iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 2 **Issue:** IV **Month of publication:** April 2014

DOI:

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

FPGA based Stepper motor control using Labview GUI techniques

Priya D[#1], PG Scholar

Mrs.P.Deepa[#2], Assistant Professor

Prof.R.Sankar[#3], Prof.A.Srinivasula reddy[#4]

[#] *Department of EEE, Anna University*
S.K.R Engineering College, Chennai-600 123

Abstract— ***The control techniques for the Stepper motor system in wireless mode using Hardware Description Language (VHDL) for solar tracking system is designed in which due to no mechanical brakes and lower torque (unique torque characteristics). Higher precision of stepper motor is achieved by implementing the techniques and controlled through SPARTAN 3E SRAM based Field Programmable Gate Array (FPGA) controller. The motor is controlled using PWM technique which produces the accurate current pulses to the motor windings to excite. The control parameters are implemented by GUI using LabVIEW platform which is sent through Bluetooth to the controller by which the motor can be controlled in either direction or any angle of rotation. These types of controlling techniques can be implemented in many fields of robot applications. The Simulation design and hardware setup are executed successfully.***

Index Terms— Solar panel, Field Programmable Gate Arrays (FPGA), Stepper Motor, Motion Control, Wireless Motor Control, Reconfigurable Motor Controller

I. INTRODUCTION

Very high speed hardware description language is implemented in Xilinx Spartan 3E to control the wireless stepper motor using Pulse Width Modulation (PWM) techniques. The PWM technique is used to control the stepper motor with high precision by imposing the current pulses to the motor. The Stepper motor has the property of achieving high torque which leads the motor to sustain any big panels. The rotor's stable stop position is in synchronization with the stator flux which means it is a synchronous electrical motor. Rotating the stator flux makes the rotor to move towards new position. Thus the step in the motor is known as step angle.

Step Angle = 360 ÷ (Nr ×P) = 360 /N

Where

Nr = Number of rotor poles

P = Number of phases

N = Total number of poles for all phases together

They consist of two main components namely: Stator (holds multiple windings/phases) and Rotor (magnetized and Non- magnetized. The controlled movement is achieved and thus they are used to control rotation angle, speed and position. Applications are printers, plotters, hard disk drives, medical equipment, etc. No feedback information about position is needed for the open loop control of the stepper motor since it is controlled accurately in this mode of operation. Thus they eliminate the usage of expensive sensing and feedback devices such as optical encoders.

A user friendly GUI designed using LabVIEW to implement the control measures for the stepper motor. To control the control measures the reprogrammable field programmable gate array (FPGA) is used to meet any specification of application. In the proposed system Very High Speed Hardware Description Language (VHDL) is used which is user-friendly and independent technology portable to digital design.

ISSN: 2321-9653

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The solar panel is tracked according to the precision rotation of the stepper motor and thus the energy is stored in the storage battery which is taken into the robotic application where the robot is accessed using the available storage energy.

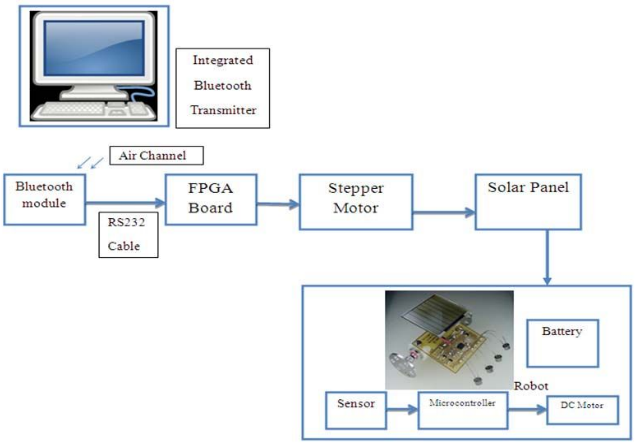

Fig.1. Block diagram.

In this proposed paper Session 2 explains the previous work, Session 3 defines the Stepper motor model, Session 4 Bluetooth function, Session 5 VHDL design and programming techniques, Session 6 functions of LabVIEW, Session 7 the proposed system output and Session 8 Concludes the paper.

II.PREVIOUS WORK

The Stepper motor control implemented in 8051 and PIC microcontroller (AT89S52) are used only for certain applications because of the use of three-phase pulse generation technique which makes the increased execution time [1]. The control of stepper motor in open-loop using FPGA leads to usage of number of components which made the system more complex and cost effective[2] also for the precise position control Analog to digital converter (ADC) is used to produce the sampling time. Logibricks implemented stepper motor control which uses DSP module to produce the control angular direction and angular displacement [3]. The novel stepper motor controller based on FPGA uses velocity profile to control the stepper motor [4]. The cost-effective PWM technique based on FPGA is proposed in this paper which controls the stepper motor through GUI. The wireless technology is used to send the control signals to the FPGA controller which consists of over 700-thousands of flip-flops in which SRAM based FPGA chip. Thus the design can be implemented according to the user choice by changing the code depends upon the condition. Thus the system is less cost, simple and easy to implement. In this system PWM technique is used to control the motor precise and to precisely position with good resolution value.

