FPGA BASED PULSE WIDTH MODULATION CONTROL FOR DC MOTOR

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Abstract*—DC Motor is been used in various applications and systems to control the different process. In such applications, the fundamental task of relevant systems is the control of DC motor. To avoid serious complications these applications require a precise speed governing of motor. There are several techniques to control the speed of motor. Aim of this paper is to design a "DC motor Control System" using ALTERA Cyclone IV-E 4CE115 FPGA device. Project is based on PWM technique. It is essential to program the device using VHDL or Verilog Programming Language. Here VHDL language is used to write program that will generate PWM signals. FPGA and digital control technique i.e. pulse width modulation is used due to its merits.*

***Keywords*—FPGA, PWM, DC Motor and Altera Cyclone IV**

1. INTRODUCTION

Motors are very popular devices that can be used in every house, industries and cars. Motor plays variety of purposes in Robotic Industries. DC motors are rarely used in ordinary applications because all electric resource firms deliver alternating current. Though, for special applications it is beneficial to convert alternating current into direct current in order to use DC motors. The cause is that the speed/torque characteristics of dc motors are much greater to that of AC motors.

Pulse width modulation provides a logic "0" and logic "1" for specified controlled period of time. In this technique, modulation of duty cycle is obtained and that's why PWM signal is square wave with varying duty cycle but has a constant period. Thus PWM signal has constant frequency. Modulation process causes change or shift in the frequency range of signal. The ON time of PWM signal can vary from 0% to 100%. The duty cycle is given by λ/T, where λ shows ON time and T show total period.

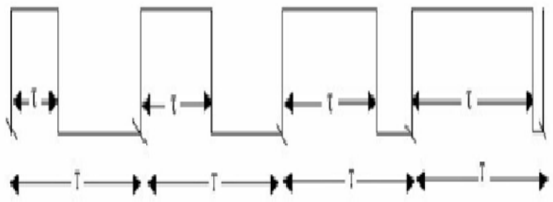

Fig.1 PWM signal with varying duty cycle

There are day today changes in electronics world. So every day, advancement and innovation is carried out in techniques to overcome limits of previous works. PWM technique is used to drive motor acting as a load. In PWM there are variations in width of pulse. As width of pulse changes then speed of the motor changes. The main component of paper is PWM pulses using FPGA. Field Programmable Gate Array (FPGA) offers the most preferred way of designing PWM Generator for Power Converter Applications.

2. RELATED WORK

Prof. C. S. Patil et al [1] has proposed a system for speed control of AC induction motor which is based on FPGA. High resolution PWM is been generated using FPGA and as it is digital control it has many advantages over analog control technique. Authors have proposed this system mainly taking into consideration industrial application. Xilinx Spartan 3e FPGA kit, Optoisolator and induction motor is used for designing purpose. The control of AC induction motor is observed to be smooth.

Nandkishor P. Joshi et al [2] has proposed a system where control of DC motor is done using digital control i.e. pulse width modulation. Controller used here is microcontroller 8051. H-bridge is used for driving the motor which is made up of four MOSFETs. Precise control of DC motor is achieved with use of low cost hardware.

Sneha R. Kirnapure et al [3] has designed a high frequency pulse width modulation signal using FPGA i.e. field programmable gate array. Here synthesis, design and implementation is performed of PWM. VHDL language is used for designing PWM. Quartus 13.0 version is used for simulation purpose. PWM developed is of 8 bit and frequency up to 250MHz can be achieved with a duty cycle resolution of 0.39%.

3. PROPOSED SYSTEM

Microprocessor, microcontroller or DSP have their own specific confines. But this paper presents a work which is done using FPGA. FPGA is used here as it overcomes all the restrictions and also its performance is superior. Microprocessor has certain drawbacks and they are:

- Microprocessor based motor control algorithms cannot be changed frequently.
- Microprocessor needs milliseconds to power up which delays the switching sequence in the motor.
- Due to these problems, work is implemented using field programming gate arrays.

Speed control of DC motor is done by changing the width of PWM signal generated using VHDL coding. FPGA device is used to control the speed of DC motor.

Altera DE2-115 device has 18 slide switches.Switche2 to switch5 are used to gradually increase the TON period of PWM wave in order to increase the speed of DC motor. So as we increase the input of switches from '0000' to '1111', speed of DC motor is increased. Speed of motor is gradually reduced by changing switches from logic value '1111' to '0000'. Switch10- Switch13 are used to define the period of one complete cycle of PWM wave.

