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Stepper Motor Controller using XC9572 CPLD through Mobile As a Remote

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***Abstract* -The theory of motion control has evolved since the late 18th century. Simply, motion control is defined as accurately controlling the movement of an object based on speed, distance, load, inertia or a combination of all these factors. Due to high system complexity and difficult software language implementation, the traditional programmable logic controller based motion control systems have gradually been replaced by CPLD based control systems. In my project, the control to a stepper motor system is accomplished from a mobile and an intuitive and easy to use graphical user interface is designed by using VHDL. My paper presents, a hardware implementation of circuit which is designed for a programmable rotational stepper motor using VHDL as a design tool and the CPLD as a target technology. The design is implemented on a XC9572 kit. The advantage of using reconfigurable hardware (CPLD) instead of a PLC, Microprocessor & Microcontroller is that the designer can make modifications to the design easily and quickly, and the total design represents an embedded system. The total programmable hardware design that make control on the stepper motor movement, occupy an area that did not exceed 12% of the chip resources.**

Keywords: CPLD, DTMF decoder, PLC, Stepper Motor, VHDL.

1. INTRODUCTION

The advantage of precision control, open-loop control of the motor, self contained braking and the absence of brushes makes the stepper motor a convenient choice for a variety of specialized applications. Printers and plotters, disk drives, robots, CNC machines, and other precision machines are common examples where the stepper motor is used extensively.

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A stepper motor's operation can be explained by considering a series of electromagnets arranged in a circle to encapsulate a rotor made up of a magnetic material. When these or electromagnets are energized in sequence, the magneto motive force (MMF) developed in them interacts with the rotor and causes it to re-align to the magnetic field, thereby causing it to rotate in a clockwise or counterclockwise direction. The motor's angular displacement can be controlled by simply switching these electromagnets on or off in a fixed pattern for the desired motion of the motor. with the 21st century if the Stepper motor and other motors operate remotely by the mobile phone it is obviously advantageous for the Industry. wireless remote reduces the difficulty for controlling the Stepper motor. But remote still offers limitations because it is limited in a particular range. If it is interfaces with the mobile phone as a remote then the project will get higher usability and scope .This project is an interfacing of mobile phone with DTMF decoder and this circuitry connected to the Stepper motor via CPLD to control the speed and rotation of the Stepper motor . In this work rotation and speed of the stepper motor is controlled by using CPLD (Complex programmable logic device) instead of Microprocessor. The characteristic of non volatility makes the CPLD the device of choice in modern digital designs to perform the function. Block diagram for controlling the stepper motor using CPLD is shown in Fig 1.

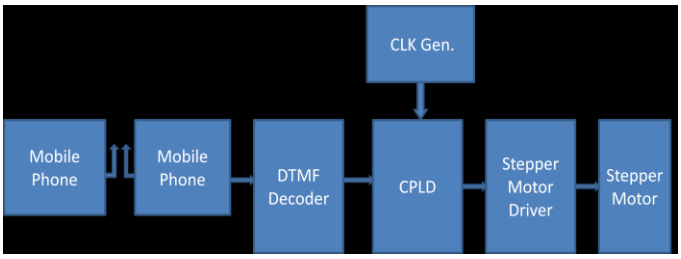


Fig : 1 ***Blok diagram for mobile based remote device for controlling the stepper motor using CPLD.***

II. CIRCUIT DESCRIPTION

Figure 1 shows the organization of the stepper motor controller. The driver circuitry is supplied by a Power source, due to the requirements of the motor's windings. In accordance with the controller logic, the ports connected to the CPLD drive the inputs of the motor driver, thereby driving the stepper motor. The controller incorporates logic for half stepping the motor. The inputs to the controller are explained in Table 1.

Table 1. *Binary Sequence of Operation*

Preprogrammed Binary Sequence

No. Pressed on mobile	*Binary input*	*Operation*
2	*0010*	*Clockwise full step*
8	*1000*	*Anticlockwise full step*
5	*0101*	*Stop*
4	*0100*	*Clockwise half step*
6	*0110*	*Anticlockwise half step*

Complex programmable logic device (CPLD) are ideal for integrating the control logic for these motors with other system control logic to minimize device count and board size. Components utilized in this project are: DTMF decoder (CM8870), CPLD 84pin IC and stepper motor driver ULN2803 IC.

III. When to Use a Stepper Motor

• A stepper motor can be a good choice whenever controlled movement is required.
• They can be used to advantage in applications where control on rotation angle, speed, position and synchronism is required.
Because
– A stepper motor is an electromechanical device which converts electrical pulses into discrete mechanical movements.
– The shaft or spindle of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in the proper sequence.

A. Open Loop Operation of stepper motor

One of the most significant advantages of a stepper motor is its ability to be accurately controlled in an open loop system. Open loop control means no feedback information about position is needed. This type of control eliminates the need for expensive sensing and feedback devices such as optical encoders. Here position is known simply by keeping track of the input step pulses [1].