III. STEPPER MOTOR

There are three types of stepper motor: 1. Variable reluctance stepper motor 2.Permanent-magnet stepper motor 3.Hybrid stepper motor.

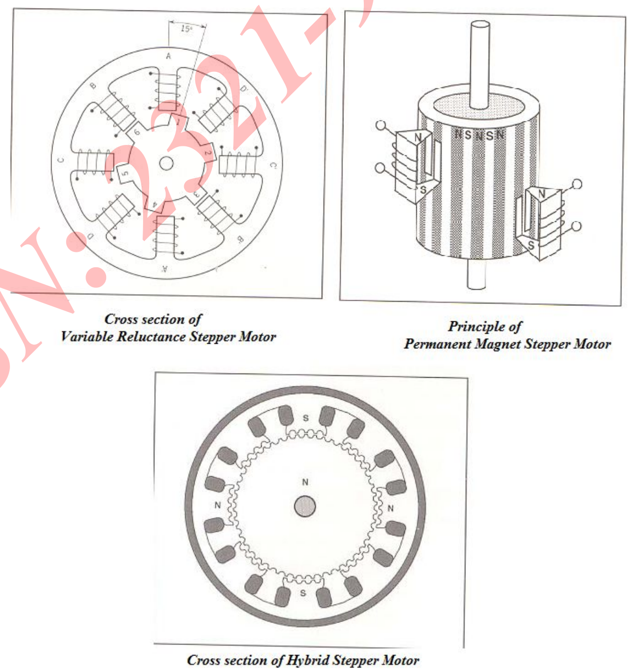

Figure 2: Stepper Motor Model

IV. FPGA SPARTAN 3E

The Spartan®-3E family of Field-Programmable Gate Arrays (FPGAs) is specifically designed to meet the needs of high volume, cost-sensitive consumer electronic applications. The five-member family offers densities ranging from 100,000 to 1.6 million system gates, as shown in Table 1.

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Device	System Gates	Equivalent Logic Cells	CLB Array (One CLB = Four Slices)				Distributed RAM bits(1)	Block RAM bits(1)	Dedicated Multipliers	DCMs	Maximum User I/O	Maximum Differential I/O Pairs
			Rows	Columns	Total CLBs	Total Slices						
XC3S100E	100K	2,160	22	16	240	960	15K	72K	4	2	108	40
XC3S250E	250K	5,508	34	26	612	2,448	38K	216K	12	4	172	68
XC3S500E	500K	10,476	46	34	1,164	4,656	73K	360K	20	4	232	92
XC3S1200E	1200K	19,512	60	46	2,168	8,672	136K	504K	28	8	304	124
XC3S1600E	1600K	33,192	76	58	3,688	14,752	231K	648K	36	8	376	156

Table 1: Summary of Spartan 3E family attributes

The Spartan-3E family builds on the success of the earlier Spartan-3 family by increasing the amount of logic per I/O, significantly reducing the cost per logic cell. New features improve system performance and reduce the cost of configuration. These Spartan-3E FPGA enhancements, combined with advanced 90 nm process technology, deliver more functionality and bandwidth per dollar.

V. VHDL DESIGN AND PROGRAMMING TECHNIQUES

VHDL stands for *very high-speed integrated circuit* hardware description language. This is one of the programming languages used to model a digital system by dataflow, behavioral and structural style of modeling.

VHDL Structure:

- Library - Definitions, constants
- Entity - Interface
- Architecture - Implementation, function

In VHDL an entity is used to describe a hardware module. An entity can be described using,

1. Entity declaration.
2. Architecture.
3. Configuration
4. Package declaration.
5. Package body.

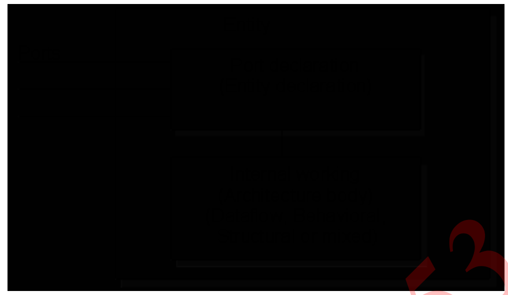

Figure 3: Structure of an Entity.

In VHDL programming the flow control like if and switch case is used.

Xilinx ISE (**I**ntegrated **S**oftware **E**nvironment) is a software tool produced by Xilinx for synthesis and analysis of HDL designs, enabling the developer to synthesize ("compile") their designs, perform timing analysis, examine RTL diagrams, simulate a design's reaction to different stimuli, and configure the target device with the programmer. Xilinx Software is used to simulate the VHDL programs for the proposed system.

VI. BLUETOOTH FUNCTION

Bluetooth is a low cost, low power, radio frequency technology for short-range communications. It can be used to replace the cables connecting portable/fixed electronic devices, build ad-hoc networks.

