International Journal of Engineering, Science and Mathematics
Vol. 6 Issue 8, December 2017 (Special Issue)
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Controlling a Wheeled Robot through Field Programmable Gate Array

Sandipan Pine
Dr B B Choudhury

Abstract

Nowadays the aim of VLSI and Embedded industry is to produce low power, high speed processing with maximum accuracy. With application of VLSI in Robotics and automation will help it to become faster and accurately controlled. It will consume less power also. So it is necessary to develop more and more embedded algorithms to be applied in robotic automation. This work shows a idea of mobile car using rapid prototyping, distributing the several control actions in growing levels of complexity and computing proposal oriented to embed systems implementation. This idea can be implemented on different platform representing the mobile robots using reprogrammable logic components (FPGA).
This mobile robot will detect obstacle and also be able to control the speed. Different modules will be Actuators, Sensors. All this modules will be interfaced using FPGA controller.

Keywords:

Field Programmable Gate Array (FPGA);
Analog to Digital Converter (ADC);
PulseWidth Modulation(PWM);

Author correspondence:

Sandipan pine
Research Scholar, Department of ECE
IGIT Sarang
Sarang, India

Dr B B Choudhury
Associate Professor
Department of Mechanical Engineering
IGIT Sarang
Sarang, India

1. Introduction

The development of reprogrammable Field Programmable Gate Arrays (FPGA) has risen to a new arena of total mobile robot control system. With FPGA devices, it is easy to change the design to fit the requirements of applications (for example, exploration and navigation functions for a robot). General-purpose computers can achieve acceptable performance when tasks are not very complex. A single processor system cannot promise real-time response (particularly in the absence of considerable additional hardware), if the environment is dynamic or semi-dynamic.
This paper aims only on the study of the moving robot platform, with four driving wheels mounted on two axes. An FPGA-based processing system is used to handle works in parallel. An FPGA-based mobile car also improves upon the general purpose processor based robot in the following areas:
a. Increased I/O ports. Anybody can map the logical design to the computing elements in FPGA devices.

b. Power consumption is low compared to others.
3. Any logical design can be implemented.
4. Any logic design modules can be correctly verified.

Wheeled robots are better energy efficient robots compared to legged or treaded robots on hard, smooth surfaces .They are basically the first mobile robots to find enormous application in industry, because of the hard, smooth plant floors in existing industrial environments. Wheeled robots need lesser and simpler parts and are thus easier to build than legged or treaded mobile robots.

Controlling wheels are easier than the actuation of multi-joint legs, and wheels cause less surface damage in comparison with treads.

The wheeled robot consists of many units:

- Mechanical Parts (chassis, housing, wheels)
- electromechanical parts (Motors)
- sensors
- Processor
- Supporting Circuit

Wheeled Robots carry out no of jobs. During these jobs the robot moves and orients. While moving, it takes signals from the environment and compare with the contents of its own memory to make proper decisions. This type of navigation may be manifold depending on the given task and problem. Often the target can be sensed, there may be no obstacle between the goal and the robot, but there are various times when this is not the same, then the judgment points must be understood and the route should be decided. In order to do this, it must contain two main components:

- Motion Drive
- Direction Control.

2. Hardware Description and Working Principle

A. Wheeled Robot

A robot which can move on a surface only through the control of wheel assemblies mounted on the robot and in touch with the surface. A wheel assembly is a device whichallows relative motion between its mount and asurface on which it is intended to have a single point of rollingcontact.The easiestexample of mobile robots is wheeled robot,as shown in Figure 1. Wheeled robots comprise of one or moredriven wheels (4 here) and have optionalpassive or caster wheels and possibly steeredwheels. This designs require fourmotors for driving (and steering) the robot.