B. Torque Generation of stepper motor

The torque produced by a stepper motor depends on several factors.

- The step rate
- The drive current in the windings
- The drive design or type

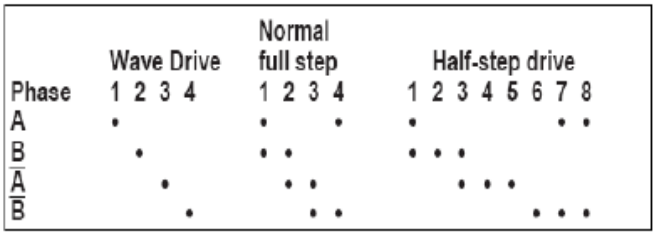
In a stepper motor a torque is developed when the magnetic fluxes of the rotor and stator are displaced from each other [1].

C. Stepping Modes of stepper motor

The following are the most common drive modes.

- Wave Drive (1 phase on)
- Full Step Drive (2 phases on)
- Half Step Drive (1 & 2 phases on)
- Micro stepping (Continuously varying motor currents)

Table 2. *Excitation sequences for different drive modes*



In Wave Drive only one winding is energized at any given time.

In Full Step Drive you are energizing two phases at any given time.

Half Step Drive combines both wave and full step (1&2 phases on) drive modes.

In Micro stepping Drive the currents in the windings are continuously varying to be able to break up one full step into many smaller discrete steps.

D. Torque Vs Speed characteristics

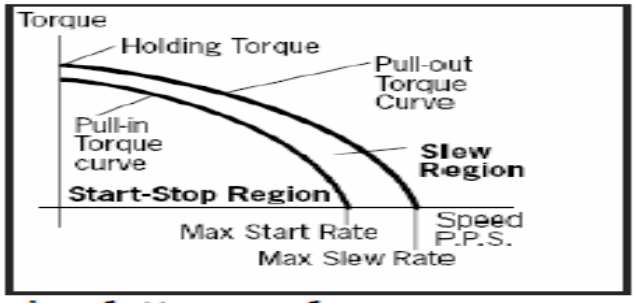
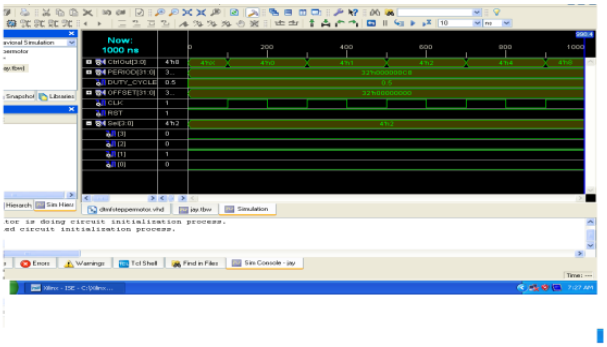


Fig : 2 Torque Vs Speed characteristics

The torque vs speed characteristics are the key to selecting the right motor and drive method for a specific application. These characteristics are dependent upon (change with) the motor, excitation mode and type of driver.
According to various situations of applications, the choice of stepper motor controller between the controlling scheme of position or speed must be made in advance. For performing high precision positioning and smooth rotation operation, design of stepper motor controller is a very important issue [2].

IV. Result and Discussion

With applications where load torque is stable and operations are at low speed, an open loop driver is preferred since it needs a simple control algorithm and an encoder is not required [12]. Here in this work as we are forcing motor to rotate in two directions clockwise and counter clock wise mode.
When coding is done in VHDL and Xilinx its Test Bench result is generated. The Test Bench view is shown below in fig 2. The Simulated output result for rotating the stepper motor in clockwise, counter clock wise full step & for half step is as follows. Simulation output is shown below-



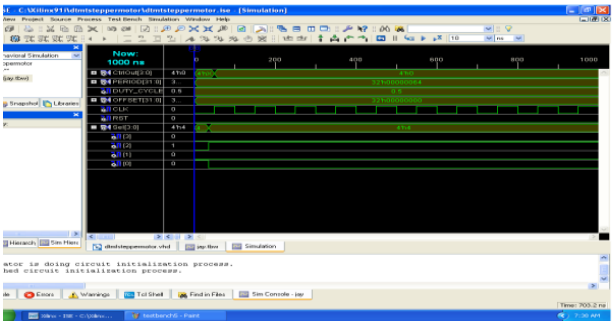


Fig: 3 Test Bench wave Form Result

V. CONCLUSION

1. This paper presents an introduction about open loop stepper motor control using a CPLD through mobile remote control unit.. The CPLD is used to build a high performance open loop driver without using a microprocessor or microcontroller. Furthermore it is compatible with ASICs and mass production methods for CPLD's & FPGA.

2. The Test Bench results are shown in Test Bench waveforms in figure 3.

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