Frequency	2.4GHz ISM band, Frequency
Modulation	Gaussian shaped BFSK
Data rate	723Kbps
Operating range	10m~100m
Power	0.1W (Active)
Security	Good. FHSS. Link layer

Table 2: Bluetooth Summary

VII. FUNCTIONS OF LABVIEW

LabVIEW is known as Virtual Instruments (VI) because their appearance and operation imitate actual instruments.

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It consists of

- Front Panel
- Block diagram

The front panel is the user interface of the VI. You build the front panel with controls and indicators, which are the interactive input and output terminals of the VI, respectively. Controls are knobs, pushbuttons, dials, and other input devices. Indicators are graphs, LEDs, and other displays. Controls simulate instrument input devices and supply data to the block diagram of the VI. Indicators simulate instrument output devices and display data the block diagram acquires or generates. The block diagram contains this graphical source code. Front panel objects appear as terminals on the block diagram. Additionally, the block diagram contains functions and structures from built-in LabVIEW VI libraries. Wires connect each of the nodes on the block.

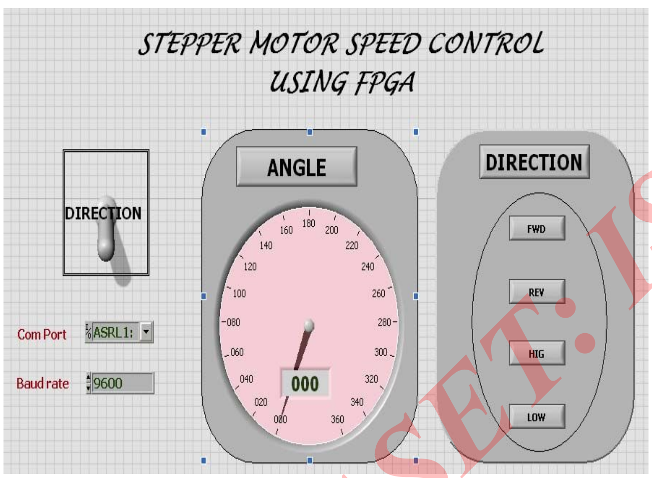

Figure 4: Proposed System LabVIEW front panel

VIII. PROPOSED SYSTEM OUTPUT

In digital, circuit design **register-transfer level** (**RTL**) is a design abstraction which models a synchronous digital circuit in terms of the flow of digital signals (data) between hardware registers, and the logical operations performed on those signals. An RTL description is usually converted to a gate-level description of the circuit by a logic synthesis tool. The synthesis results are then used by placement and routing tools to create a physical layout.

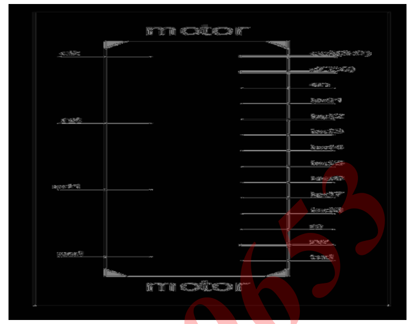

Figure 5: RTL Schematic of the proposed system

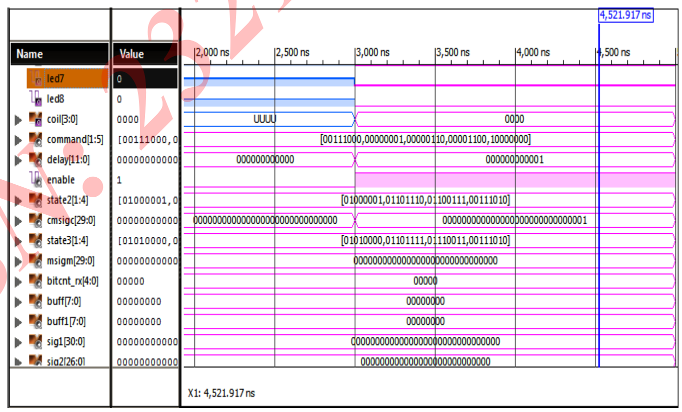

Figure 6: Timing Graph of the proposed System

IX. APPLICATION

The main application of the proposed system is robotic control and implementation. The robot is accessed by the solar energy and controlled through Microcontroller.

X. CONCLUSION

Thus the proposed paper proposes the control techniques for the stepper motor to achieve the precise control through the wireless network. LabVIEW based GUI technique is used in order to control the motor and to reduce the cost to implement and make the control user-friendly.

The proposed system can be implemented any industrial applications to achieve high resolution stepping functions.

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

XI. ACKNOWLEDGEMENT

I wish to express my deep sense of gratitude and sincere thanks to our Professor and Head of the Department, for their encouragement, timely help and advice offered to me. I am very grateful to my guide, who has guided with inspiring dedication, untiring efforts and tremendous enthusiasm in making this project successful and presentable. I would like to extend by sincere thanks to my parents and friends for guiding me to do the project successfully.

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