The Sinusoidal Ministep Drive Technique

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Abstract

This paper presents the sinusoidal current ministep technique to drive stepping motor. The stepping motor is coupling to the increment encoder to detect the position and speed of the stepping motor. The data from the encoder is decoded to sine and cosine signal and fed to the driver system. The driver system has two loops control, the inner loop and the outer loop. The inner loop is used to control the rotating of the stepping motor and the outer is used to control the speed of the motor. The rotating of the stepping motor is controlled with the sinusoidal signal . The test results of the inner loop control can control the revolution of the stepping motor is smooth and continuously with similar to the DC motor. The outer loop uses to control the speed of the stepping motor with control the DC voltages apply to the driver. The DC voltages that apply to the driver is controlled by the AC-DC converter. The test results of the outer loop control , it can control the speed of motor which is provide the any load in the design.

1. Introduction

The ministep drive is a method to subdivide one step into many small step by means of electronics. The idea of ministep comes from the sinusoidal bipolar drive of a hybrid stepping motor as a synchronous motor. The stepping motor is driven from a two phase of the sine wave supply, instead of square wave, the rotor motion is stepless and smooth. The paper presents the sinusoidal ministep drive technique, which used the increment encoder coupling to the motor . The increment encoder detects the rotor position and supplied its information which proper the phase to be decoded to the sinusoidal signal. The loop control of the driver system has two loops, the inner loop and the outer loop. The inner loop is used to control the rotating of the stepping motor with sinusoidal signal . The outer is used to control the speed of the motor with AC-DC converter when the loads apply.

2. Principle and Theory

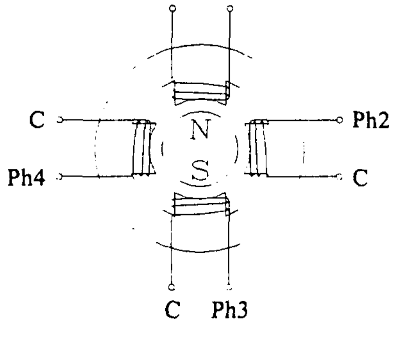

Fig. 1. Cross-section model of a four-phase PM (Permanent Magnet) motor

A basic four-phase PM stepping motor in the Fig.1. A cylindrical permanent magnet is employed as the rotor, and the stator has four teeth around which coils are wound. The basic scheme for the driving circuit is shown in Fig. 2

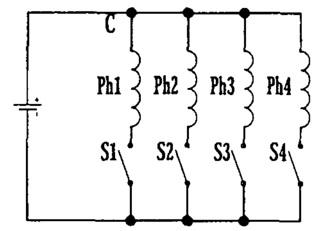

Fig. 2. Basic drive circuit for a four phase PM motor

The terminal marked C at each of phases is connected in turn to the positive terminal of the power supply. If the phases are excited in the sequence Ph1→ Ph2 → Ph3→ ... the rotor will be driven clockwise, the step angle is obviously 90° in this machine. The speed of rotation of a stepping motor is given in term of the number of step per second, which is called stepping rate. The term stepping rate can indicat the rotation speed. The relation between the rotation speed and the stepping rate is given by

$$n = \frac{60f}{s} \quad \text{rpm} \qquad (1)$$

where n = rotation speed
f = stepping rate (Hz)
s = step number

Mode of excitation

Single-phase Excitation

The single-phase excitation mode for four-phase motors. The shaded parts in the table 1 represent the excited state, and the white blanks show the phases to which current is not supplied and so are not excited. When a motor revolves clockwise in the excitation sequence of Ph1→Ph2→Ph3 ..., it will revolve counter-clockwise by simply reversing the sequence to Ph3→ Ph2→Ph1 ... .

Two-phase Excitation

A big characteristic difference between the single-phase exciting and two-phase exciting appears in the transient response. The two phase exciting the oscillation damps more quickly than is the case of the single-phase exciting. The step sequences are shown in the table 2.