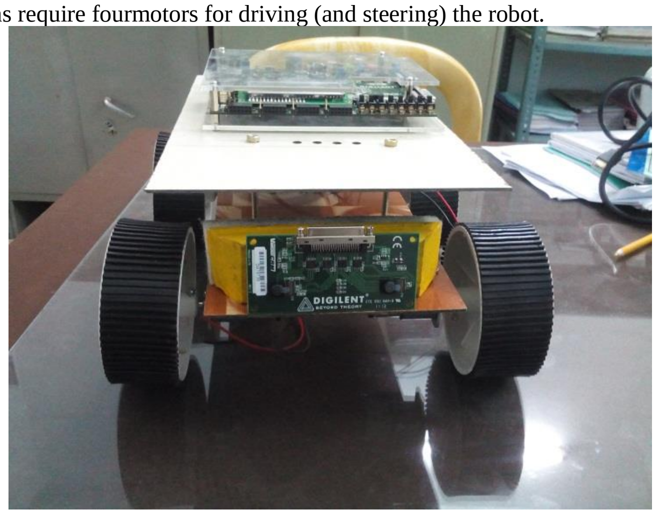

Fig-1:- Wheeled Robot

B. Architecture

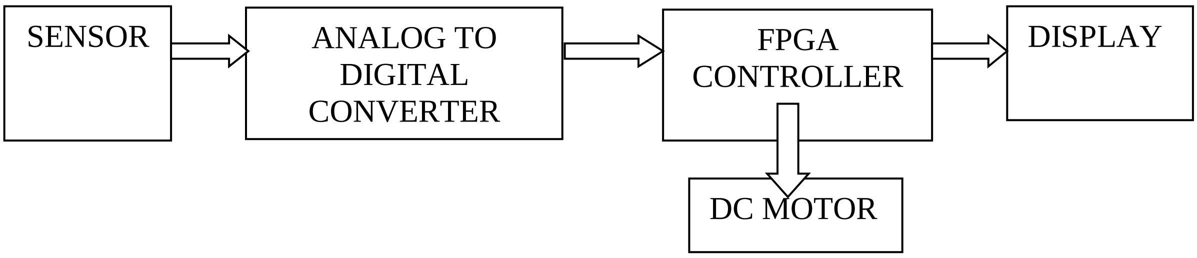

Fig-2 Block Diagram of the System

In the arena of Wheeled robot design, the use of FPGA Controller, with control software especially developed for the necessary applications is considered using structured libraries to design, simulation, and verification throughSIMULINK.The model to function prototyping is converted using FPGA hardware.Figure 2 shows the overall flow of designing the system. The output of the Analog to digital counter is connected to theFPGA board and it is used as the input to the source code. Verilog is used here as assembly language. After the simulation and the synthesis process, theprogram has been implemented on the FPGA board.

C. FPGA

Fig-3:- Vertex-5 FPGA Board

Fig 3 shows Xilinx's Virtex®-5 FPGA board which has 112 FPGA I/Os routed to expansion connectors (two high-speed parallel VHDC connectors and four 8-pin headers). This board is used in this design

D. Interfacing Vertex-5 with Controller

The Vertex 5 will process the instruction and the output will be given to enable pin of L293D which activate the L293 quadruple high current half H-Driver chip and controls the speed of the motor. Table 1 shows the truth table to get the L293 to perform the different movement operations.

Functions	Inputs					
	ENA	ENB	1A	2A	3A	4A
Forward	1	1	1	0	1	0
Reverse	1	1	0	1	0	1
Left	0	1	0	0	1	0
Right	1	0	1	0	0	0

Table 1: Truth table for L293

E. Interfacing Vertex-5 with Analog to Digital Converter

An Analog to digital converter converts an analog signal into a digital value. An 8 channel, 8-bit A/D input is available to read analog voltages between 0 to 5 Volts. Devices such as an analog joystick or potentiometers can be connected to one of ADC channel and converted digital output can be read and is sent back to the FPGA board to control the speed of DC motor. Figure 4 shows the construction of the ADC. The characteristics of an A/D converter include:

- Accuracy expressed in the number of digits it produces per value
- Speed expressed in maximum conversions per second
- Measurement range expressed in volts

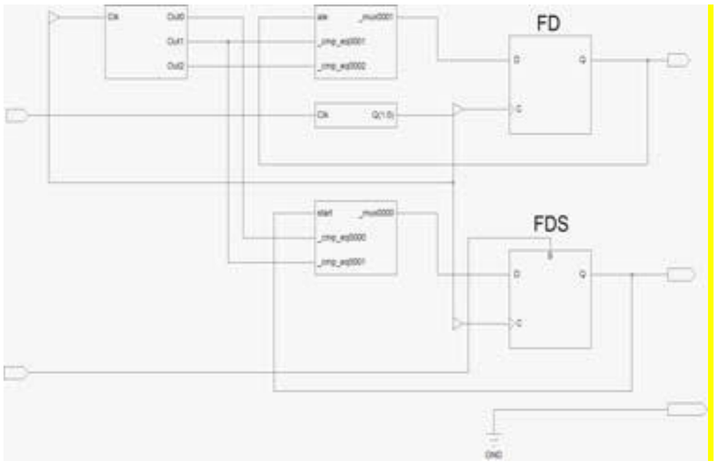

Fig-4 Analog toDigital Converter in Xilinx System

F. Analog Sensor
The analog sensor Sharp GP2D12 indicates a voltage level with respect to the measured distance. Figure 5 shows a comparison of actual data and output. It is clear that the relationship is not proportional, so some postprocessingof the raw sensor value is necessary. The simplest way of solving this problem is to use a lookup table which can be calibrated for each individual sensor.

