Stepper Motors Controller

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ABSTRACT

The powerful computer is the corner stone for any successful business and industry in today's turbulent and rapid changing environment. This leads to the explosive growth of computer Industries. Due to this, there has been widespread demand of stepper motors. The stepper motor can also be known as stepping motor, step motor, in German *Schrittotoen,* in French *Moteurs pas a pas*, and in Spanish *Motor paso paso.*

Stepper motors are ideally suited for precision positioning of an object or/and precision control of speed without using closed-loop feedback for any automation systems. It is also translate switched excitation changes into precisely defined increments of rotor position {'step'}. Accurate positioning of the rotor is generally achieved by magnetic alignment of iron teeth on the stationary and rotating parts of the motor.

The basic function of stepper motor is that its output shaft rotates in a series of discrete angular intervals or steps, one step being taken each time a command pulse is received. When a definite number of pulses are supplied, the shaft turns through a definite known angle. The name stepper is used because this motor rotates through a fixed angular step in response to each input current pulse received by its controller. These controllers can be computers, microprocessor and programmable controllers.

A stepper motor requires an electronic controller to energies its windings in the proper sequence, thereby causing it to step. We designed this stepper motor controller and than testing of the same has been performed. In this paper we have described all their parts with

their functions with proper block and circuitry diagrams. We have developed methodology for the same is narrated here. The limitations and future scopes are highlighted.

Key words: design, methodology and testing of stepper motors controller

INTRODUCTION

Stepper Motor is also called steeping motor or step motor. The name steeper is used because this motor rotates through fixed angular step in response to each input current pulse received by the controller. The growing popularity of stepping motors is only due to falling prices; another factor must be that they logically fit into digital thinking. So they can be controlled directly by computers, microprocessors & programmable controllers. Many computer peripherals, such as disk drives, printer & plotters or computer-controlled equipment like XY table & robot limbs, make use of steeping motor. In computer CPU have a brain but not the (whole) body. Now with the aid of steeping motor they can create an interface between that brain and mobile reality [2].

Stepping motors are electromechanical converters. This type of motor responds in a well-defined way to certain digital signals fed to their control electronics. Stepping motors may therefore be used as an open system i.e. without feedback for control purposes. This obviates problems often encountered in feedback systems such as instability and overshoot. A stepping motor may therefore replace a conventional D.C. servo system with feedback.

PRINCIPLE OF OPERATION

A stepping motor may be compared with a synchronous motor as far as operation is concerned: a rotating field, here generated by the control electronics, pulls a magnetic rotor along. Stepping motors are sub divided according to the manner in which the rotating field is generated, that is with unipolar or bipolar stator windings and the material from which the rotor has been constructed – permanent magnetic material or soft iron.

Step angle: The angle through which the motor shaft rotates for each command pulse is called the step angle φ = 360°/No. of stator faze X No of rotor teeth

Smaller the step angle, greater the number of step per revolution and higher the resolution or accuracy of positioning obtained. The angle can be as small as 0.72° or as large as 90°.but the most common step angle 1.8°, 2.5°, 7.5°, 15°[1]

Unipolar and bipolar stepping motor can be operated in following modes.

Stepping Motor Modes

A Bipolar stepping motor with a permanent magnetic rotor is shown in fig 1.At the onset, both windings carry a current the stator is magnetized correspondingly, and the rotor has oriented itself accordingly. If the polarity of the current in A is reversed the field shifts 90° anticlockwise and pulls the rotor along. The sequence of activation for a complete revolution is AB-A’B-A’B’-AB’-AB that is four steps 90° each. So digital sequences are applied to power driver in binary values 10011001, 01101001, 01100110, 10010110.These digital sequences in hexadecimal format in shown in tables 5 & 7.It is also possible before reversing the polarity in a phase, to switch off the current to that winding. The sequence then becomes: AB-B-A’B-A’-A’B’-B’-AB’-A-AB. In this semi step operation, the steps are smaller but the moment is less regular and, on average, smaller because during half the time only one half of the number of phases is being used. Here in tables 6& 8 represents the equivalent hexadecimal values they are 99,09,69,60,66,06,96,90.

Unipolar stepping motors look the same as Bipolar ones, but they are wound differently. Each phase now consists of a winding with a center tap or two separate windings, so that the magnetic field can be inverted without the necessity of changing the direction of the current. A unipolar stepping motor with a permanent magnetic rotor is shown in fig 2.At the onset, both windings carry a current the stator is magnetized correspondingly, and the rotor has oriented itself accordingly. If the polarity of the current in A is reversed the field shifts 90° anticlockwise and pulls the rotor along. The sequence of activation for a complete revolution is AB-A'B-A'B'-AB'-AB that is four steps 90° each. So digital sequences are applied to power driver in binary values 1010, 0110, 0101, 1001.These digital sequences in hexadecimal format in shown in tables 1 & 3.It is also possible before reversing the polarity in a phase, to switch off the current to that winding. The sequence then becomes: AB-B-A'B-A'-A'B'-B'-AB'-A-AB. In this semi step operation, the steps are smaller but the moment is less regular and, on average, smaller because during half the time only one half of the number of phases is being used. Here in tables 2& 4 represents the equivalent hexadecimal values they are 0A, 02,06,04,05,01,09,08.

