

Position Control of Hybrid Stepper Motor Using PIC16F877A Microcontroller

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Abstract: Motion control of hybrid stepper motor for video surveillance system (CCTV) is very important issue in today life. Hybrid stepper motor is widely used in precision position application because resolution of hybrid stepper motor is high. In open loop control, the speed response of HSM suffer from large overshoot, oscillatory response and settling time. Additionally the motor must respond to each excitation change. If the excitation change is made too quickly, the stepper motor may lose some steps and therefore it will be unable to move the rotor to new demanded position. There for, a permanent error can be introduced between the load position and the expected by the controller. Due to this limitation, the stepper motor cannot be used without feedback sensor and closed loop control system with high performance application where the exact position or rotor speed is required.

Keywords: PIC16F877A Microcontroller, encoder, 6 wire Stepper motor, Stepper motor drive L293D, LCD 16*2 (LMO16L), LM7805 3-Terminal Voltage Regulator, matlab

1. Introduction

Stepper motors convert electrical power into rotation. A stepper motor is an electromechanical device which converts electrical pulses into discrete mechanical movements. The sequence of the applied pulses is directly related to the direction of motor shafts rotation. For applications where precise measuring of a motors' rotor position is critical, a Stepper Motor is the best choice. Stepper motors operate differently from other motors; rather than voltage being applied and the rotor spinning smoothly, stepper motors turn on a series of electrical pulses to the motor's windings. Each pulse rotates the rotor by an exact degree. These pulses are called "steps", hence the name "stepper motor"[2].

The two major advantages of stepper motor are:

- 1) They do not require a closed-loop system for positional control and
- 2) Positional error is not cumulative.

There are currently three general types of step motor.

- 1) Permanent Magnet (PM)
- 2) Variable Reluctance (VR)
- 3) Hybrid

Each has its own particular advantages and disadvantages. The permanent magnet motor (PM) or "can type" motor is economical, small and very simple in design. The variable reluctance (VR) and hybrid motors offer more torque with greater accuracy but come with the penalty of higher cost and larger size.

Regardless of the type of motor, all have some common characteristics. The two main components of stepping or stepper motors are the rotor and stator. The rotor in a PM motor generally contains a smooth ceramic magnet while the VR type motor has teeth and may be made entirely of laminated iron. The hybrid motor tends to be a combination of the PM and VR motor, its rotor is a permanent magnet housed within a machined iron core.

The stator is the outer stationary housing which contains the stator poles and the windings. By sequencing the current through the windings, the rotor teeth are aligned with corresponding teeth on the stator poles thereby causing motion of the rotor. Stepping motors have been used in open-loop mechanical positioning systems for many years, and are still the motor of choice in a wide range of applications. Their ability to move through fixed angular increments or steps means that stepping motors can be used without feedback and that interfacing to digital positioning systems is particularly easy.

2. Mathematical Model of the Hybrid Stepper Motor

The mathematical model that describes the dynamics of the hybrid stepper motors is well known [1], [2], [3]:

$$dI_a/dt = 1/L(V_a - RI_a + K_m \omega \sin(N\theta)) \dots\dots(1)$$

$$dI_b/dt = 1/L(V_b - RI_b - K_m \omega \cos(N\theta)) \dots\dots(2)$$

$$d\omega/dt = 1/J(-K_m I_a \sin(N\theta) + K_m I_b \cos(N\theta) - K_v \omega - T_L) \dots\dots\dots(3)$$

$$\frac{d\theta}{dt} = \omega \dots\dots\dots(4)$$

- V_a , and V_b voltages of phase,
- J is inertia of the motor,
- F is viscous friction coefficient,
- I_a and I_b are the currents of phase,
- K_m is motor torque constant,
- R is resistance of the phase winding,
- L is inductance of the phase winding,
- N is number of rotor teeth,
- θ is rotor position (rad),
- T_L indicates load torque.