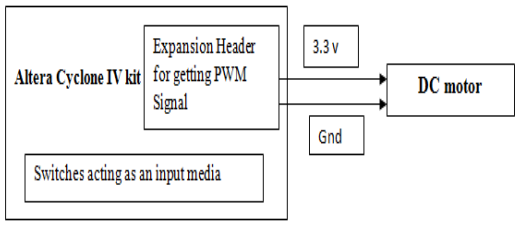

Figure 2: Block diagram of the proposed system

4. RESULTS

A. Compilation report

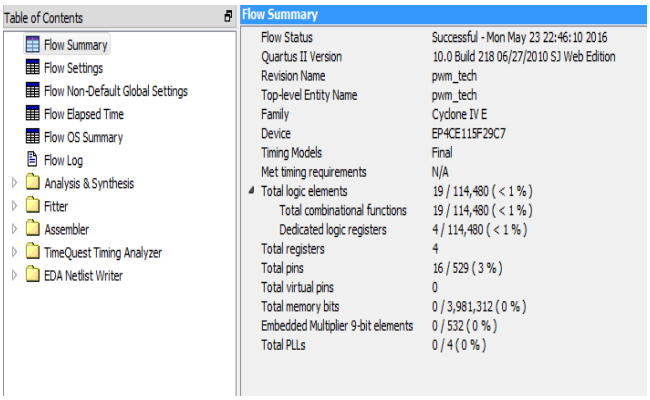

Fig 3. Project report

B. RTL Schematic of Project

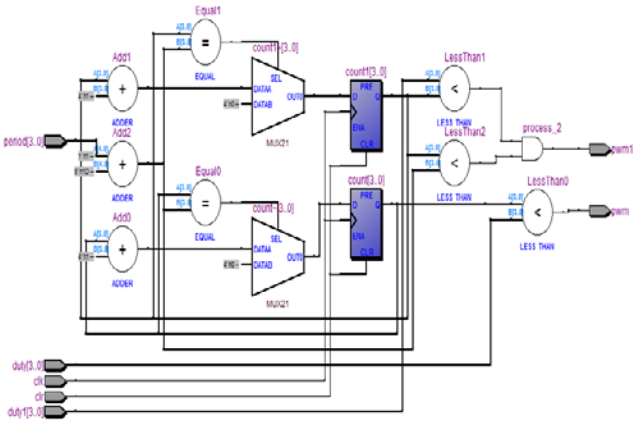

Fig 4. RTL Schematic

Figure 3 gives the compilation report from which gives lots of information such as total logic elements used, total pins used, total memory required etc. While figure 4 shows us RTL i.e. register transfer logic.

C. Results for various binary inputs

Following Image displays result of PWM for the binary input **"1100".**
Duty= 74.48%
Total Period=320 nsec
TON=230 nsec

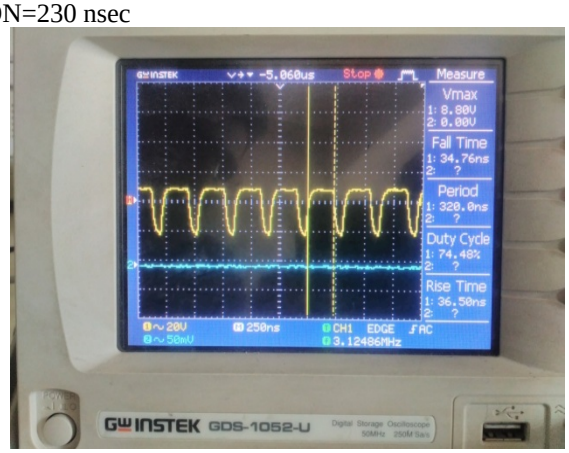

Fig 5. Result for input "1100"

Following Image displays result of PWM for the binary input **"0101".**
Duty=31.73%
Total Period=320 nsec
TON=130 nsec

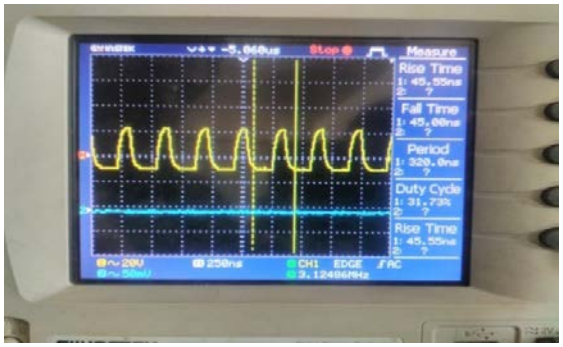

Fig 6. Result for input "0101"

Figure 5 & 6 shows the signal for different inputs from which pulse width modulation is seen. Total period is constant but as the ON time is changing, duty ratio is also changing. So when duty ratio is larger motor runs with high speed and when duty ratio is small, motor runs with low speed.

Table 1 gives the summary about various input values and their respective Ton, Toff and duty ratio.

Table 1: Results for various binary inputs

Decimal Value	Binary Value	Total	Ton	Toff	Duty (%)
5	0101	320nsec	130nsec	190nsec	31.73
6	0110		150nsec	170nsec	37.74
7	0111		170nsec	150nsec	43.55
8	1000		190nsec	130nsec	50.00
12	1100		230nsec	90nsec	74.48

5. CONCLUSION AND FUTURE WORK

This project uses Altera Cyclone IV 4CE115 FPGA device to control the speed of motor which minimizes the drawbacks of speed controller over microcontroller. It is possible to use this speed controller in the application which requires precise speed controlling. As the binary values are increased, it varies TON period of PWM more precisely. Hence, you get more accurate result and much tight controlling.

6. ACKNOWLEDGEMENT

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