If Unipolar windings are to be housed in the same space as one Bipolar winding, it is evident that either fewer turns per winding, or thinner wire must be used. In either case, the result is fewer ampere-turns and consequently a weaker magnetic field .A unipolar stepping motor, therefore has a smaller moment than a bipolar one of the same dimensions. The maximum stepping rate is limited because the permanent magnet rotor causes an inductive voltage in the stator. Motors with relatively high rotating speeds, therefore often use soft iron rotors that have fewer poles than the stator, which is always unipolar [4].

As show in fig 3 Stepper motor controllers consists of Logic sequencer, Power driver. Logic sequencer provides digital sequences to power driver. Power driver increase the power level of the digital data & energies the windings of stepper motor. Logic sequences can be generated by microprocessor or Logic sequencer.

Table1 Whole Step (Uni)				
1	2	3	4	HEX
1	0	0	1	09
1	0	1	0	0A

Table 3 Continue (Unit)				
1	2	3	4	HEX
1	0	1	0	0A
0	1	1	0	06
0	1	0	1	05
1	0	0	1	09

Table4Semi Conti (Unit)				
1	2	3	4	HEX
1	0	1	0	0A
0	0	1	0	02
0	1	1	0	06
0	1	0	0	04
0	1	0	1	05
0	0	0	1	01
1	0	0	1	09
1	1	0	0	08

Table 2 Semi step (Uni)				
1	2	3	4	HEX
1	0	0	1	09
1	0	0	0	08

Table 5 whole step (Bi)								
1	2	3	4	5	6	7	8	HEX
1	0	0	1	1	0	0	1	99
0	1	1	0	1	0	0	1	69

Table 6 semi step (Bi)								
1	2	3	4	5	6	7	8	HEX
1	0	0	1	0	1	1	0	96
0	0	0	0	0	1	1	0	06

Table 7 Continue (Bi)								
1	2	3	4	5	6	7	8	HEX
1	0	0	1	1	0	0	1	99
0	1	1	0	1	0	0	1	69
0	1	1	0	0	1	1	0	66
1	0	0	1	0	1	1	0	96

Table 8 Semi continue (Bi)								
1	2	3	4	5	6	7	8	HEX
1	0	0	1	1	0	0	1	99
0	0	0	0	1	0	0	1	09
0	1	1	0	1	0	0	1	69
0	1	1	0	0	0	0	0	60
0	1	1	0	0	1	1	0	66
0	0	0	0	0	1	1	0	06
1	0	0	1	0	1	1	0	96
1	0	0	1	0	0	0	0	90

We designed logic sequencer (Fig) using EPROM (2732), 555 timer, counter (7493), and NAND gates. Digital sequences in table 1 to 8 are stored in EPROM using microprocessor.555 timer provides CLK signal to the counter. Counter's four output lines are connected to A0 to A4 address lines of EPROM.Four switches are connected to A4 to A7. So desire mode can be selected by switches S1 to S4.Each mode has 16 locations in EPROM, corresponding digital sequence are stored in it. To automatically reset the counter, there is 00H store at the end of each table. Counter will automatically reset using NAND gates when all bits are zero so stepper motor can be run in selected mode until we change the switch position. Speed of motor can be controlled by varying the CLK frequency. It provides *f* range from 1 to 100 Hz [4].

A7	A6	A5	A4	A3	A2	A1	A0
Bipolar (0)/ unipolar (1)	Whole (0)/ step (1)	Step (0)/ Continue (1)	Forward (0) /reverse (1)	Counter			

POWER DRIVERS

The signals produced by the logic sequencer are so weak that they are unable to energies the motor windings. We have, therefore, got to use power drivers to raise the power level sufficiently to energies the motor windings. Power drivers are made up of power transistor or thyristors, depending on the required power level. A possible circuit for driving uni polar motor is given in fig 2. It requires one darling tone transistor per winding. Bi polar motor need to be controlled to be via a bridge; i.e. four transistors per winding as shown in figure 1. It is possible to use only two transistors per winding, but a symmetrical power supply is then required. In stepper motor, due to finite winding inductance, phase current cannot be switched off instantaneously. If the base drive of the switching transistor were suddenly removed a large induced voltage would appear between transistor collector and emitter, causing permanent damage to the drive circuit. These possibilities are avoided by providing an alternative current path known as the freewheeling circuit for the phase current. When the switching transistor is turned off the phase current continue to flow through path provided by the freewheeling diode and freewheeling resistance [5].