3. Block Diagram of Video Surveillance System

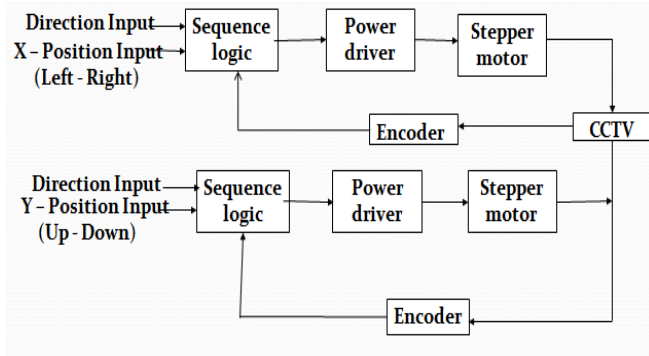


Figure 1: Block diagram of the system

4. Simulation of Hybrid Stepper Motor

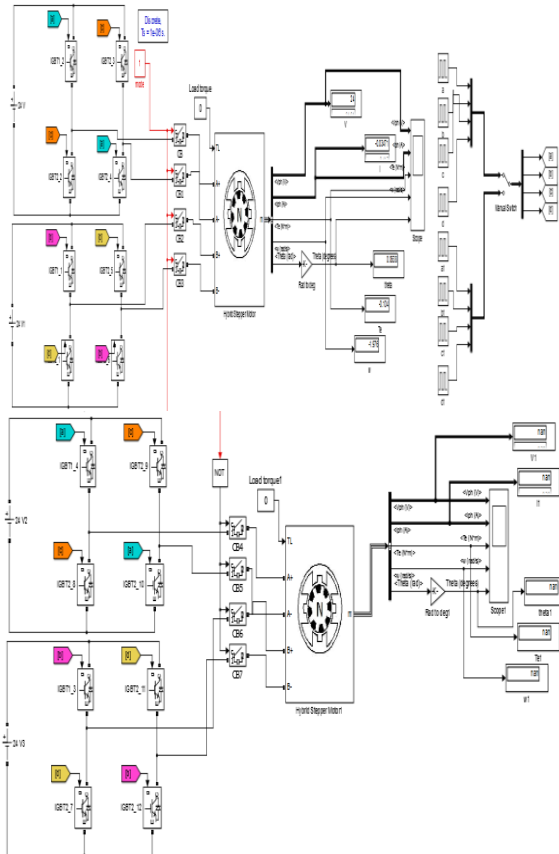


Figure 2: Simulation Of Hybrid Stepper Motor

4.1 Output of Motor for Open Loop Simulation

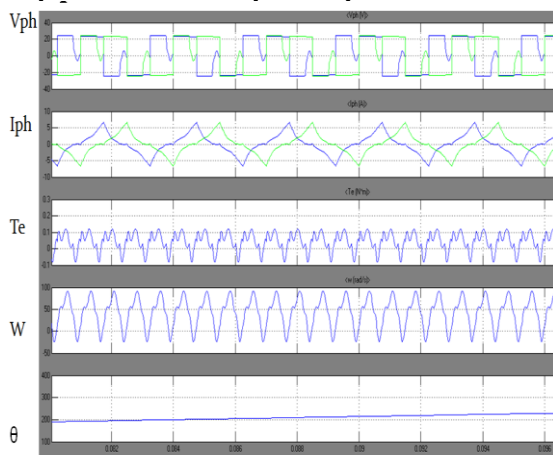


Figure 3: Output Of Motor For Open Loop Simulation

5. Component

A) 6 Wire unipolar Stepper motor

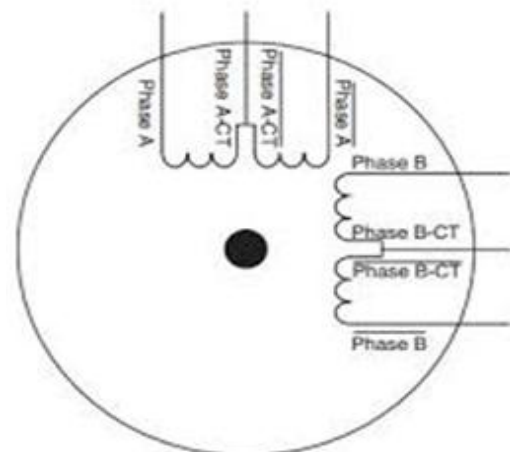


Figure 4.6: Wire unipolar stepper motor

The specific stepper motor we are using for our experiments has 6 wires coming out of the casing. If we can see that 3 wires go to each half of the coils, and that the coil windings are connected in pairs. 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.

B) Rotary Encoder



Figure 5: Rotary encoder

This rotary encoder is high quality, with detents(steps feel) and a nice continuous rotation. It is panel mountable for placement in a box, or you can plug it into a breadboard (just cut/bend the two mechanical side tabs.). This encoder also has a push-button built into it so you can press onto the knob to close a separate switch. One side has a 3 pin connector (ground and two coding pins) and the other side has two pins for a normally-open switch.

Rotary encoders are useful as rotation sensors or selectors and look similar to potentiometers. However they are not like potentiometers at all, so it's important to realize the difference! These rotary encoders rotate all the way around continuously, and are divided up into 18 'segments'. Each segment has a click-y feeling to it, and each movement clockwise or counter-clockwise causes the two switches to open and close. There is no way to know what the current 'position' is - instead you would use a microcontroller to count how many 'clicks' left or right it has been turned. If you need to detect rotational 'position' a potentiometer would be a better choice.

C) Stepper motor drive L293D

Wide Supply-Voltage Range: 4.5 V to 36 V
 Separate Input-Logic Supply,
 Internal ESD Protection,
 Thermal Shutdown,
 High-Noise-Immunity Inputs,
 Output Current 600mA Per Channel ,
 Peak Output Current 1.2 A Per Channel.

