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# FPGA Based High Frequency PWM Waveform Generator Controller With Variable Duty Cycle

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***Abstract*—Field Programmable Gate Arrays (FPGA) provides very good hardware design flexibility. This paper specifies the generation of PWM signals for variable duty cycles using VHDL. The project employs the use of Spartan3e board. The PWM waveform generated is integrated with the MATLAB module to show simulation and after that the comparison with the arduino board. Pulse Width Modulation found in large number of applications as a voltage controller. It is used in controlling output voltage of inverter in most of the applications.PWM has a fixed frequency and a variable voltage. Voltage value changes from 0V to 5 V. The advantage of this method is that it is used to generate High-frequency variable duty cycle PWM output. The VHDL code is written and synthesized using Xilinx ISE. Behavioral simulation was performed and the results are verified by downloading the code into SPARTAN 3 FPGA. Pulse-Width modulation is commonly used in industrial applications for electrical motor control but is also used in audio applications, such as compact class-D power amplifiers, and drivers for light source based on light emitting diodes our main focus in this project is to control speed of DC motor at high frequency.**

***Index Terms*— FPGA, Xillinx, Arduino, Rotary Encoder, VHDL, DC Motor.**

## I. INTRODUCTION

Pulse Width Modulation (PWM) has now become an integral part of almost all Embedded systems. It has been widely accepted as control technique in most of the electronic appliances. These techniques have been extensively researched during past few years. There are various methods depending upon architecture and requirement of the system. Their design implementation depends upon application type, power consumption, semiconductor devices, performance and cost criteria all determining the PWM method. In this project what we are trying to do is that, we are generating the PWM waveform by using VHDL code on Xilinx software and then implementing it on FPGA board. There are basically two PWM techniques – Analog and Digital Techniques. In analog techniques there is a carrier signal and a modulating signal. These two signals are compared using comparator. The output of this comparator is the desired PWM output. The disadvantages of these analog methods are that they are prone to noise and they change with voltage and temperature change. lso they suffer changes due to component variation. They are less flexible as compared to digital methods. Digital methods are the most suited form for designing PWM Generators. They are very flexible and less sensitive to environmental noise. Also they are simple to construct and can be implemented very fastly. Most of the digital techniques employ counter and comparator based circuits. This project involves the use of FPGA. Field Programmable Gate Array (FPGA) offers the most preferred way of designing PWM Generator for Power application.

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## II. PROPOSED PWM ARCHITECTURE

To produce the input data to generate the PWM using high speed N-bit free running counter, whose output is compared with register output and stores desired input duty cycle with the help of comparator. The comparator output is set equal to 1 when both these values are equal. This comparator output is used to set RS latch. The overflow signal from counter is used to reset RS latch. The output of RS latch gives the desired PWM output. This overflow signal is also used to load new N-bit duty cycle in Register. PWM has a fixed frequency and a variable voltage. This voltage value changes from 0V to 5 V. The basic PWM generates the signals, which gives the output of PWM, requires a comparator that compares between two values. The first value represents the square signal generated by N bit counter and the second value represents the square signal which contains the information about duty cycle. Counter generates the load signal whenever there is an overflow. Once load signal becomes active, the register loads the new duty cycle value. Load signal is used to reset the latch also. Latch output is a PWM signal. This is varying with change in duty cycle value.

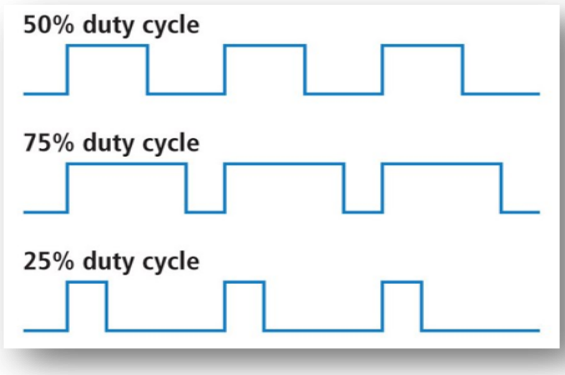


Fig 1:PWM Waveform With Different Duty Cycles

## III. Simple PWM Control Algorithm

• An n-bit counter continuously increments from 0 to its maximum value, i.e., 2n-1 and then repeats the cycle.

```
if ( counter < x_in )
 PWM_out <= 1;
else
 PWM_out <= 0;
counter <= counter+1
```