APPLICATION

Stepper motor uses for operation control in computer peripherals, textile industry, IC fabrication and robotics etc. Incremental motion of typewriters, line printers, tape drives, floppy disk drives, NC machine tools, process control system and X-Y Plotters etc are also controlled by the same. Stepper motors also performs lot of task out side the computer industries. It includes commercial, military and medical application where this motor performs such functions as mixing, cutting, striking, metering, blending and purging. They also take part in the manufacturing of packed foodstuffs, commercial end products and even the production of science fiction movies [3].

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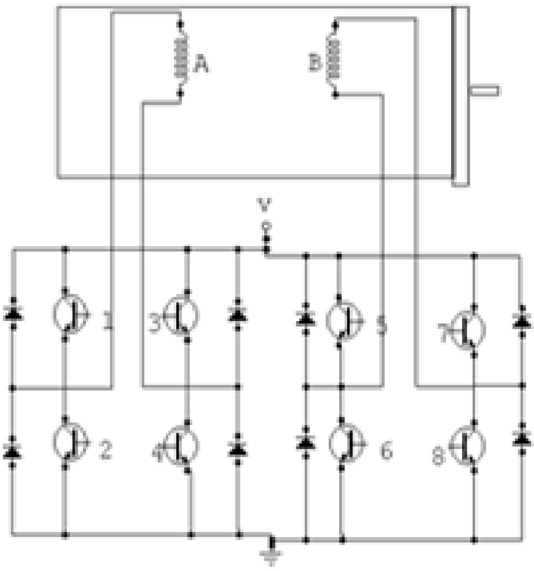


Fig 1

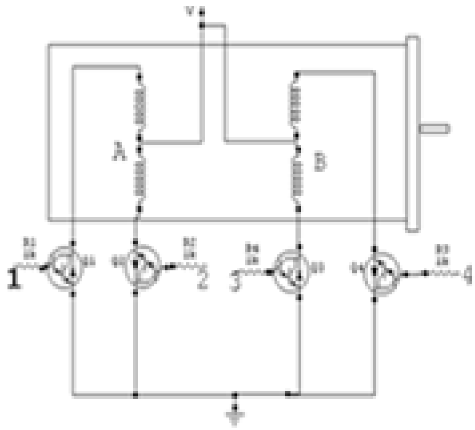
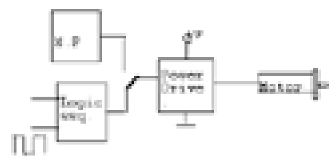
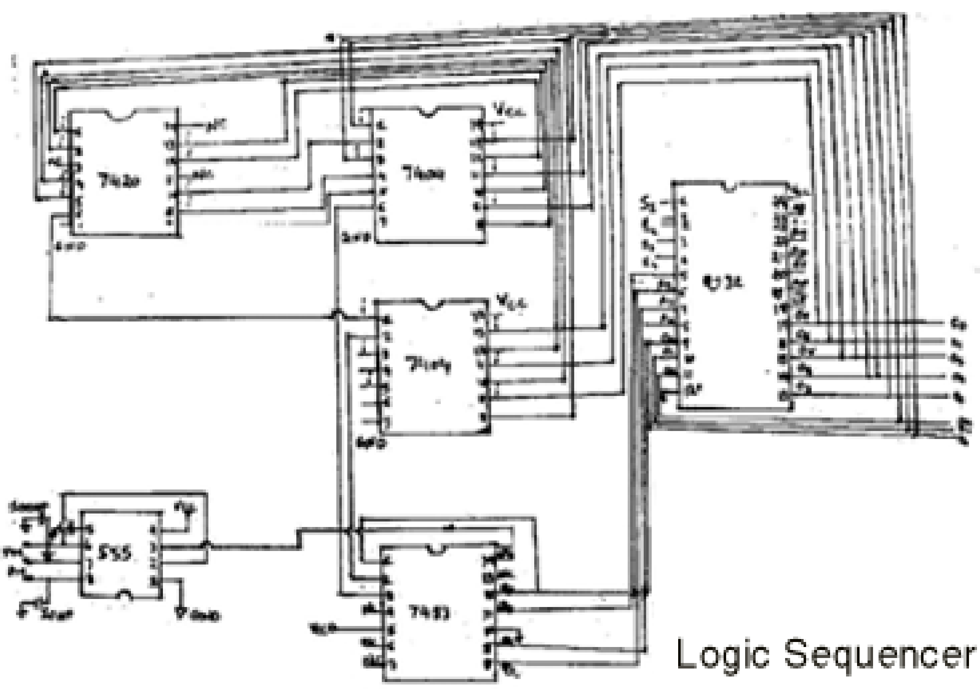


Fig 2





Logic Sequencer