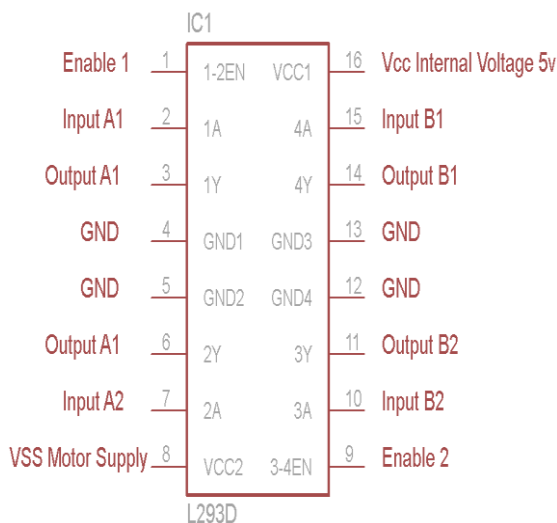


Figure 6: Pin diagram of L293D

The L293D are quadruple high-current half-H drivers. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. this devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo- Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled, and their outputs are active and in phase with their inputs. When the enable input

is low, those drivers are disabled, and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications.

D) LCD 16*2 (LMO16L)

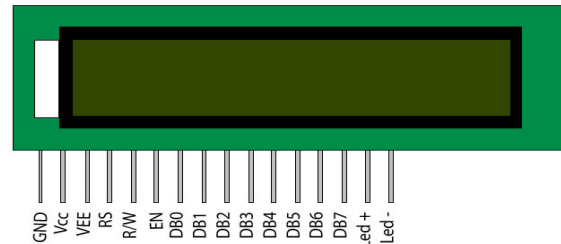


Figure 7: (16*2 LCD)

FEATURES

- 16*2 LCD
- Built-in controller (KS 0066 or Equivalent)
- + 5V power supply (Also available for + 3V)
- 1/16 duty cycle
- B/L to be driven by pin 1, pin 2 or pin 15, pin 16 or A.K (LED)

LMO16L Consist of four sections,

- 1) Power supply section
- 2) Control section
- 3) Data port section
- 4) Back light section

E) PIC16F877A

The PIC16F877A CMOS FLASH-based 8-bit microcontroller is upward compatible with the PIC16C5x, PIC12Cxxx and PIC16C7x devices. It features 200 ns instruction execution, 256 bytes of EEPROM data memory, self programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, a synchronous serial port that can be configured as either 3-wire SPI or 2-wire I2C bus, a USART, and a Parallel Slave Port.

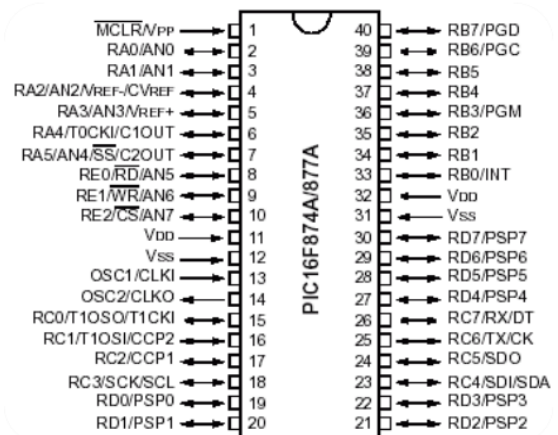


Figure 8: Pin diagram of PIC16F877A

PIC16F877A Microcontroller Features

High-Performance RISC CPU

- Lead-free; RoHS-compliant

- Operating speed: 20 MHz, 200 ns instruction cycle
- Operating voltage: 4.0-5.5V
- Industrial temperature range (-40° to +85°C)
- 15 Interrupt Sources
- 35 single-word instructions
- All single-cycle instructions except for program branches (two-cycle)

Special Microcontroller Features

- Flash Memory: 14.3 Kbytes (8192 words)
- Data SRAM: 368 bytes
- Data EEPROM: 256 bytes
- Self-reprogrammable under software control
- In-Circuit Serial Programming via two pins (5V)
- Watchdog Timer with on-chip RC oscillator
- Programmable code protection
- Power-saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug via two pins

6. Hardware Design

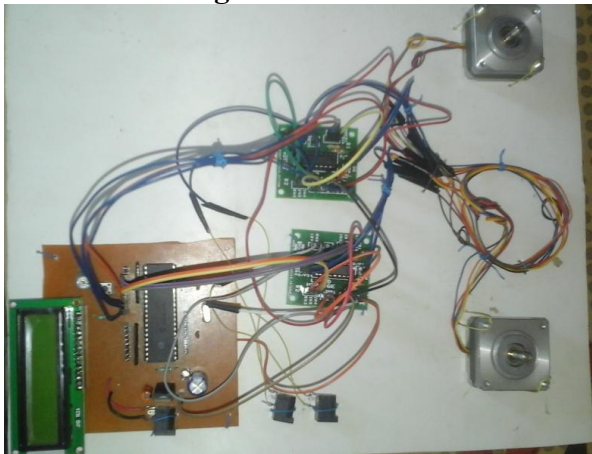


Figure 9: Hardware Layout

7. Conclusion

We control the motion of the camera, we have used two hybrid stepper motor in which one for left side motion and for right side motion and another stepper motor is for upper motion and lower motion with higher accuracy.

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