

Description

The present invention relates to a method of, and apparatus for, damping the movement of a stepper motor.

In conventional 2-phase stepper motor there are two poles each pole having two windings. In normal application current is applied in a pre-determined sequence to the windings (Figs. 1, 2) and the motor moves accordingly, controlled motion of the stepper motor being achieved by digitally switching the current between motor windings. During this switching at least one winding always remains "on" and the remaining windings are switched off i.e. open circuit. With this method of driving the stepper motor there is relatively little damping of the motor when it completes its last step. This can result in overshooting of the desired final position with corresponding increase in settling time. This is considered a disadvantage of conventional stepper motors.

FR-A-1 555 056 describes an attempt to meet this problem, in which capacitors are selectively switched across windings of the stepper motor as the destination track is approached. This alters the time constant of the circuit of the relevant winding or windings, which has the effect of reducing, but not eliminating, the settling time.

It has also been proposed to brake the motor by short-circuiting windings to provide a back-EMF path. DE-A-2 742 932 uses this approach; however it requires a relatively complex circuit arrangement, and short-circuits all windings simultaneously in an additional process step. EP-A-0012885 also discloses short-circuiting, but only following crossing of the destination track and only uni-directional short-circuiting is shown.

An object of the present invention is to obviate or to mitigate the above disadvantages.

It has been found that the damping characteristics of the motor can be considerably improved if those windings which would otherwise be open circuit are short-circuited during at least the penultimate driving step. This short-circuiting provides a current path for any EMF induced in the unused windings.

Accordingly, a method for controlling the damping of a stepper motor as specified in the pre-characterising portion of Claim 1 is characterised by providing a bi-directional short circuit path to the windings not receiving current. An apparatus with the corresponding means is specified in Claims 2 to 4.

An embodiment of the present invention will now be described by way of example with reference to the accompanying drawings in which:—

Fig. 1 is a table showing a half-step sequence for a 2-pole stepper in which current is applied to the stepper motor windings.

Fig. 2 is similar to Fig. 1 and shows a full-step sequence for a 2-pole stepper motor.

Fig. 3 is a circuit diagram showing the circuit arrangement for short-circuiting one winding.

Fig. 4 is similar to Fig. 3 and shows the complete circuit configuration with a short-circuit arrangement for each winding.

Referring now to the drawings a winding A has two PNP transistors 1, 2 (Figs. 3, 4) connected in parallel. The transistors 1, 2 are connected across the winding A in an opposite sense; the emitter 1a is connected to the collector 2b and the collector 1b is connected to the emitter 2a. The bases 1c, 2c of the transistors are connected commonly viz a buffering resistor R, an amplifier 3 to a microprocessor (not shown). This circuit arrangement is repeated for each winding B, C, D as shown in Fig. 4.

In use current is applied to the windings in accordance with Fig. 1 if a half-step sequence is used or in accordance with Fig. 2 if a full-step sequence is used.

As a first example consider the operation of the invention with the half-step sequence shown in Fig. 1.

To go from step 2 to step 3, winding C remains "on" and winding A is switched off. A signal programmable from the microprocessor (not shown) to the respective windings which remain switched off, B, D. (Fig. 4) causes both transistors connected to each winding to be switched on.

The time when the windings are short-circuited is programmable, and is such that the performance of the stepper motor is not limited by short-circuiting too soon after a particular winding is switched-off. The windings B and D are therefore short-circuited producing two closed circuit loops. The two loops are required because the stepper motor can move in either direction setting up a back EMF and a current flow in either direction across the winding. For example, if the end Ba of the winding is positive the current flows through transistor 3 in the direction shown (Fig. 4). Alternatively if the end Bb is positive the current flows through transistor 4 in the direction shown. Whichever loop conducts, the other loop is effectively a high impedance.

As a second example with the half-step sequence consider moving from step 3 to step 4. In this case the winding "C" remains "on" and winding B is switched on.

A signal from the microprocessor to windings A and D simultaneously switches the transistors connected to each winding on short-circuiting the windings. The operation is then the same as described in the first example, and is repeated for the other steps in the sequence.

Without departing from the scope of the invention various modifications may be made to the circuits shown in Figs. 3 and 4. For example, switchable diodes or other suitable switching elements may replace the PNP transistors. Although a microprocessor is used to control the short-circuiting of the windings an equivalent logic circuit could be used to perform the same function.

In addition, in certain circumstances in the

full-step or half-step operation, the winding which has just been switched-off i.e. winding C, step 4—5 in Fig. 1 or winding A, step 1—2 in Fig. 2 is short-circuited in addition to the "dead" windings. In the full-step sequence that provides symmetry to the short-circuiting applied to the windings resulting in a more balanced response and in the half-step sequence the damping response is improved.