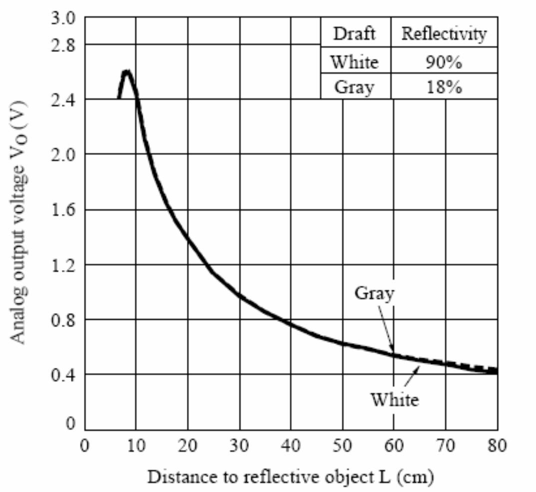

Fig-5 :- Relationship between Output and actual distance

3. Results and Analysis

Complete System consists of all the previous blocks connected together, and simulated as a whole.Then they were implemented on Vertex -5. Figure 7 shows the simulation results obtained from the ADC block. Here START and ALE signals must be high for atleast 100ns to start the conversion process of ADC converter. When conversion is completed, then EOC & OE signals will be pulsed high. The output in digital form is then given to FPGA as an input. Depending on digital input, PWM output will be calculated. Figure 8 shows simulation result of PWM block. Other simulations results are of seven segment display as shown in figure 9 which display the correct numeral numbers, when adc_in[0:3] input given is in between 0-9 i.e; in binary “0000” to “1001”. It displays the measured distance in cm by GP2D12 sensor. Figure 10 shows total simulation result.