## IV. COMPARISON WITH ARDUINO

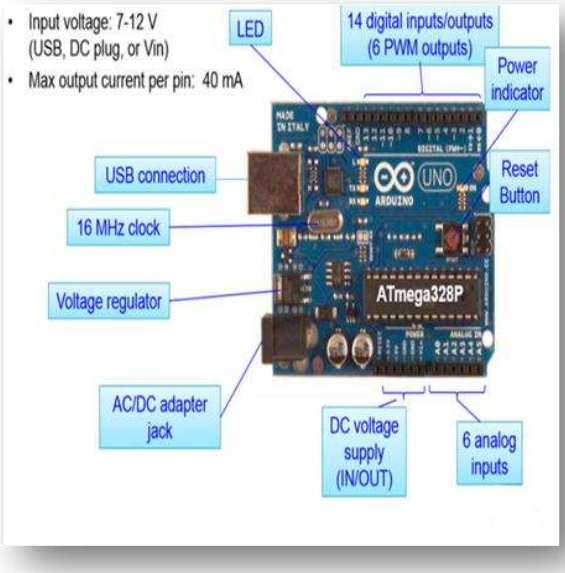


Fig 2

It's a movement, not a microcontroller: Founded by Massimo Banziand David Cuartielles in 2005 Based on "Wiring Platform", which dates to 2003 Open-source hardware platform Open source development environment –Easy-to learn language and libraries (based on Wiring language) –Integrated development environment (based on Processing programming environment) –Available for Windows / Mac / Linux

FPGA generates higher frequency PWM signal than the arduino, hence PWM waveform generated by this method can be directly applied in their application without the need of modulation. FPGA can be used in the power applications. FPGA programs can be easily modified as per the requirement. Millions of calculations can be done by the number of blocks present in FPGA , These cant be done in arduino.

Pulse Width Modulation is a process that is used in many applications. One of the easiest ways to implement this is by using an Arduino. The Arduino can do this in a number of ways. This application note will look at what Pulse Width Modulation is and will also explain how to perform Pulse Width Modulation using two different methods. FPGA generates higher frequency PWM signal than the arduino ,hence PWM waveform generated by this method can be directly applied in their application without the need of modulation. FPGA can be used in the power applications. FPGA programs can be easily modified as per the requirement. Millions of calculations can be done by the number of blocks present in FPGA , These can't be done in arduino.

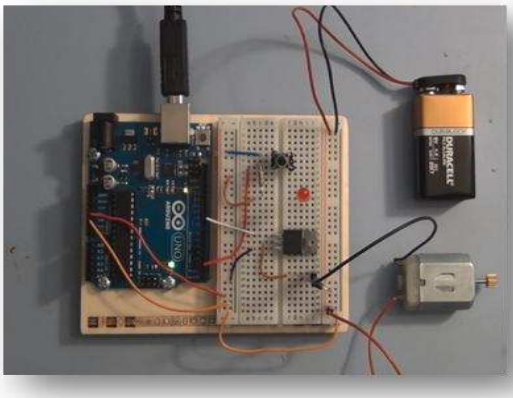

Fig 3: Circuit Diagram For PWM Generation By Arduino

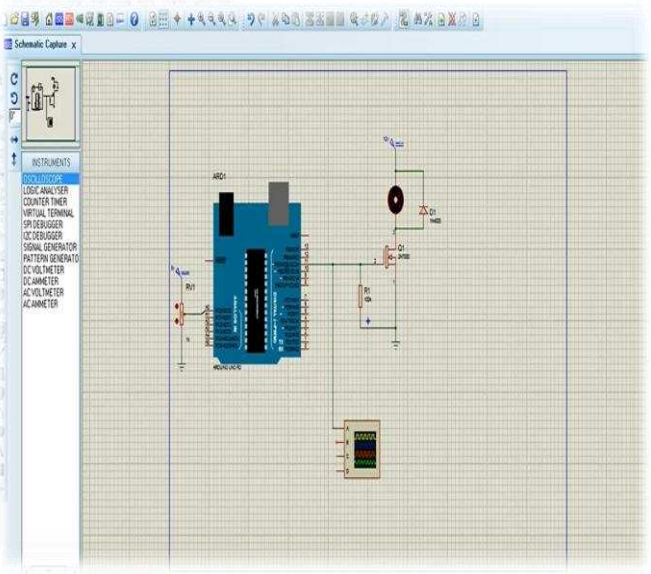

Fig 4: Showing Virtually on Proteus Using Another Circuitry on Arduino.