The circuits hereinbefore described are particularly suited for use with the microprocessor based stepper motor control circuit discussed in European Patent application No. 82302197.7 the short-circuiting of the windings being carried out at the final step during an inter-track stepper motor movement, that is when micro-stepping begins. The eight short-circuiting transistors are located on 2 "chips" and the four buffering resistors are located on a separate chip.

Advantages of the present invention are, damping produced by the retarding torque results in a faster track access time, and the accuracy of operation is improved. The circuit involves very few components and is also suited to control by the existing microprocessor present in the stepper motor control circuit.

Thus there is provided a method of, and apparatus, for damping the movement of the stepper motor using the non-active stepping motor windings.

Claims

1. A method of controlling the damping of stepper motor movement, including sensing at least at the penultimate step which windings (A—D) are receiving current, and switching current to the appropriate winding(s) in accordance with the step sequence; characterised by providing a bi-directional short circuit path to the windings not receiving current.

2. Apparatus for controlling the damping of movement of a stepper motor, including means for sensing at least at the penultimate step which windings (A—D) are receiving current; characterised by bi-directional short-circuiting means (1, 2) connected in parallel with each winding, and control means (3) responsive to said sensing means to actuate the short-circuiting means (1, 2) of those windings not receiving current to provide a path for back EMF.

3. Apparatus as claimed in claim 2 characterised in that said short-circuiting means is a pair of transistors connected in parallel with each other in opposite polarity.

4. Apparatus as claimed in claim 2 or claim 3 characterised in that the control means is a microprocessor which controls the switching on and off of said short-circuiting means in accordance with the position of the last step.

Patentansprüche

1. Verfahren zum Steuern der Dämpfung der Bewegung eines Schrittmotors, bei welchem min-

destens in der vorletzten Stufe ermittelt wird, welche Windungen (A—D) Strom aufnehmen, und Strom auf die entsprechende(n) Windung(en) entsprechend der Schrittfolge geschaltet wird, dadurch gekennzeichnet, daß die Windungen, die keinen Strom empfangen, mit einem bi-direktionalen Kurzschlußweg versehen werden.

2. Vorrichtung zur Steuerung der Dämpfung der Bewegung eines Schrittmotors, mit Mitteln, die mindestens bei der vorletzten Stufe gestellen, welche Windungen (A—D) Strom aufnehmen; gekennzeichnet durch zu jeder Windung parallel geschaltete bi-direktionale Kurzschlußmittel (1, 2) und eine Steuereinrichtung (3), die als Antwort auf die Mittel zum Feststellen die Kurzschluß-einrichtung (1, 2) derjenigen Windungen betätigt, die keinen Strom aufnehmen, um einen Strompfad für die Rück-EMK zu schaffen.

3. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß die Kurzschluß-einrichtung aus einem Paar Transistoren besteht, die parallel zueinander in entgegengesetzter Polarität geschaltet sind.

4. Vorrichtung nach Anspruch 2 oder Anspruch 3, dadurch gekennzeichnet, daß die Steuereinrichtung ein Mikroprozessor ist, der das Ein- und Ausschalten der Kurzschluß-einrichtung entsprechend der Position des letzten Schrittes ausführt.

Revendications

1. Procédé de commande de l'amortissement du mouvement d'un moteur pas-à-pas, comprenant la détection, au moins lors de l'avant-dernier pas, de ceux des enroulements (A—D) qui reçoivent le courant et la commutation du courant à l'enroulement ou aux enroulements appropriés conformément à la séquence de pas, caractérisé en ce qu'il consiste à créer un passage de court-circuit bidirectionnel pour les enroulements qui ne reçoivent pas de courant.

2. Appareil de commande de l'amortissement du mouvement d'un moteur pas-à-pas, comprenant des moyens de détection, au moins à l'avant-dernier pas, de ceux des enroulements (A—D) qui reçoivent le courant, caractérisé en ce qu'il comprend des moyens (1, 2) de court-circuit bidirectionnel, raccordés en parallèle avec chaque enroulement, et des moyens de commande (3) qui répondent aux moyens de détection pour actionner les moyens de court-circuit (1, 2) de ceux des enroulements qui ne reçoivent pas de courant, de manière à créer un passage pour une force contre électromotrice.

3. Appareil suivant la revendication 2, caractérisé en ce que les moyens de court-circuit sont constitués de deux transistors raccordés en parallèle l'un à l'autre et en polarité opposée.

4. Appareil suivant la revendication 2 ou la revendication 3, caractérisé en ce que les moyens de commande comprennent un microprocesseur qui commande la commutation à l'état conducteur et non conducteur des moyens de court-circuit, conformément à la position du dernier pas.

full-step or half-step operation, the winding which has just been switched-off i.e. winding C, step 4—5 in Fig. 1 or winding A, step 1—2 in Fig. 2 is short-circuited in addition to the "dead" windings. In the full-step sequence that provides symmetry to the short-circuiting applied to the windings resulting in a more balanced response and in the half-step sequence the damping response is improved.

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