

A Research of a New Technique of Open Loop Control Algorithm For Stepper Motor Using CPLD

Mohini Ratna Chaurasia, Nitin Naiyar

Abstract: With the 21st century if the Stepper Motor and other motors operates remotely by the mobile phone it is obviously advantageous for the Industry. A 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 interfaced with the mobile phone as a remote control then the project will get higher usability and scope. Previously Stepper Motor movements were controlled through various types of devices such as microprocessor, microcontroller and PLC (programmable logic device) but all these have certain limitations that's why in this research, another hardware solution is incorporated. Complex programmable logic device (CPLD) is suitable for fast implementation and quick hardware verification. CPLD based systems are flexible and can be reconfigured unlimited number of times. In this research Hardware Description Languages (VHDL) is used.

Keywords: Stepper Motor, CPLD, Mobile phone, VHDL.

I. INTRODUCTION

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. The motors rotation has several direct relationships to these applied input pulses. The sequence of the applied pulses is directly related to the direction of motor shafts rotation. The speed of the motor shafts rotation is directly related to the frequency of the input pulses and the length of rotation is directly related to the number of input pulses applied.

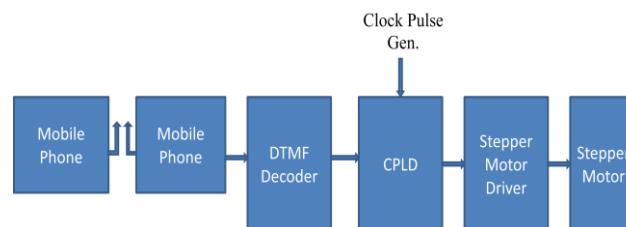


Fig1: Block diagram for mobile based remote device for controlling the stepper motor using CPLD

II. PROBLEM IDENTIFICATION

This work is mainly focused on speed control of stepper motors without use of Microprocessor, Microcontroller and DSP because these devices have their own limitations, CPLD overcomes all the limitations and improves the performance of the system. Despite of various advantages, microprocessor has certain limitations –

- i. Microprocessor based stepper motor control algorithms cannot be changed frequently.
- ii. Microprocessor needs milliseconds to power up which delays the switching sequence in the stepper motor.
- iii. In view of these disadvantages posed by microprocessor, this work attempts to implement through CPLD for development of VHDL based stepper motor controller.

We use CPLD to control the states of the motor and actual speed and position of the motor. The voltage input, which is in the form of a sine and cosine for the two windings, is generated through the CPLD and drive circuit.

III. CIRCUIT DESCRIPTION

Components utilized in this project are: DTMF decoder (CM8870), CPLD 84pin IC and stepper motor driver ULN2803 IC. The pictorial representation of the same is illustrated in Fig.1.

Advancements in digital motion control systems are mainly due to advances in power electronics, microprocessor technology and digital control systems.

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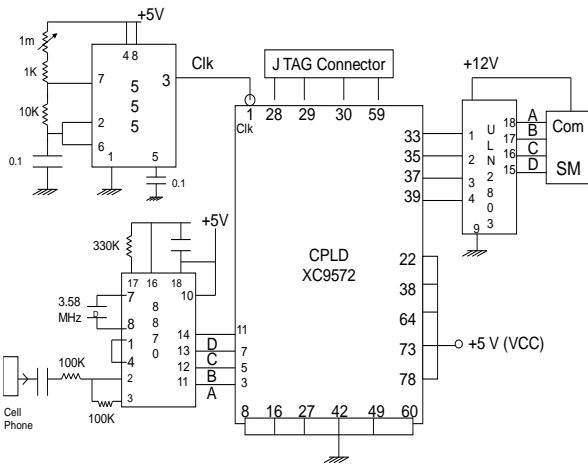
A modern motion control system such as a robotic manipulator arm or a positioning system consists in general of several electrical drives such as stepper motors. There are many previous methods for controlling the stepper motor motion. These methods like operating under the command of a computer system, or using microprocessor system (μp). In the stepper motor motion is controlled by using microcontroller. This type of control can be also done by using a modern programmable logic control (PLC), with a suitable selection for the necessary timers in its software.

A. Circuit diagram and Hardware Section

Circuit diagram of the Stepper Motor controller consists of 4 major IC's i.e.

- i. CPLD(complex programmable logic device) XC9572
- ii. Stepper Motor Driver (ULN 2803)
- iii. DTMF (dual tone multiple frequency) Decoder (MM8870)
- iv. 555 Timer IC.

Finally the stepper motor, mobile phone and power supply section are needed.



B. Working

A cell phone connected through the resistor & capacitor to the DTMF decoder IC on pin no. 2 and 3. When call is generated from the mobile then mobile works as a remote control, through this call and connection is established between remote and Stepper motor circuit because cell phone is in auto answering mode at the another end. Cellular phone generating the call acts as a remote control obviating the need for construction of superfluous receiver and transmitter units and thus it can be used for tele-control of motors.

After establishing the connection any button pressed on mobile will send the DTMF Tone to receiving end mobile. This Tone will transfer to the DTMF decoder through resistor & capacitor. This eliminates the noise included in the signal. Noiseless DTMF Tone decoded by the decoder and converts it into the equivalent binary. This binary output appears on the

pin 11,12,13 & 14 and given to the CPLD on pin no.3,5,7 & 11 and also the clock input at pin no. 1. According to the status of the pin CPLD performs the function as shown in the table below.

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

IV.CHARACTERISTICS OF STEPPER MOTOR

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.

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

Phase	Wave Drive				Normal full step				Half-step drive								
	1	2	3	4	1	2	3	4	1	2	3	4	5	6	7	8	
A
B			
A				
B			

D. Torque Vs Speed characteristic

- 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 or drive method.

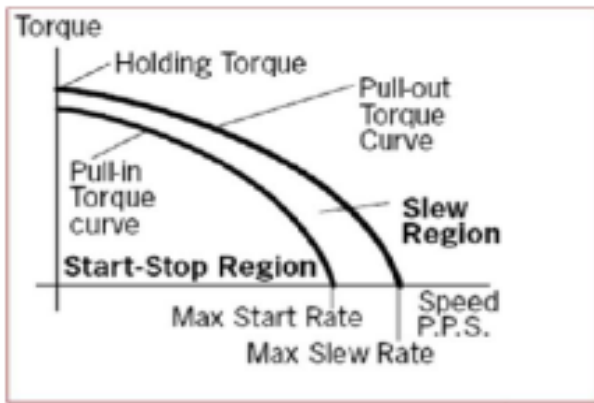


Fig : 2 A Typical "Speed – Torque Curve"

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.

V. CONCLUSION

This paper presents Block diag. and Circuit diag. of open loop stepper motor control using a CPLD through mobile remote control. 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.

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