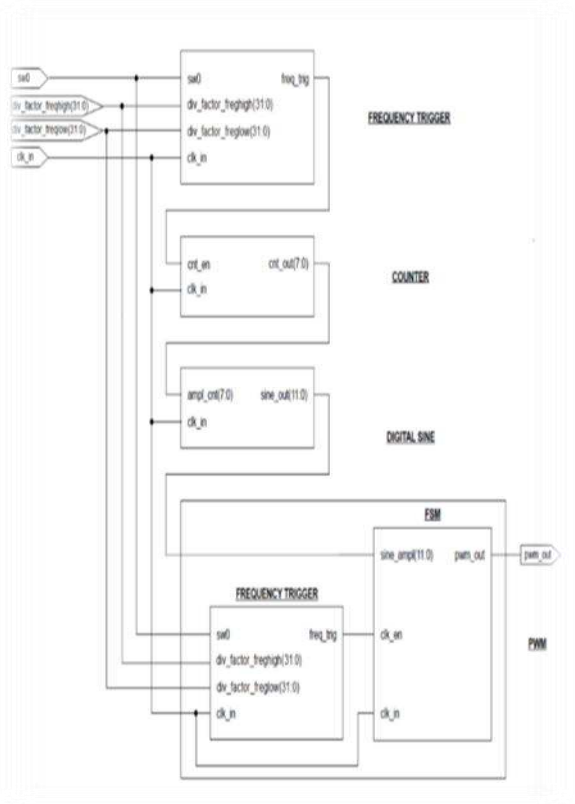


Fig 5: Circuit Diagram


Fig 6: Sparatan 3e Board DC Motor

A DC motor is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line

## V. DC MOTOR CONTROLLING

The use of pulse width modulation to control a small motor has the advantage in that the power loss in the PWM is small because the PWM signal thus generated is either fully "ON" or fully "OFF". As a result the switching transistor has a much reduced power dissipation giving it a linear type of control which results in better speed stability. Here DC MOTOR controlling is done by the rotary encoder.

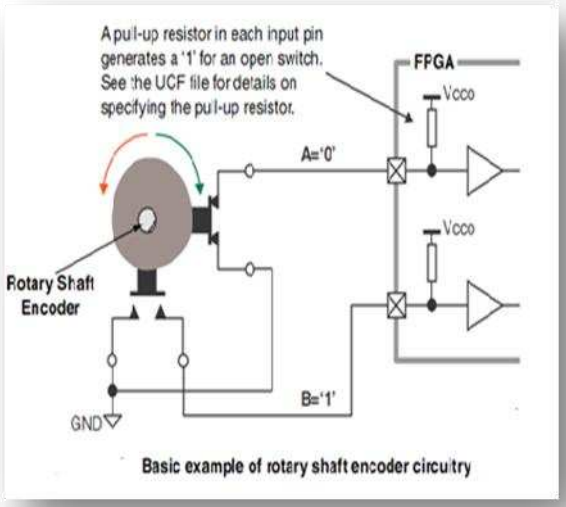


Fig 7: Rotary Encoder

The basic principle of the rotary encoder is that of a cam connected to a shaft which is used to operate two switches. When in the stationary 'detent' position both switches are closed. Then depending on which way the shaft is rotated, one switch will open before other. Likewise, as the rotation continues, one switch will be closed before the other. This diagram only depicts that one sequence of the switches will occur for every 360˚revolution. The encoder on the board actually repeats the sequence every 18˚(20 clicks per revolution).

