 is OFF. When X2 is ON, Y1 is deactivated. This is called a self-holding logic.

PLC instruction sequence for the above ladder diagram.

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LD    X1
OR    Y1
ANI   X2
OUT   Y1
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V. Use of FPGAs in Industrial Applications

With broad range of FPGA devices from low cost low power to high performance, it is possible to make designs with various complexities. With FPGAs it is also possible to integrate third-party IP.

A. Motor Controller:

An integrated high-performance motor controller can be designed based on the XADC, a soft core MicroBlaze processor, DSP blocks, and support logic functions, including pulse width modulation (PWM), counter-timers, and serial communications channels.

B. Machine Vision:

Machine Vision is used to inspect manufacturing lines for quality control and item tracking purposes. All components of the machine vision can be realized using a single FPGA.

C. Video Surveillance:

Current growth in the use of high-definition, Internet Protocol (IP) based video cameras are helping in video surveillance. FPGAs, allow for implementation of special sensors as well as customer specific IP and image processing functions.

VI. Conclusion

To meet the today's industrial requirements it is necessary to design PLCs based on FPGA technology. It greatly saves design space and gives better performance compared to PLCs. FPGAs are an excellent choice for designers building industrial applications. With FPGAs, flexibility, cost competitiveness, ease of development and integration with other systems are all advantages that make FPGAs a better solution for factory automation and control.

References

[1] Shunzhou Yu; Xiaodong Xu, An Input and Output Monitoring System for FPGA-based Hardware PLC, March 2012
[2] Shuichi Ichikawa, Masanori Akinaka, Hisashi Hata, Ryo Ikeda, Hiroshi Yamamoto: "An FPGA implementation of hard-wired sequence control system based on PLC software," IEEJ Transactions on Electrical and Electronic Engineering, Vol. 6, No. 4, pp. 367--375 (2011)
[3] Synthesis and Implementation of PLC on FPGA, Sonali Khairnar, Savita Sandip Raut, International Journal of Modern Trends in Engineering and Research, e-ISSN No.:2349-9745, Date: 2-4 July, 2015
[4] Using FPGAs to solve challenges in industrial applications, Yvonne Lin, Xilinx, http://www.eetimes.com/document.asp?doc_id=1279239