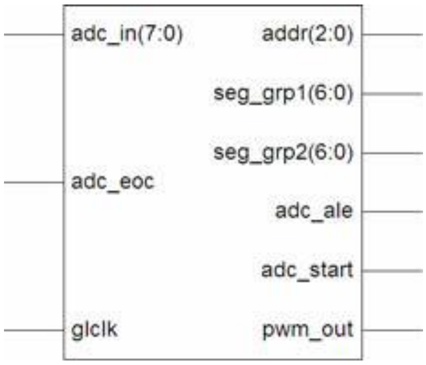

Fig-6 Schematic of the Controller

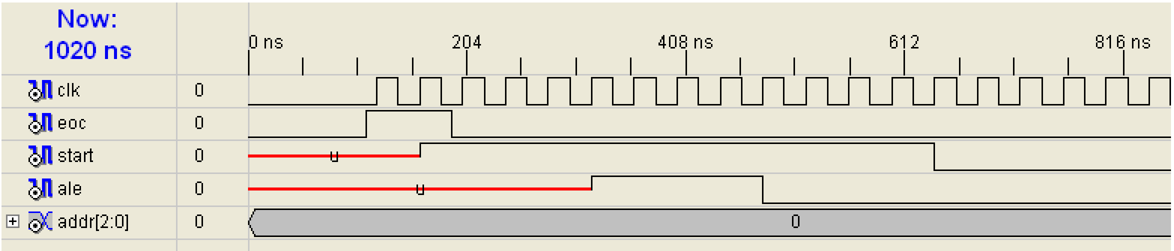

Fig-7 Output of the ADC

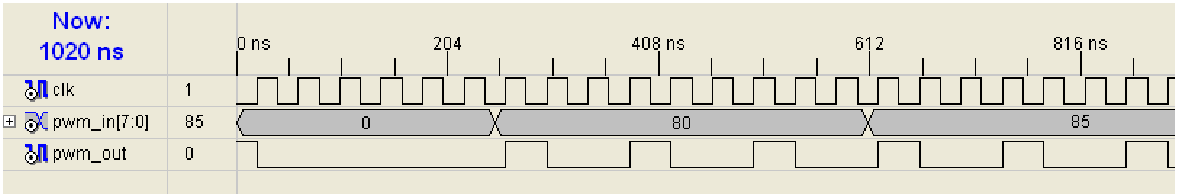

Fig-8 Output of the PWM

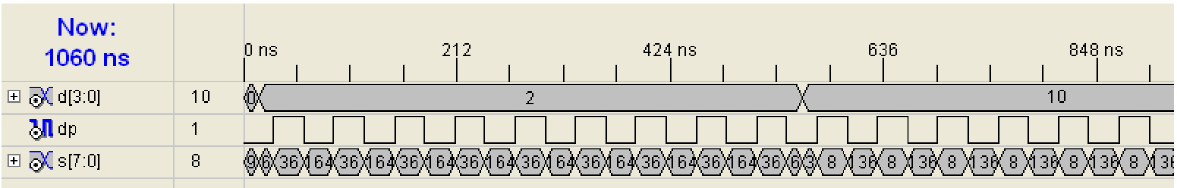

Fig-9 Output of the 7 Segment Display

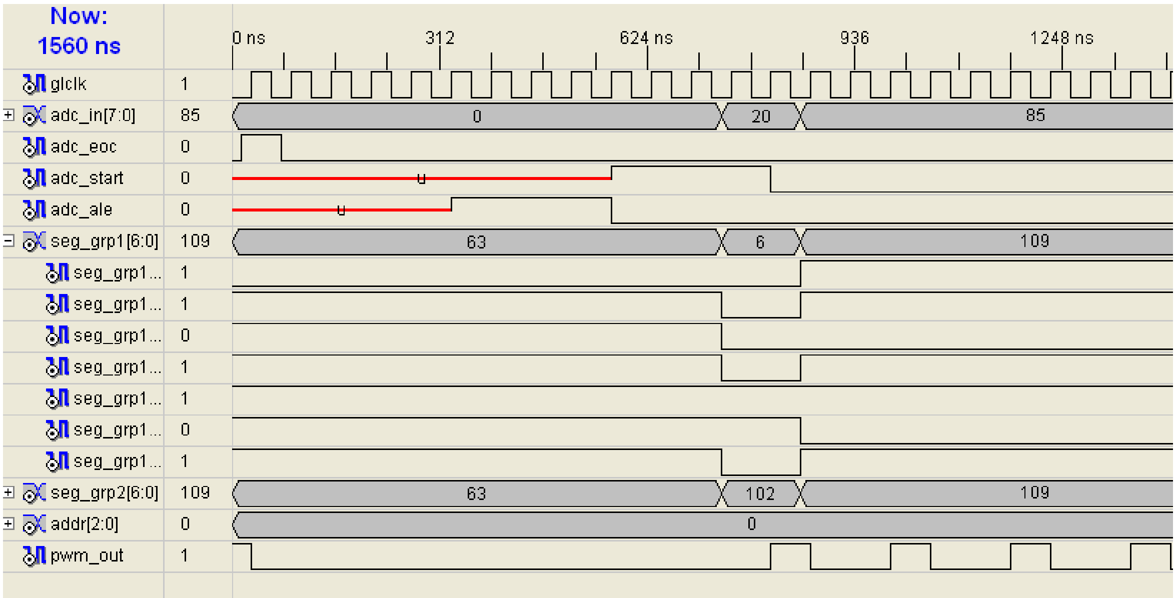

Fig-10:- Output of the complete System

4. Conclusion

The useof the mobile robots appears to be quite anattractive solution in automation area. It allows the integration of severalimportant areas of knowledge and a low cost solution. The main objective of this work was to propose ageneric platform toobtain a support tool for automation. Autonomous mobile robots can beused to deliver parts in factories, being complementaryplatforms in a security system and they also can be used inhazardous areas where humans can not stay.
The wireless channel may also be added to increase systemflexibility. The proposed framework remains simple and userfriendly; additionally it provides enough flexibility for thespecific application. This approach can be extended to moredemanding applications by adding more modules, or otherperipheral interfaces.

References

[1] Horanzy J, inventor; Computer Network Technoloy Corp., assignee. Method and apparatus for configuring a programmable logic device. United States patent US 7,146,598. 2006 Dec 5.

[2] J.M. Rosario, R. Pegoraro, H. Ferasoli. "Conceptionof Wheeled Mobile Robots with ReconfigurableControl using Integrate Prototyping". Laboratory ofAutomation and Robotics, Sao Paulo, Brazil

[3]Maxim V, Zidek K. Design of high performance multimedia control system for UAV/UGV based on SoC/FPGA Core. Procedia Engineering. 2012 Jan 1;48:402-8.

[4] Ha QP, Yu YH, Quang NK. FPGA-based cooperative control of indoor multiple robots. International Journal of Advanced Mechatronic Systems. 2012 Jan 1;4(5-6):248-59.

[5] Commuri S, Tadigotla V, Sliger L. Task-based hardware reconfiguration in mobile robots using FPGAs. Journal of Intelligent and Robotic Systems. 2007 Jun 1;49(2):111-34.