**How Waveforms controlled by rotary encoder**?

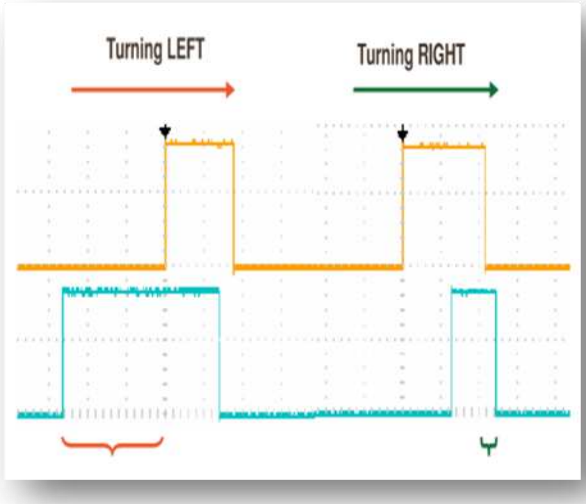


Fig 8

The diagram below indicates how switch chatter could be interpreted as additional rotation 'clicks' in either direction even when the intention is only to take one step to the right**.**

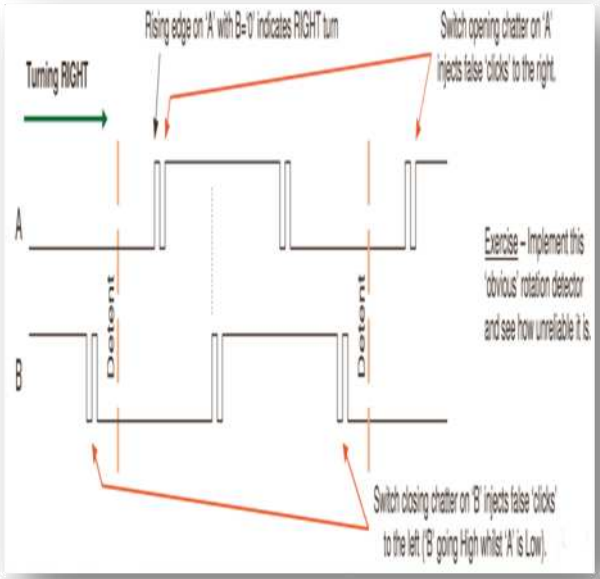


Fig 9

## VI. SIMULATION RESULT

A VHDL program has been written for the proposed architecture and synthesized and simulated using Xilinx ISE Simulator.

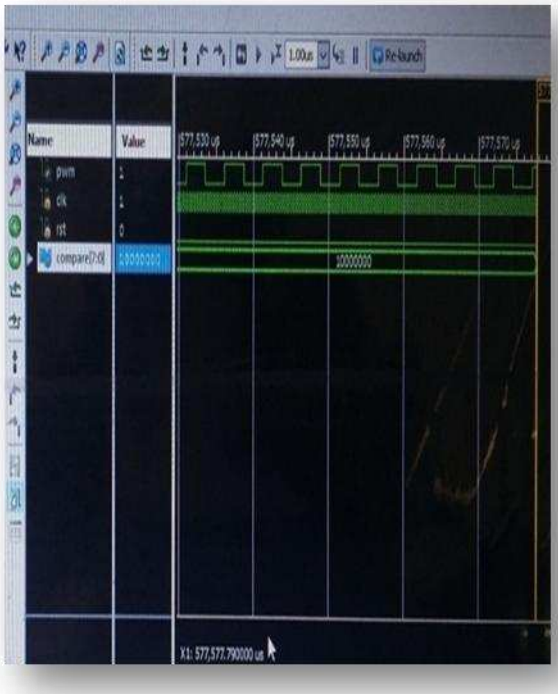

Fig 10

## VII. CONCLUSION

Here we discussed regarding generation of PWM signals with varying duty cycle using VHDL code and tested on FPGA. A FPGA SPARTAN3 board is used as hardware and ISE XILINX is used as software. The comparator is necessary to compare between the data available in register and counter to generate suitable PWM signals. The generated PWM signals have a fixed frequency (10 MHz) depended on the frequency of square wave, and a variable duty cycle that changes from 0% to 100%. But the frequency can be changed on FPGA board based on our requirement, without changing anything in program. These signals can be used to drive a motor.

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